ICTS 2015

17th International Conference on Transport Science

MARITIME, TRANSPORT and LOGISTICS SCIENCE

~ Conference proceedings ~

Organized by:

Slovene Association of Transport Sciences

Faculty of Maritime Studies and Transport, Portoroz, Slovenia

Faculty of Maritime Studies, Split, Croatia

Polish Naval Academy, Gdynia, Poland

May 21st—22nd, 2015, Portoroz, Slovenia

Slovensko društvo za znanost v prometu
in
Fakulteta za pomorstvo in promet (Univerza v Ljubljani)
Pomorski fakultet (Sveučilište u Splitu)
Polish Naval Academy (Gdynia)

17. MEDNARODNO POSVETOVANJE O PROMETNI ZNANOSTI

17TH INTERNATIONAL CONFERENCE ON TRANSPORT SCIENCE

ICTS 2015

POMORSTVO, PROMET IN LOGISTIKA

MARITIME, TRANSPORT AND LOGISTICS SCIENCE

ZBORNIK REFERATOV

CONFERENCE PROCEEDINGS

21. – 22. MAJ 2015
PORTOROŽ, SLOVENIJA

PROGRAMSKI ODBOR
PROGRAM COMMITTEE

Elen Twrdy, *Slovenia* – President
Nikola Račić, *Croatia* – Vice-president

Milan Batista, *Slovenia*
Kristi Bombol, *FYR Macedonia*
Stane Božičnik, *Slovenia*
Olja Čokorilo, *Serbia*
Karel Havel, *Slovakia*
Janis Kokars, *Latvia*
Serđo Kos, *Croatia*
Tomasz Lus, Poland
F. Xavier Martínez de Osés, *Spain*
Sanja Steiner, *Croatia*
Pero Vidan, *Croatia*

ORGANIZACIJSKI ODBOR
ORGANIZING COMMITTEE

Marina Zanne, *Slovenia* – President
Patricija Bajec, *Slovenia* – Secretary
Pero Vidan, *Croatia*

CIP - Kataložni zapis o publikaciji
Narodna in univerzitetna knjižnica, Ljubljana

656(082)(0.034.2)

MEDNARODNO posvetovanje o prometni znanosti (17 ; 2015 ; Portorož)
Pomorstvo, promet in logistika [Elektronski vir] : zbornik referatov = Maritime, transport and logistics science : conference proceedings / 17. mednarodno posvetovanje o prometni znanosti = 17th International Conference on Transport Science - ICTS 2015, 21.-22. maj 2015, Portorož, Slovenija ; [organizirala] Slovensko društvo za znanost v prometu in Fakulteta za pomorstvo in promet (Univerza v Ljubljani) ... [et al.] ; [uredniki Marina Zanne, Patricija Bajec, Pero Vidan]. - Portorož : Fakulteta za pomorstvo in promet, 2015

ISBN 978-961-6044-98-1
1. Gl. stv. nasl. 2. Vzp. stv. nasl. 3. Zanne, Marina 4. Slovensko društvo za znanost v prometu
279640320

Referati so recenzirani z mednarodno recvenzijo.
Založnik: Fakulteta za pomorstvo in promet, Portorož, 2015
Uredniki: Marina Zanne, Patricija Bajec, Pero Vidan
Naklada: 100 izvodov

INDEX

A CONCEPTUAL FRAMEWORK FOR MARITIME PROJECT TOWARDS HUMAN RELIABILITY ANALYSIS AND MONITORING IN SHIPBOARD OPERATIONS (H-RAMS)

Emre Akyuz, M.Sc
Piri Reis University
Department of Maritime Transportation and Management Engineering
Istanbul, Turkey, Tuzla 34940
emreakyuz82@gmail.com, eakyuz@pirireis.edu.tr

Metin Celik, Ph.D
Istanbul Technical University
Department of Marine Engineering
Istanbul, Turkey, Tuzla 34940
dr.celikm@gmail.com

ABSTRACT

In recent years, human performance prediction has become a focal issue of maritime organizations since the ship accident statistics have still been addressing the crew errors as main contributing factor. In fact, key maritime stakeholders such as International Maritime Organization, International Labour Organization, and Ship Classification Societies have closely monitored the mentioned problem by professionals who are trying to find and adopt an effective solution through ship operational level. This paper outlines how to design and implement an on-site operational analysis using human reliability theories in a maritime project context. Besides conceptual framework, the test and verification issues of product (i.e. crew reliability monitoring software) are extensively elaborated. Furthermore, the adaptation of the system into shipboard platform in terms of achieving end-user (ship crew) requirements via improving database mechanism and procedural integration, etc. are discussed. Consequently, the study clarifies the potential of the maritime project to derive a global feasible solution along with reducing the crew error rates in ship operations and management in international level.

Key words: Human reliability analysis, human error probability, maritime safety, decision-making, H-RAMS.

1 INTRODUCTION

In the recent times, investigation of the human performance affecting factors has become one of the substantial subjects of industrial and academic organizations. There are ongoing extensive studies about it in industries such as nuclear energy [1,2], defence industry [3], electronic systems [4], product industry [5], transportation [6,7], etc. Despite the fact that accidents that happen and hazards occur on ships mostly on human factor, it is seen that there are limited studies that can meet the needs of maritime industry. In recent years, it is observed that international authorities (International Maritime Organization, International Labour Organization, Ship Classification Societies etc.) increased their studies. As statistical studies point out that mentioned human error proportion reaches 80% level and the problem becomes obstinate, the subject of human safety analysis on ships is chosen [8]. Because of that this study is parallel to expectation of a solution to this problem of maritime industry decision-makers and their stakeholders. In this context, the aim of this study is to develop an unique human reliability analysis and monitoring system (H-RAMS) by knowledge-base system in order to minimize the operational problems that may arise from human errors on-board ships. This system, additionally contributing current human reliability analysis methods in academic literature, will be tested on vessel fleets such as container, chemical tanker, petrol tanker, LGP tanker, bulk carrier and their operational feasibility and validity will be verified. In the light of above, it is predicted to reach solid targets mentioned below.

- To minimize the error risk by assessing human reliability in shipboard operations;
- To test proposed approach for critical shipboard operations such as loading or discharging cargo, bunkering, ballast operations, anchoring, shipboard contingency actions, working in enclosed space, maritime pollution prevention;
- To create available solutions for shipboard operational environment by developing a valid approach to human error assessment;
- To support proposed approach to constant observation of human reliability on-board ship with a user interface software;
- To determine preventive actions (that improves human reliability) against pivotal factors that cause errors in shipboard operations;
- To contribute to ship safety management system in practice.

Since there have been a few studies existing with respect to human reliability analysis (HRA) for marine industry [9-11]; nuclear [12], railway [13] and aviation [14] industries had successful applications which have their own specific parameters to assess human reliability. Therefore, the project, so called H-RAMS, proposes an empirical human reliability analysis which has marine-specific parameters for critical operations on-board ship to enhance safety and operational reliability in marine industry by integrating HEART and AHP as well as HFACS technique. The next section gives brief explanation of methodologies to conceptualise the H-RAMS.

2 RESEARCH METHODOLOGIES

2.1 HEART technique

HEART (human error assessment and reduction technique) is recognized as a well-known modelling tool in safety and reliability analysis where critical operation is performed. It is currently applicable to wide range of industry. Since the human error data is scarce in the literature, it is quite tough to apply stochastic models such as Bayesian Network or Markov chain into marine HRA concept in order to predict human error probability (HEP) value. Furthermore, the current HRA techniques are limited to reveal all of the significant aspects of human performance in marine industry such as insufficient data, subjectivity of expert judgement, uncertainty, etc. Therefore, using the empirical method such as HEART seems more reasonable and consistent to support the consideration of human performance. The technique is quick and flexible requiring few researches only. It was presented to assess human tasks with defined values for HEP calculation [15]. The fundamental is to depend on two parameters; the first one is generic task type (GTT) and second one is error-producing condition (EPC). The GTT allows user to find suitable task under HRA and then define the generic error probability (GEP) value (also known as nominal human unreliability), while EPC defines the performance shaping factor (PSF) of human which influence the probability of human error in the related task. This means that EPCs are expected to affect human performance negatively and leading to increase HEP associated with generic task. The HEP value can be found with following equation (1) [15].

$$HEP = GEP_{value} \times [(W_i - 1) \times APOA_1 + 1] \times \left[\left(W_j - 1\right) \times APOA_2 + 1\right] \times \ldots \quad (1)$$

2.2 AHP (Analytic Hierarchy Process)

The AHP is a robust multi-criteria decision making (MCDM) method. It was presented to acquire relative weight of criteria according to hierarchical structure [16]. The method depends on the pair-wise comparison matrix where alternatives are compared respectively. The technique is widely utilised to solve complicated decision problems. It fundamentally divides the complicated problem into small parts in order to rank hierarchically. The method comprises basically four steps in which dividing the problem into small parts, comparing the elements with a pair-wise matrix, evaluating relative importance and ranking of elements. The following equations are used sequentially [16, 17].

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \qquad a_{ii} = 1, a_{ji} = 1/a_{ij}\,, a_{ij} \neq 0 \quad (2)$$

$$w_i = \frac{1}{n}\sum_{j=1}^{n} \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \quad (3)$$

$$CI = \frac{\lambda_{max.} - n}{n-1} \quad (4)$$

$$\sum_{j=1}^{n} \alpha_{ij}\, w_j = \lambda_{max}\, w_i \quad (5)$$

$$CR = CI/RI \quad (6)$$

In the project, the AHP method which quantifies the subjective expert judgements and confirms the consistency of collected data is used to weight/prioritise proportion effect of EPCs as well as weighting EPCs during derivation process.

2.3 HFACS (Human Factor Analysis and Classification System)

The HFACS is a comprehensive tool to analyse role of human factors in accident. The method was developed by Wiegmann and Shappell [18] to investigate and analyse accident causes in aviation accidents. Indeed, it should be noted that the fundamental framework of the HFACS method was tailored from the Swiss cheese model (Figure 1) which is initially introduced by Reason [19]. But, the HFACS model was successfully extended by introducing a user-friendly and comprehensive framework to analyse human error in accidents effectively. The fundamental aim of the method is to provide a framework in order to assist users for investigating and analysing human error in accidents. Number of causal classifications is defined within four levels of human failures; i) Organisation influences, ii) Unsafe supervision, iii) Pre-conditions for unsafe acts and iv) Unsafe acts.

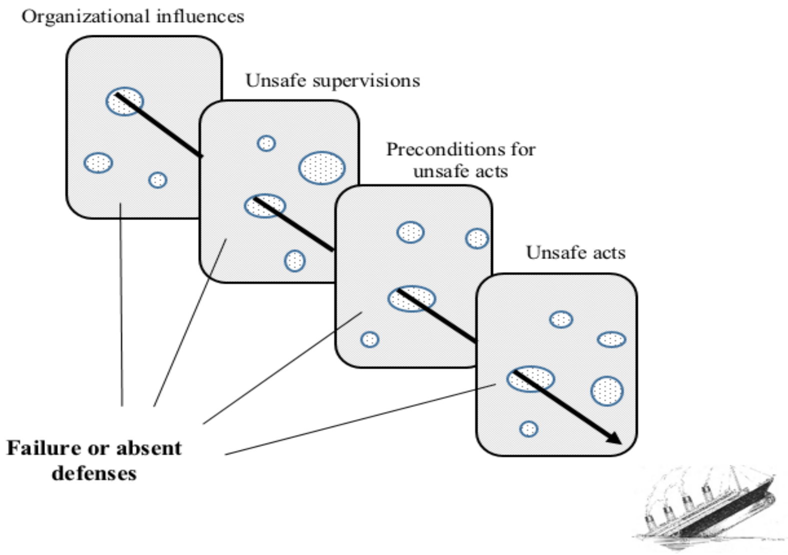


Figure 1: Swiss cheese model for human error causation

The objective evidence with respect to the each HFACS layer defines the active and latent failures in the system [19]. Thus, the users take benefits of the method by identifying active or latent failures and may have a change to prevent accident causes in advance. In the project, the HFACS method is used to investigate and classify marine accident causes due to human factors.

3 SYSTEM DESIGN

Outlines of the method that will be followed in this project are designed on conceptual research, procedure development, software development with application interface design and test phases. In human reliability analysis study of correlation among variables in particular accident causalities generic task types (GTT) and error producing conditions (EPC), suitable customization to ship platform, weighting of variables related to decision-making method, consistency in weighting and increasing sensitivity can be mentioned as original aspects of the project. Figure 2 depicts the conceptual framework to establish proposal approach. The concept consists of three main stages. The first one is data gathering where required data including marine accident causes are provided. Since obtaining quantitative human error data on the nature of maritime industry is very challenging, the aim of this phase is to gather data by analysing marine accident cases. In this sense, marine investigation branches such as MAIB, ATSB, NTSB and JTSB are exploited. The second stage is EPC derivation part where HFACS and AHP methods are combined to generate validated marine specific performance shaping factors. The last stage is system application part in order to assess human error. This part involves APOA (Assessed proportion of affect) and HEP calculation.

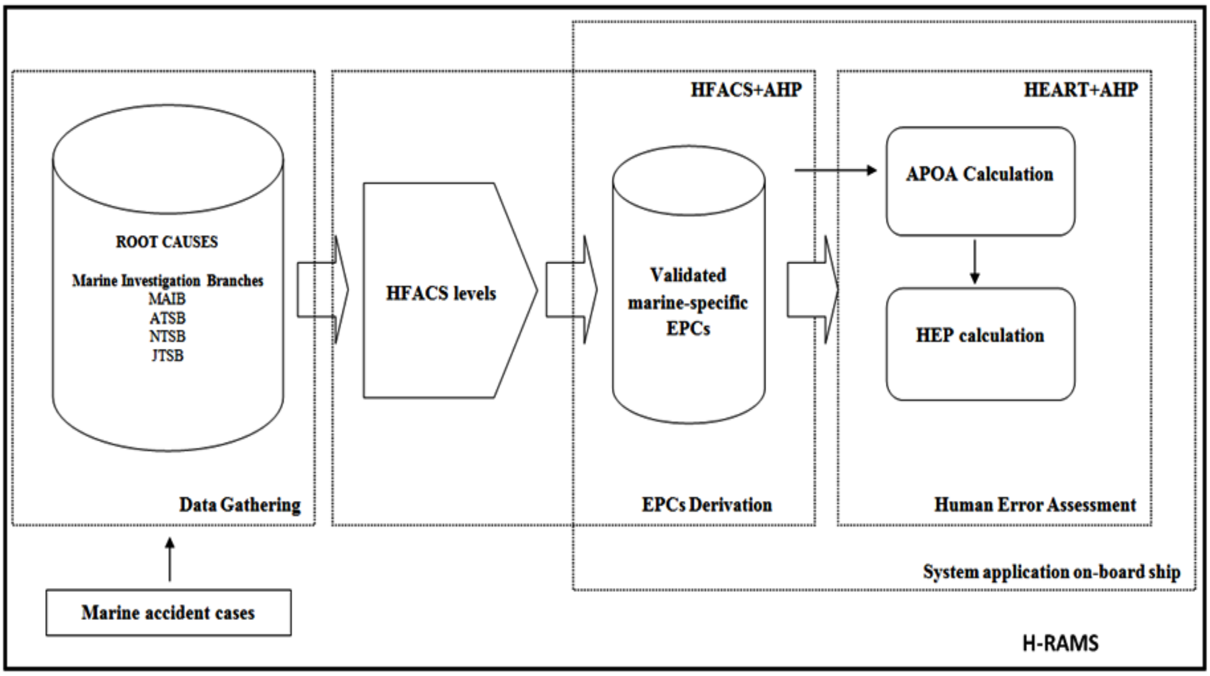


Figure 2: Conceptual framework of project methodology

3.1 Generation of EPC for marine industry

The conventional HEART method is based on data mining to generate EPC values from different industry such as power plant, petrochemical industry, offshore platforms, and service industry. Instead of using data mining, this project brings a new perspective to generate marine-specific EPCs. The study proposes a methodological approach to quantify and validate the EPCs for H-RAMS project since obtaining historical data with respect to human error on the nature of maritime industry is very challenging and mostly unknown due to scarce of data. The EPC derivation process mainly consists of two parts; derivation and validation.

3.1.1 Quantification of EPCs

The first step of generation process is to quantify EPC for marine industry. In order to fulfil that relation matrix is constructed by distributing EPCs into relevant each HFACS sub-level. At this point, the elaborative survey is performed with five marine experts who are working in prestigious five different shipping companies. The each expert is asked to distribute relevant EPCs through HFACS sub-levels which may potential effect on error production. Totally five different experts' opinion have obtained via surveys and those transform into useful information by performing majority rules which is kind of a decision-making technique to eliminate minor alternatives and select majors that is more than half the votes.

After having completed relation matrix, pair-wise comparison matrices are established in order to prioritise EPCs which are distributed under each HFACS sub-levels. In this context, equation (2) is used. The pair-wise comparison matrices are built up in accordance with 1-9 linguistic scale of the analytic hierarchy process which is showing the intensity of importance each criterion [16]. The judgements upon EPC comparison for each HFACS level are obtained from the marine experts. Since there are five marine experts are asked for judgements, the result is reduced to one by getting geometric means of them. Respectively, EPCs pair wise comparison matrices for each HFACS levels are established. Thereafter, weighting of the EPC under relevant HFACS level is carried out by using equation (3). Thus, the prioritization of EPCs will be provided by quantification the subjective judgement of experts and confirms the consistency of data. In order to get consistent and reasonable results, the CR values will also be calculated in accordance with equation (4), (5) and (6). If the CR values are found bigger than 0.10, the pair-wise comparison matrix shall be revised. The final process is to quantify the final EPC value. In this step, each EPC column is accumulated vertically to find out total EPC effect since there are existing 19 HFACS sub-levels.

3.1.2 Validation of EPCs

The second step of generation process is to validate numbers derived for marine industry. This step is to provide real data using marine accident causes since the human factor is one of the most significant contributory factor of marine incidents. Therefore, significant numbers of marine accidents are examined and analysed to find out the causes. In order to reach accurate findings, those cases were selected in accordance with distribution of world ship fleets in terms of tonnage and percentage of accident causality (collisions, groundings, fires/explosions, machinery damage, listing, and other significant accidents) during 2013. Thereafter, marine accident causes are identified. The database involves plenty of different accident causes from range of different investigation branches such as Marine Accident Investigation Branch (MAIB), Australian Transportation Safety Bureau (ATSB), National Transportation Safety Board (NTSB), Japan Transport Safety Board (JTSB) and Turkish Accident Investigation Board (KAIK). Then, these accident causes are classified in accordance with the HFACS framework. After having completed classification, accumulated accident causes are distributed through the related EPC under corresponding HFACS sub-levels by marine experts. The final value is normalized by dividing to the total number of accident causes classified under corresponding HFACS sub-level. Thereafter, the total EPC effect is found by getting sum of each column vertically. Finally, the generated EPC values are compared with statistical values since real data are used to validate the calculation.

3.2 Proportion affects assessment (APOA)

The assessed proportion of affect is one for the critical point during HEP calculation in H-RAMS. In conventional HEART approach, if there are more than one EPC, the experts assign a proportion of the effect which is weighted (prioritised) for each EPC based on its importance. Instead of conducting traditional APOA assessment, this project proposes to apply smart solution utilising the AHP technique to weight the importance of each EPC since they are weighted from 0 to 1. So that, the methodological extension improves the consistency of the calculation during HEP calculation. In order to apply APOA calculation, equation (2), (3), (4), (5) and (6) will be conducted respectively.

4 SYSTEM APPLICATION

The system of application on-board ship is illustrated in Figure 3 where H-RAMS software to operate the system on the principle of flow diagram. The software will include human reliability analysis and monitoring system which will be easily used by the Masters or shore-based executives. The software will transform the theoretical information into practice application by using hybrid decision-making HRA model. The system will start to define the relevant task in accordance with the scenario which is including main and sub-tasks on-board ship. This is performed in line of hierarchical task analysis (HTA) where main tasks are divided into sub-tasks [20].Then, numerous scenarios representing in a broad sense will be defined at the second phase. These scenarios include numerous conditions such as working environment, operator/crew experiences, noise level, stress, operator/crew workforce morale, disruption, available time for task, time of day or organisation quality, etc. Thereafter, the relevant GTT is assigned by the software in accordance with defined scenario in the course of eight qualitative descriptions of actions (A to M) [15]. Thus, quantitative GEP value is determined for each sub-step.

The next step is required to select marine-specific EPC/s in accordance with the condition of operator. After having assigned relevant EPCs, APOA calculation will be held if there are more than one EPC. The software will create comparison matrix for EPCs and user is asked to compare each criteria with respect to Saaty's linguistic scale [16]. The next phase includes calculating criteria (EPC) weights. As a result, relative importance of EPCS will be calculated. In order to obtain consistent result during comparison matrix, the software will calculate CR (consistency ratio) values. If CR values are found more than 0.10, the judgements inserted by user are considered as inconsistent. Therefore, the pair-wise comparison matrix shall be revised by user. The next phase enables to calculate HEP value in line of the equation (1). In order to get final HEP value, the software is asked to define dependency among the sub-tasks in the course of HTA PSA which addresses that whether the system is serial or parallel. Accordingly final HEP will be calculated.

In case of final HEP value is found higher than desired level, recovery proposal will be recommended to mitigate HEP value. At this point, appropriate mitigation measures are taken for EPCs which may cause to increase HEP values. Before do that, it is checked whether final HEP value is acceptable level or not by using risk matrix [21]. If the final HEP value is placed inside the red boxes in the risk matrix, then recovery proposal is needed to mitigate HEP into desired level (lower risk level-yellow blocks).

In this context, error reduction measures for relevant EPCs are proposed to remove the impacts of error producing conditions. The final phase provides re-calculation of final HEP, after having applied recovery measures. In case re-calculated final HEP value is not decreased into desired level again (lower risk level- yellow blocks), the recovery measure shall be revised and final HEP re-calculated again. If the final HEP is acceptable, then software allows user to do operation.

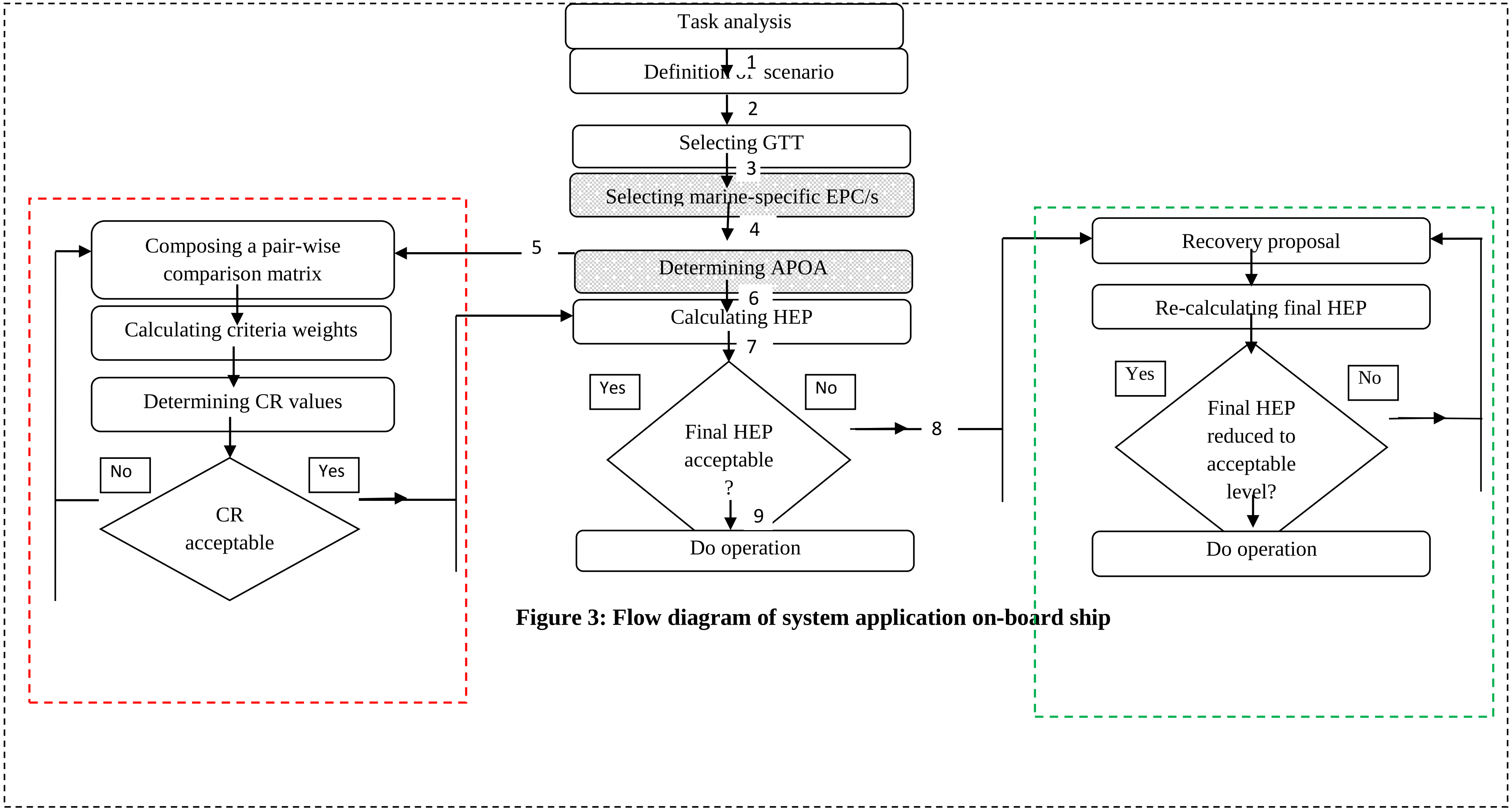


Figure 3: Flow diagram of system application on-board ship

5 CONCLUSION

As a result, proposed project with these aspects will be providing new perspective to human reliability assessment researches and will provide knowledge based technological solution to a focal subject in marine industry. Along with being supported at national level at first, with interdisciplinary project team`s continuity to work in accordance with above mentioned principles, based on knowledge measurement of human reliability in maritime and sensitivity level concepts that is improved in short term, presentation of a new safety concept (like ship crew reliability index) in medium and long term to maritime authorities will carry our country to a standard where we propose solutions in maritime knowledge and technologies subjects. Within this context, the targets and expected outputs of the proposed project are as follows: i) Developed parameters of human reliability analysis model suitable into shipboard operation management concept, ii) Model integration in transition from accident analysis to human reliability analysis parameters, iii) Human reliability analysis and monitoring system- H-RAMS software, iv) Test and application results of the developed system, v) Safety factor enhancement level of developed new reliability concept.

With this project, via offering solutions to related points, implementation of management of human error analysis and reduction technique will be consistently provided in maritime industry. Specially, even though there are peculiar, developed human reliability analysis methods in aviation and railway industry, there is no unique method for maritime industry yet. With the hybrid method presented by the project will both satisfy this requirement and it is expected to be utilized in similar sectors such as ports, shipyards, off-shore platforms, oil rigs, floating- production-storage and offloading units.

ACKNOWLEDGEMENT

*This article is partially produced from PhD dissertation entitled “A decision-making model proposal on human reliability analysis on-board ship” which has been executed in Maritime Transportation Engineering Program of ITU Graduate School of Science, Engineering and Technology.

*This article is prepared during the research project entitled “Human Reliability Analysis and Monitoring System Proposal in Shipboard Operations (H-RAMS)” (Project no: 114M352) of the Scientific and Technological Research Council of Turkey (TUBITAK). The authors wish to give their appreciation to TUBITAK for financial support.

REFERENCES

[1] Chang, Y.J., Bley, D., Criscione, L., Kirwan, B., Mosleh, A., Madary, T., Nowell, R., Richards, R., Roth, E.M., Sieben, S. Zoulis, A. (2014). The SACADA database for human reliability and human performance. Reliability Engineering and System Safety, 125, 117-133.

[2] Zubair, M. & Zhijian, Z. (2013). Reliability data update method (RDUM) based on living PSA for emergency diesel generator of Daya Bay nuclear power plant. Safety Science,59, 72–77.

[3] Hausken, K. (2008). Strategic defense and attack for reliability systems. Reliability Engineering and System Safety, 93,1740–1750.

[4] Liang, G.S. & Wang, M.J.J. (1993). Evaluating human reliability using fuzzy relation. Microelectronics Reliability,33, 63-80.

[5] Bertolini, M., Bevilacqua, M. and Cooper, S.E. (2010). Fuzzy cognitive maps for human reliability analysis in production systems. Production Engineering and Management Under Fuzziness Studies in Fuzziness and Soft Computing, 252, 381-415.

[6] Calhoun, J., Savoie, C., Randolph-Gips, M. and Bozkurt, I. (2014). Human reliability analysis in spaceflight applications Part 2: Modified CREAM for spaceflight. Quality and Reliability Engineering Int., 30, 3–12.

[7] Guo, H., Wang, W., Gou, W., Jiang, X., Hubb. H. (2012). Reliability analysis of pedestrian safety crossing in urban traffic environment. Safety Science, 50, 968–973.

[8] Kirwan, B., (1987). Human reliability analysis of an offshore emergency blowdown system. Applied Ergonomics, 18.1, 23-33.

[9] Deacon, T., Amyotte, P.R., Khan, F.I., MacKinnon, S. (2013). A framework for human error analysis of offshore evacuations. Safety Science ,51, 319-327.

[10] Akyuz, E. & Celik, M. (2015). Application of CREAM human reliability model to cargo loading process of LPG tankers. Journal of Loss Prevention in the Process Industries, 34, 39-48.

[11] Martins, M.R. & Matuna M.C. (2013). Application of Bayesian Belief networks to the human reliability analysis of an oil tanker operation focusing on collision accidents. Reliability Engineering and System Safety, 110, 89–109.

[12] Kirwan, B., Gibson, H., Kennedy, R., Edmunds, J., Cooksley, G., Umbers, I., (2004). Nuclear Action Reliability Assessment (NARA): A Data-Based HRA Tool. Probabilistic Safety Assessment and Management, 1206-1211.

[13] Gibson, W.H., Mills, A.M., Smith, S., Kirwan, B.K., (2012). Railway action reliability assessment, a railway specific approach to human error quantification. Rail Human Factors. Supporting reliability, safety and cost reduction. Taylor & Francis.

[14] Kirwan, B. & Gibson, W. H., (2008). Human reliability assessment (CARA) development for EUROCONTROL Q07/22268NC.

[15] Williams, J.C. (1988). A data-based method for assessing and reducing human error to improve operational performance. In: Proceedings of IEEE 4th conference on human factor and power plants. Monterey, California, 436–453.

[16] Saaty, T. L. (1980). The Analytic hierarchy process: Planning, Priority Setting, Resource Allocation, McGraw-Hill.

[17] Vargas, L. (1982). Reciprocal matrices with random coefficients. Mathematical Modelling, 3, 69–81.

[18] Wiegmann, D. & Shappell, S., (2003). A Human Error Approach to Aviation Accident Analysis: The Human Factors Analysis and Classification System. Ashgate Publishing Ltd., Aldershot.

[19] Reason, J. (1990). Human Error. Cambridge University Press, New York.

[20] Shepherd, A. (2001). Hierarchical Task Analysis. Taylor and Francis, London.

[21] DiMattia, D., Khan, F.I., Amyotte, P.R. (2005). Determination of human error probabilities for offshore platform musters. Journal of Loss Prevention in Process Industry, 18, 488–501.

POLYCYCLIC AROMATIC HYDROCARBONS (PAH) IN SEDIMENTS OF THE GULF OF TRIESTE-DISTRIBUTION, SOURCES AND TEMPORAL TRENDS

Oliver Bajt, PhD
National institute of biology
Marine biology station
Fornace 41, Piran, Slovenia
University of Ljubljana
Faculty of maritime studies and transport
Pot pomorscakov 4, Portoroz, Slovenia
oliver.bajt@mbss,org

ABSTRACT

The Gulf of Trieste (northern Adriatic) is one of the most urbanized and industrialized areas in northern Adriatic, with intense maritime traffic (ports of Trieste, Koper, Monfalcone, marinas, harbors). The impact of maritime traffic on pollution by hydrocarbons in this area was assessed in this work. Concentrations of hydrocarbons were higher near the expected pollution sources and still elevated in the adjacent offshore areas. Compared to the prevailing pyrolytic origin (fossil fuel combustion), the petrogenic PAH origin (petroleum) seems to be less important, but not negligible. The temporal trends in PAH concentrations showed quite constant concentrations, with some decrease at some sampling sites, e.g. Port of Koper, Marina of Portoroz. This could be due to better environmental management in such areas with intensive maritime traffic. The presented results revealed the impact of intensive maritime traffic on pollution with hydrocarbons in the investigated area, which is largely limited to the areas near the pollution sources.

Key words: PAH, Gulf of Trieste, sediments, maritime traffic, pollution.

1 INTRODUCTION

Hydrocarbons of natural and anthropogenic origin are widely distributed in the environment throughout the world. The most important sources of the introduction of these compounds into the natural environment are oil seepage, oil spillage, ship traffic, urban runoff, waste water and sewage effluents, as well as atmospheric deposition [1]. Determination of the various sources of the introduction of such compounds into the marine environment as well as the concentrations of these compounds in sea water, sediments and marine organisms is of crucial importance to adequately assess the state of the environment. This is especially important where extensive industrial activity or maritime traffic might be expected. Hydrocarbons, especially polycyclic aromatic hydrocarbons (PAH), have been recognized as hazardous environmental chemicals [1]. Many marine organisms, living in contaminated areas, accumulate hydrocarbons. As a consequence, the elevated concentrations of these compounds in sea food could also be harmful to human health.

Hydrocarbons are hydrophobic compounds. Because of their low solubility in water, they tend to adsorb on organic or inorganic particles in the water column and settle to the bottom surface sediment. Therefore, marine sediments often contain hydrocarbons in higher concentrations than those in the overlaying water.

The composition of PAHs usually reflects the sources that produced the PAHs. Some molecular indices play a major role in establishing the origin of PAHs in marine waters and sediments, in particular, the ratios between low molecular weight (LMW) and high molecular weight (HMW) PAHs or the ratio of some isomers, e.g. phenanthrene/anthracene, fluoroanthene/pyrene [2].

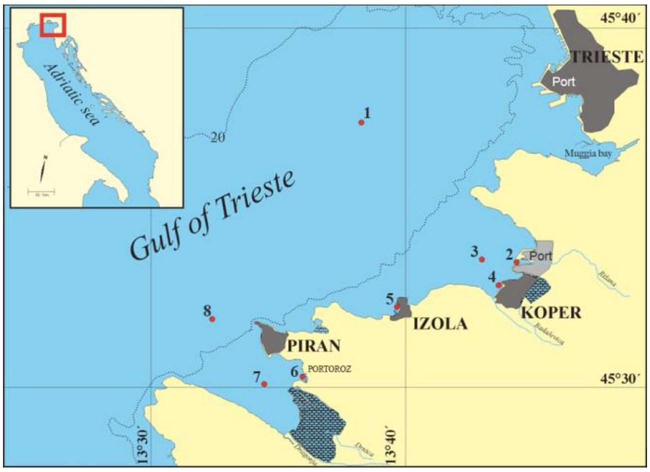


Figure 1: Location of sampling sites within the investigated area

Source:Author

The investigated area (Gulf of Trieste) is a part of the northern Adriatic (Fig. 1). It is a rather shallow and semi-enclosed area with an estimated surface of 600 km^2 and a maximum depth around 25 m. The marine environment along the coast is affected by contamination from different sources because this area is one of the most urbanized and industrialized in the northern Adriatic. Maritime traffic to the three ports (Koper, Trieste, Monfalcone) is quite intensive. These ports handle about 70 million tons of cargo per year. The estimated annual quantity of oil and oil products carried by ships in the Gulf of Trieste is more than 35 million tons. In addition to the intensive maritime traffic, nautical tourism is also well developed (there are more than 15 marinas and small harbors). Coastal waters of the Gulf of Trieste are also used for other economically important activities, such as tourism, fisheries and mariculture.

Table 1: Description of sampling sites

Site	Description	Depth (m)
1	Central part of the Gulf of Trieste	24
2	Port of Koper, Marina of Koper	10
3	Central part of the Bay of Koper	16
4	Municipal harbor of Koper	3
5	Municipal harbor and marina of Izola	4
6	Marina of Portoroz	10
7	Central part of the Bay of Piran	16
8	Offshore site, 2 NM from the main shipping	21

Source: Author

The aim of the present work was to determine the distribution, origin and temporal trends of polycyclic aromatic hydrocarbons in surficial sediments in the southeastern part of the Gulf of Trieste in order to assess the state of pollution and the contribution of maritime traffic.

2 EXPERIMENTAL

High purity hexane, methanol and methylene chloride were used for the extraction of hydrocarbons. Sediment samples were taken by gravity corer. The top 2 cm layer was used for further analyses. Samples were frozen and after that freezedried. Dry sediment was homogenized. About 10 g of sediment was transferred in a Soxhlet apparatus and extracted for 8 hours with 200 ml of hexane/methylene chloride (1:1). The extracts were concentrated on a rotary evaporator and additionally in a nitrogen stream. Sulphur was removed overnight by the addition of activated Cu. The partitioning in aliphatic and aromatic fraction was performed on SiO_2/Al_2O_3. Aromatic fraction was concentrated and used for the analyses. Concentrations of polycyclic aromatic hydrocarbons were determined using gas chromatography.

3 RESULTS AND DISCUSSION

Concentrations of PAHs are presented in Table 2. The highest concentrations were detected in Izola and Koper harbors. Concentrations at all other sites were much lower, only in the marina of Portoroz were they relatively slightly elevated. As expected, the lowest concentrations were detected at site 8. Concentrations in the port of Koper are quite low and do not differ significantly from those at the offshore site. The area in the Port of Koper is rather open and the exchange of water is more intensive. In addition, dredging activities in the port, as well as the resuspension of sediments caused by ship screws, can influence the distribution of contaminants. Somewhat elevated concentrations were also obtained in the central part of the Gulf of Trieste (site 1). This could be an indication of the influence of the Port of Trieste and the City of Trieste. Concentrations of sedimentary PAHs in the port of Trieste, as well as in the surrounding area in Muggia Bay are two orders of magnitude higher compared to other areas of the Gulf of Trieste [3]. They ranged from 2.37 µg g^{-1} dw to 64.56 µg g^{-1} dw.

Table 2: The content of PAHs (ng g^{-1} dw) in sediment samples

	Sampling site							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Naphthalene	3	7	n.d.	22	n.d.	2	n.d.	1
Acenaphthylene	n.d.	1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Acenaphthene	n.d.	n.d.	1	7	n.d.	n.d.	n.d.	2
Fluorene	27	41	21	7	27	19	9	25
Phenanthrene	52	40	28	289	657	30	38	32
Anthracene	2	4	2	57	240	2	2	1
Fluoranthene	98	28	75	482	1402	156	74	26
Pyrene	81	27	59	487	1211	125	78	33
Chrysene	13	61	17	446	298	86	94	34
Benzo[a]anthracene	40	13	23	316	244	22	10	3
Benzo[b]fluoranthene	19	18	26	464	61	50	29	18
Benzo[k]fluoranthene	23	21	46	239	70	56	11	12
Benzo[a]pyrene	34	14	38	269	122	46	25	18
Indeno[1,2,3-c,d]pyrene	33	14	31	159	35	22	14	3
Dibenzo[a,h]anthracene	8	17	4	128	34	24	3	3
Benzo[g,h,i]perylene	9	29	10	156	15	26	3	3

	Sampling site							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Total PAH	**442**	**335**	**381**	**3528**	**4416**	**666**	**390**	**214**
LMW/HMW	0.2	0.4	0.2	0.1	0.3	0.1	0.1	0.4
PHE/AN	26.0	10.0	14.0	5.1	2.7	15.0	19.0	32.0
FLU/PY	1.2	1.0	1.3	1.0	1.2	1.2	0.9	0.8
AN/(AN+PHE)	0.04	0.09	0.07	0.16	0.26	0.06	0.05	0.03
FLU/(FLU+PY)	0.55	0.51	0.56	0.50	0.54	0.56	0.49	0.44

Source: Author

Two primary origins are usually considered in the case of PAHs, petrogenic (from petroleum) and pyrolytic (combustion of organic matter, e.g. fossil fuels). In most cases, sources are mixed, with prevalence varying. To distinguish between petrogenic and pyrolytic origins, different evaluation indices have been used [2]. Some of the most frequently used are presented at the end of Table 2. It is well known that high molecular weight PAHs (HMW; 4, 5 and 6 aromatic rings) are mostly formed during the combustion of organic matter (pyrolytic origin), e.g. wood, petroleum, coal [2]. On the other hand, low molecular weight PAHs (LMW; 2 and 3 aromatic rings) usually contribute to pollution by petroleum and its products (petrogenic origin) [2]. For this reason the ratio LMW/HMW PAH is frequently used for the first general determination of PAH origin. This ratio is <1 for pyrolytic origin and >1 for petrogenic origin [4]. In our case all the calculated ratios were far below 1, indicating a strong prevalence of pyrolytic origin. The four ring PAHs comprised more than 40 % of the total PAH concentration at all sites, composing, together with those with 5 and 6 rings, more than 70% of the total PAH concentration. The amount of 2 and 3-ring compounds was higher than 20% only at sites 2 and 8, which implies a relatively higher content of petrogenic PAHs.

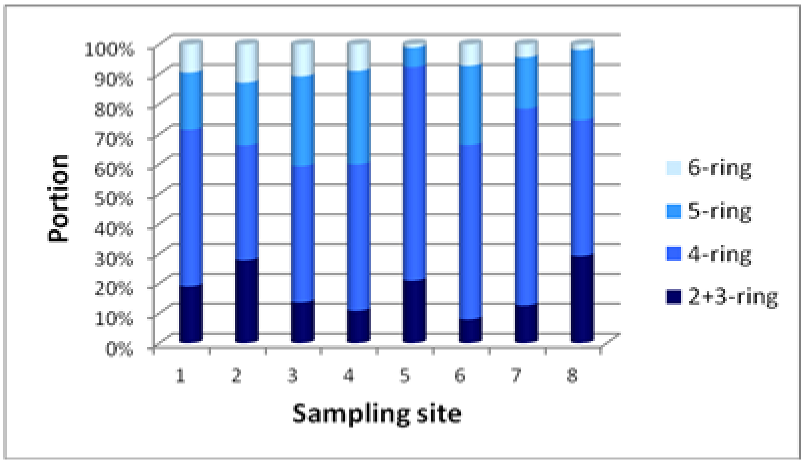


Figure 2: PAH distribution according to the number of aromatic rings

Source: Author

PAH isomer pairs with a similar molecular weight have also been widely used as diagnostic ratios for the identification of potential sources of PAHs [2]. The resistance of these isomers to degradation is different due to their different thermodynamic stability. For further elucidation of PAH origin in the studied area, the two most commonly used ratios were applied. The ratio fluoranthene/pyrene is <1 for petrogenic origin and >1 for pyrolytic origin, while the phenanthrene/anthracene ratio is <10 for pyrolytic origin and >15 for petrogenic origin [4]. Ratios, presented in Table 2, confirm the primary pyrolytic origin, with different contributions of the petrogenic. Pyrolytic origin is the main origin at sites 4 and 5 (AN/(AN+PHE)>0.1)). The FLU/(FLU+PY) ratio also reveals coal/wood combustion as an important source at sites 4 and 5 (>0.5), while petroleum combustion seems to be more important at sites 7 and 8 (0.4-0.5) [5]. This is also shown in Figure 3.

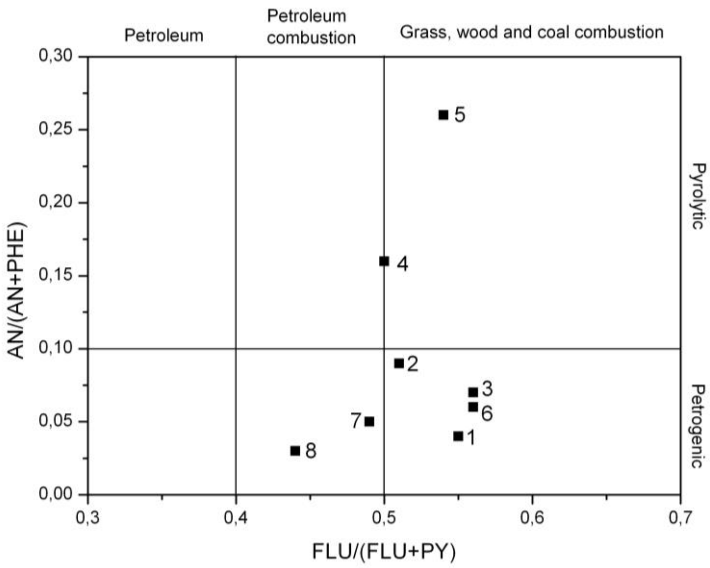


Figure 3: Determination of PAH origin

Source: Author

The temporal trends in PAH concentrations for the period 2004-2011 showed quite constant concentrations, with some decrease at some sampling sites, e.g. Port of Koper and Marina of Portoroz (Figure 4). This indicates a pretty weak impact of the increase of maritime traffic in the investigated area in the last decade. This could be also due to the better environmental management in such areas under strong anthropogenic impact.

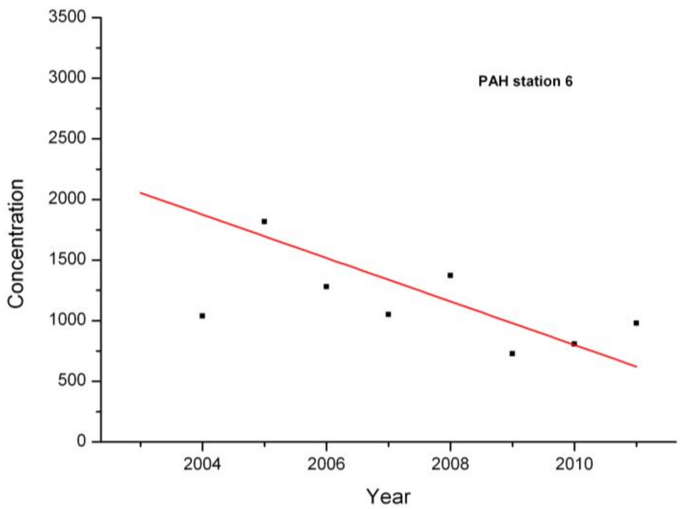


Figure 4: Temporal trend of PAH concentrations in the marina of Portoroz

Source: Author

In conclusion, results of the present study revealed that maritime traffic is one of the sources of contamination by hydrocarbons in the Gulf of Trieste. Its impact seems to be rather limited to areas near the contamination sources. Concentrations of hydrocarbons are higher near the expected sources and still elevated in the adjacent offshore areas. This is more pronounced in the northern part of the Gulf of Trieste (ports of Koper and Trieste). The impact of maritime traffic in terms of PAH concentrations and distribution is not so uniform. In general, concentrations are higher close to contamination sources and the petrogenic PAH origin is not negligible. However, the prevailing origin is pyrolytic, with an important input from other sources on the coast.

REFERENCES

[1] GESAMP (1993). Impact of oil and related chemicals and wastes on the marine environment, XXII/4. Joint group of experts on the scientific aspects of marine pollution. Reports and studies, IMO, London, UK.

[2] Magi, E., Bianco, R., Ianni, C., & Di Carro, M. (2002). Distribution of polycyclic aromatic hydrocarbons in sediment of the Adriatic Sea. Environ. Pollut., 119, 91-98.

[3] Adami, G., Barbieri, P., Piselli, S., Predonzani, S., & Reisenhofer, E. (2000). Detecting and characterising sources of persistent organic pollutants (PAHs and PCBs) in surface sediments of an industrialized area (harbour of Trieste, northern Adriatic Sea). J. Environ. Monit., 2, 261-265.

[4] Gschwend, P. M., & Hites, R. A. (1981). Fluxes of polycyclic aromatic hydrocarbons to marine and lacustrine sediments in the north-eastern US. Geochim. Cosmochim. Acta, 45, 2359-2367.

[5] Yunker, M. B., Macdonald, R. W., Vingarzan, R., Mitchell, R, H,, Goyette, D., & Sylvestre, S. (2002). PAHs in the Fraser River basin: a critical appraisal of PAH ratios as indicators of PAH source and composition. Org. Geochem., 33 (4), 489-515.

AIR TRANSPORT DEVELOPMENT WITHIN THE ADRIATIC BASIN

Ivana Čavka, M.Sc.
Olja Čokorilo, D.Sc.
University of Belgrade
Faculty of Transport and Traffic Engineering
Vojvode Stepe 305, Belgrade, Serbia
i.cavka@sf.bg.ac.rs, oljav@sf.bg.ac.rs

ABSTRACT

Results provided in this paper have been obtained from the EA SEA-WAY project which intends to evaluate the relevance and the sustainability of an integrated network consisting of the ports facing the Adriatic in the field of passenger traffic. The general objective of the EA SEA-WAY is to improve the accessibility and the mobility of passengers across the Adriatic basin and its hinterland, through the development of new cross border, sustainable and integrated transport services and the improvement of physical infrastructures related to those new services. The paper considers state of the art in the Adriatic region in air transport sector. Special attention is given to multi-modal connectivity based on Adriatic ports hinterland with neighboring airports. The paper presents a multi-choice methodology built on existing infrastructure (connectivity nodes, closeness (distance)), travel time, travel costs and aircraft characteristics (capacity, comfortability, availability and sustainability). Related research should be implemented on other macro regions.

Key words: Aircraft, Adriatic region, connectivity, air transport, multi-modal.

1 INTRODUCTION

The most conspicuous strategic advantage of the Adriatic region can be defined through its typical characteristic which is placed at the active confluence of two regions – the Italian and Balkan Peninsula, which are both very close to the growing market of Middle East. The Adriatic region has a favorable geo-strategic position for attracting air traffic in over-flights and regarding the projection of traffic growth between Northwestern Europe and the Mediterranean and the Near East.

However, small size of national aviation markets in the Adriatic countries and the geographical location of many airports positioned close to national borders have impact on passenger air traffic volumes in the region as well as on intraregional air transport connectivity. Also, the competition among the airports with overlapping hinterlands can be fostered by improving road and rail links and cross-border procedures.

EA Sea Way study aims to improve intraregional connectivity within the Adriatic basin, as well as better connectivity with global markets. The study should balance modal share and passenger accessibility from ports to hinterland within the Adriatic basin. Moreover, it would require improvement of existing services and some infrastructural investments in the near future.

1.1 State of art in air transport development in the Adriatic region

After signing the ECAA (European Common Aviation Area) agreement in 2005, the air services were liberalized and the Adriatic route network has grown rapidly. New established routes are connecting European destinations within the Adriatic region serving neighboring hub airports as feeders while regional main airports, which could compare to European hubs, have been established mainly in Italy. It implicates the lack of domestic traffic, with exception in Italy and Croatia, which highlights the importance of cross border international traffic on regional level. Table 1 provides overview of the current list of national airlines in the Adriatic basin.

Table 1: List of national airlines in the Adriatic basin (2014)

Regional Participant	National Airline	Ownership	Former ownership	Number of aircraft	Aircraft types	Number of destinations
Albania	-	-	Albanian Airlines, ceased operation in 2011	-	-	-
Bosnia and Herzegovina	B&H Airlines	Government 99.93%	-	2	2 ATR 72-212	4
Croatia	Croatia Airlines	Government 96.22%	-	12	4 A319 2 A320 6 Q400	27
Italy	Alitalia	Fully private company with 24 shareholders	-	103	22 A319 47 A320 12 A321 12 A330 10 B777	83
Montenegro	Montenegro Airlines	Government 100%	-	6	1 E-190LR 3 E-195LR 2 Fokker 100	13
Serbia	Air Serbia	Government 51%	-	19	8 A319 2 A320 3 ATR 72-200 2 ATR 72-500 4 B737	41
Slovenia	Adria Airways	Government 69.9%	-	10	2 A319 2 CRJ200LR 6 CRJ900LR	23
Kosovo*	-	-	-	-	-	-

Key determinants of air transport connections development are based on contracts for the joint operations of air carriers and associated partners within airline alliances. Star Alliance, with Austrian Airlines, Lufthansa, Croatia Airlines and Adria Airways as members, dominates in this region, particularly within SEE (South East Europe) area. Accordingly, the highest frequency air transport connections in the Adriatic region are linking the Adriatic region and Western Europe, with the largest number of flights to European nodal airports (Rome, Frankfurt, Munich and Vienna). Whilst number of destinations served from airports in Slovenia, Croatia, Montenegro, Albania coast are less than 50 per airport (for example: Rijeka-10 destinations in 2010, Split-50 destinations in 2010, Tivat-11 destinations in 2010, Dubrovnik-49 destinations in 2010, Tirana-35 destinations in 2010), Italian coast is more developed by the number of served destinations (for example: Bari-32 destinations in 2014, Venice-64 destinations in 2014).

Main indicators of current state of air transport in the Adriatic region are modes traffic flows that represent 2% of passenger transportation in the world schedule traffic and 1.5% of the number of international airports in the world as well as underdeveloped intra-regional connectivity and lack of intercontinental flights (Table 2).

One of the highest air transport growth rates in Europe were recorded in the Adriatic region but the traffic volume figures in comparison with other European regions are low (SEETO, 2014). In the last decade the Adriatic region recorded tremendous yearly growth rate in airport traffic volumes in some regional participants exciding even 10%. Constant changes were also noted in passenger traffic figures. The reasons for such developments in traffic volumes can be found in entrance of low cost carriers' on the SEE market in 2003.

Table 2: Indicators of passenger and cargo traffic on the airports in the Adriatic basin

Airport	**Passengers**	**Cargo (t)**	**Passengers**	**Cargo (t)**	**Passengers**	**Cargo (t)**
	2011		**2012**		**2013**	
Tirana	1,817,073	2,656	1,665,331	1,875	1,757,342	2,164
Sarajevo	599,978	-	580,058	-	665,638	-
Dubrovnik	1,356,036	389	1,490,844	344	1,526,841	294
Pula	351,394	2	375,979	4	359,490	3
Rijeka	78,890	-	72,762	-	140,776	-
Split	1,302,084	619	1,424,013	577	1,587,264	450
Zadar	298,366	284,980	379,165	371,256	483,163	472,572
Zagreb	2,269,191	8,012	2,323,904	8,133	2,291,566	7,699
Podgorica	611,666	-	620,117	-	680,854	-
Tivat	647,169	-	725,392	-	868,423	-
Belgrade	3,124,633	8,025	3,363,919	7,253	3,543,194	7,679
Pristina	1,422,302	-	1,527,134	-	1,628,678	-
Ljubljana	1,359,646	19,659	1,168,261	17,031	1,269,192	17,777
Trieste	857,134	-	880,543	-	853,981	-
Venice	8,572,909	32,695	8,192,296	33,112	8,401,085	37,728
Rimini	918,863	787	799,828	744	562,554	834
Ancona	606,591	6,997	564,476	6,864	501,689	6,680
Pescara	550,062	1,200	563,187	1,221	548,217	721,1
Bari	3,724,058	2,127	3,791,977	1,999	3,601,377	2,033
Bologna	5,943,835	43,788	6,022,740	40,645	6,245,909	44,149.6
Verona	3,408,516	334	3,231,463	175	2,739,151	534
Florence	1,893,306	176	1,841,006	136	1,971,895	121
Rome	37,897,931	151,867	37,219,446	143,244	36,393,505	141,911
Naples	5,784,798	3,024	5,824,839	3,446	5,465,636	5,542
Total	**85,396,431**	**567,337**	**84,648,680**	**638,059**	**84,087,420**	**755,382**

By applying TEN-T (Trans-European Transport Networks) categorization on the airports in the Adriatic region it can be noted that 4 airports on the basis of their traffic performance (Venice, Bologna, Rome and Naples) are considered as International connecting points, other 10 could be in the second category as Community connecting points (Tirana, Dubrovnik, Split, Zagreb, Belgrade, Pristina, Ljubljana, Bari, Verona and Florence), while other 10 (Sarajevo, Zadar, Rijeka, Pula, Podgorica, Tivat, Trieste, Rimini, Ancona and Pescara) are in the third category as Regional connecting points.

The airports in Adriatic region which could be considered as the second category are equipped with one runway longer than 2,400 meters enabling operations of narrow and wide body jets such as B767-300 and A310-300, while runway systems in the airports Belgrade, Dubrovnik, Zagreb, Tivat, Ljubljana, Trieste, Venice, Verona and Rome are able to accept even the largest body passenger aircraft (B474-400, A380, A340-500). Other airport capacity limitations are visible in taxiway systems, aprons, gates and passenger terminal areas and even though airport runways that are capable to accommodate largest passenger aircraft mentioned limiting factors preclude its usage.

In a view of airports expansion and modernization, preliminary process focuses on identification of highest priority capacity limitations. At the moment, apron and terminal building construction are the highest priority in the airports expansions. Current airport capacity within this region satisfies current demand but additional reconstructions and modernizations especially regarding apron areas and terminals are needed.

2 ACCESSIBILITY ASSESSMENT OF THE ADRIATIC REGION NETWORK AIRPORTS

The stumbling block in the further recognition of the airports in Adriatic basin in relation to the inland transport modes are airport connections with other transport modes and with city centers. The multimodal dimension in passenger transport is underdeveloped and hampers its full integration in the transport system.

Air transport is not possible without the other means of transport. These serve as conveyer and distributor. The national air traffic services are in demand of the road and railway traffics ahead of all things. Because of the dimension of the catching and target areas of the air traffic passengers and the airfreights, a narrow networking of the airports as an interface to the road and railway traffic is an indispensable prerequisite for the development and competitiveness of an airport. This is obliged to the interests of the respective country and the international interests as a national instrument tied regionally. With the integration of the surface-bound transport services in aeronautics these traffics also undergo their internationalization and the operative and administrative necessities connected with the integration.

An efficient road network linked to the local system is an essential requirement when dealing with ground access infrastructure projects. This relates not only to cars but also to buses, where infrastructure for buses can extend beyond basic bus stops to a city bus interchange or a regional bus (or coach) station. On the other hand, train services can range from links to a city’s metro, subway or local transit trains, to the integration of a major train hub with intercity train services. It is important to note that a dedicated high-speed rail link between the airport and the city might be a solution for large airports isolated from a city’s main train or other transport systems.

Road traffic is still predominant on the Adriatic basin network since this is the only transport mode connected to all observed ports. Railway traffic is quite less used since the infrastructure is not equally developed in the whole region and this market is still deregulated which in some connections require much more travel time compared to other modes, especially with air transport.

Passengers travelling by air have to consider fixed time blocks, respecting their duration, mostly set by air transport. One of the major disadvantages of air transport to rail and to some extent to road is the check in time, asking the passengers to be at the airport much sooner before the actual flight. In general, for European airports it is two hours for economy travelers on international flights and about 90 minutes for domestic. Travel time used in analysis is calculated as a sum of waiting time at the airport before the flight, flight time and waiting time at the airport after the flight (Figure 1). Time spent at the seasonal airports in Adriatic basin before and after the flight (45 minutes) is lower in comparison to European airports due to its smaller capacity and volume of traffic.

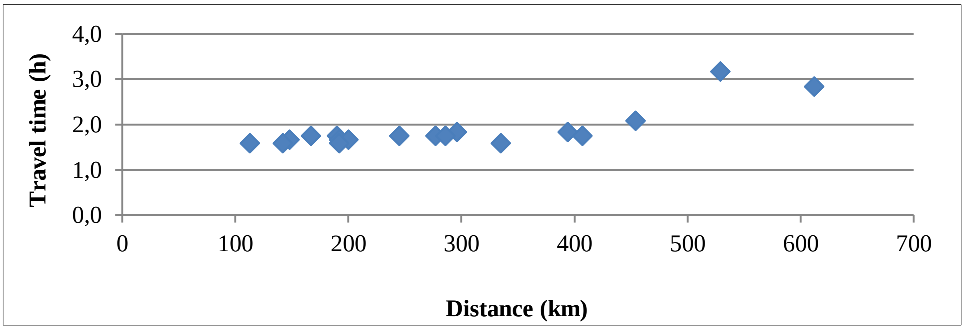


Figure 1: Ratio of travel time and distance on available air transport connections among airports

Source: South East Europe Transport Information System (SEETIS) III

Travel time is the most significant factor of influence which in the main aspect is determining air/rail/road market share. Travel time has been analyzed in correlation to transport price which is defined as second most important factor of influence on passenger choice (Figure 2). However, since among Adriatic region airports only road transport is available on all port connections while rail and air transport is available majority but not at all connections, it should be taken into account that passengers are given reduced choices of available transport services.

The EU transport study that examined interactions between HSR and passenger air transport stated that shortening of travel time of 7h20 before the opening of HSR transport to 4h50 which influenced the travelers to change the mode. In spite further shortenings of travel time to 4hl0 many passengers choose again the air transport mode. The investigation of modal shifts on 25 city-pairs has shown that a change in modal choice took place where scheduled rail travel time is less than 3-3h30 hours and for business 2 hours. The same principle can be applied on road transport given that most people preferred to drive than fly on journeys of 300 km or less (3 hours equivalent travel time) with cost and convenience being major factors (Bureau of Transport and Regional Economics, 2003).

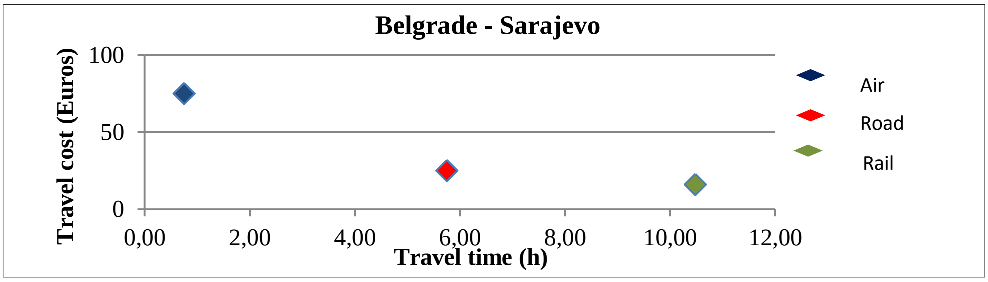


Figure 2: Ratio of travel time and cost on two sample connections among Sea-Way airports

Source: Official Airline Guide (OAG) Database

When elaborating external costs of air, road and rail transport, with 93% in the EU, road transport is responsible for the lion share of the external costs, aviation (only intra-EU flights are included) has the second largest share in external costs with about 5% while rail transport is responsible for less than 2% (CE Delft, INFRAS and Fraunhofer ISI, 2011).

However, when comparing travel costs of road, rail and air transport, as Figure 3 depicts, air fare outpaces road (+129%) and rail (+57%) transport in terms of overall cost advantages in operations, infrastructure, and cost of utilization, external environmental and accident costs. Travel by air, starting from the routes of 500 km and beyond, is more cost-efficient than road or rail. This fact certainly supports the action stated in the White Paper 2011 which requires tripling the length of the existing HSR network in order to transfer majority of medium-distance passenger transport from air to rail by 2050 (European Commission, 2011).

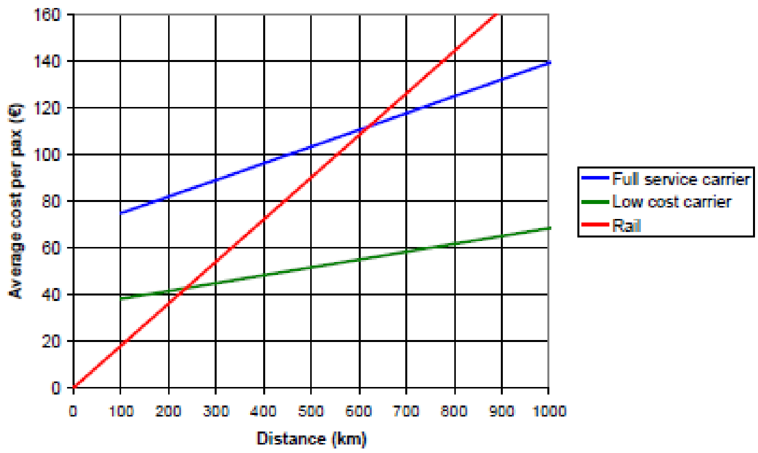


Figure 3: Rail and air costs per passenger, by route length

Generally speaking about future air transport development within Adriatic region, it should be mentioned some overall goals to be achieved in the near future. There is a strong EU influence on providing action plans related to similar regional initiatives such as European Union Strategy for the Danube Region. The main goals to be achieved are mentioned below and fully applicable to the Adriatic region (EU, 2010):

- "Enhancing cooperation between air traffic stakeholders in order to prepare a plan to implement shorter plane routes". The basic principle behind this goal lies in achieving better coordination between the 'Functional Airspace Blocks' that can ensure a needed transition from domestic air traffic management arrangements to a more integrated European dimension.
- "Developing further nodal planning for multimodality". In order to resolve the problem of congestion and loss of productivity in many nodes characterized by the overlap of different freight and person transport, as well as underdeveloped terminal infrastructure, air transport can play a key role in allowing access to remote regions. In addition, this would improve the conditions for shifting transport volumes to more energy efficient and environmentally friendly transport modes like rail and water.

3 AIR TRANSPORT FORECASTS

Air transport capacity has been one of the major trends investigated in contemporary air transport development. Many of capacity indicators are the basis for huge infrastructure investments as well as for passenger capacity growth. Main indicators are based on measuring: IFR flights forecast by EUROCONTROL, GDP in the observed zones (Eurostat

2013), GDP by flights and other relevant parameters (local airports statistics), relevant economic facts (Eurostat 2013), fares, travel time, etc.

Air travel demand can be affected by various factors that feature air transport market maturity: airport capacity and congestion; the policy and regulatory environment; low cost carrier stimulation; and taxation and pricing regimes. However, the relationship between economic growth and air travel demand can be used to justify the growth or decline in some markets, where economic development and prosperity are the principal drivers for the underlying demand for air transport, with GDP and its growth being the main measurement of economic activity for econometric-based air transport forecasts (European Commission, 2013). As shown on Figure 4, the global GDP will grow on average 3.2% per annum between 2012 and 2032 (Figure 4).

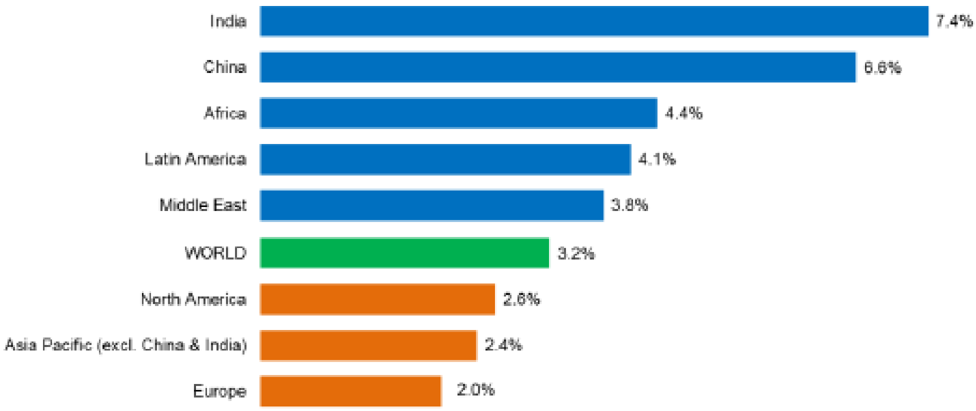


Figure 4: Average annual GDP growth 2012-2032

Source: Bombardier/Global Insight

As indicated by European Commission (2013), GDP is not the exclusive variable factor for the explanation of variation in air transport main KPIs (passengers, aircraft movements and cargo traffic). A number of other factors are being considered by aircraft manufacturer forecasts, which can be divided into several groups depending on their principal influence – economic, political or operational (for example, the rapid urbanization resulting from the rise of the middle classes in emerging economies, or continued liberalization and deregulation of air transport markets that allow further adoption of the low cost carrier business model).

Air transport demand is often measured in RPK (Revenue Passenger Kilometer), a measure that indicates the number of fare paying passengers multiplied by the number of kilometers flown. ICAO has produced a short term passenger traffic forecast for the period 2013 to 2015 based on RPK using 2012 preliminary figures as a base. The results are summarized in Table 3, from which it can be observed an expected global growth in 2013, 2014 and 2015 of 4.8%, 5.9% and 6.3% respectively. While the Middle East is projected to be the fastest growing region, Europe is projected to grow faster than North America, albeit this growth will be slower than in the emerging markets.

Table 3: ICAO-RPK annual growth rate forecast

Region of Airline registration	History		Forecast		
	2011(%)	2012* (%)	2013 (%)	2014 (%)	2015 (%)
Europe	9.5	3.9	4.4	5.5	6.2
Africa	0.9	4.2	5.2	5.7	6.0
Middle East	9.2	13.7	10.2	11.2	10.8
Asia Pacific	6.8	6.4	5.5	6.4	6.8
North America	2.4	1.3	2.3	3.3	3.8
Latin America/Caribbean	11.1	8.6	7.6	8.8	8.0
World	**6.5**	**4.5**	**4.8**	**5.9**	**6.3**

Source: ICAO Medium Term Forecast 2012 **Preliminary figures*

Aviation activity can also be measured through the number of IFR movements that provides an insight from an operational standpoint. This allows for the analysis of overall aircraft operational activity within European airspace, and thus helping to determine its pressures, demands, capacities and constraints. This in turn is useful for planning improvements and efficiencies in the aviation system; essential for projects such as SESAR, Clean Sky JTI, the Emissions Trading Scheme and airport infrastructure and capacity. However, these forecasts do not consider aircraft size or average numbers of passengers per flight.

4 AIR TRANSPORT ASSESSMENT IN THE ADRIATIC REGION

4.1 SWOT analysis

Development within the aviation sector is the key driver for medium and long-term planning of infrastructure capacities (ATM, airports, etc.) as well as for increasing capacity related to aircraft operations. Within the project scope, the SWOT analysis has been conducted in order to evaluate the strengths, weaknesses, opportunities and threats involved in a project (Table 4).

Table 4: SWOT analysis

S	W
- Geographic position and level of air routes network development; - Airports infrastructure resources; - Available resources for aviation sector connection to port, road and rail resources; - Membership in European aviation organizations of Adriatic region countries; - Available sources for potential regional airports network development and its connectivity with the rest of Europe	- Insufficiently usage of existing airport infrastructure (particularly for small size airports with seasonal character of aircraft operations); - Lack of modern air navigation system (in some airports); - Lack of financial resources for air mode infrastructure development; - Weak and insufficiently steady political position of some non EU countries; - National monopoly on several airports; - Lack of cargo resources; - Lack of airports interconnection by rail; - Insufficient airports utilization by passengers and aircraft due to their capacities; - Lack of certain airports interconnection with ports

O	T
- Interests of airports development as an open markets in European air transport network; - Future possibility to air cargo transport increase; - Possibility for establishing international and regional port connectivity by air; - Possibility for reducing travel time within the ports by air connection	- Lack of aviation infrastructural development projects in relation to ports hinterland by air connectivity; - Slow aviation infrastructure development due to single air package projects; - Manifestation of partial and local interests inside the countries; - Long lasting economic crisis aiming the passenger decreasing trend; - Airports seasonal character

4.2 Scenarios analysis for air transport

The analysis of the future air transport development of the Adriatic basin is neither possible from the regional, national or EU integrated view but by an assessment from an international perspective. The valuation basis is the macroeconomic valence of the economic instrument: aeronautics as a means of transport for persons and high-quality goods. The possible socio-economic effects at a national and regional level are only then assessable if the international possibilities for development are known and the prerequisites necessary for it were defined.

The overall goal of future transport development within the Adriatic region should be based on attracting international transport flows and increasing regional development (Šimecki et al., 2013). Air transport is recognized for adequate tool for connecting ports and hinterland due to the easiest of new routes establishment. The existing capacity of airports and aircraft is sufficient for the forthcoming period. As it is shown before, an important parameter of future air transport development is GDP which is evaluate for Europe as 2% of average increase until 2032. As a key driver in aviation development, this parameter is function of RPK which from the Boeing statistics could be measured round 5% of growth rate for intra and inter regional flights for the Adriatic region. Air transport has been in constantly growth rate in the last decade.

Three potential scenarios are related to air transport development within the Adriatic region:

1. International and Intercontinental flights development (optimistic scenario - Best)

   It is not possible to expect that the future development of airports in the Adriatic region would be equal for all countries, but there is still great opportunity to develop new routes which will continue to expand the number of potential passengers use ports services. The possible way of future development should be based on hub connectivity (Roma, Milan, Belgrade, Zagreb, etc.) with the expected growth rate of 5% RPK.

2. Regional and International flights development (realistic scenario - Modest)

   This scenario considers existing flights routes between Adriatic region and other European cities. The expected growth rate is evaluated as 2% of RPK growth, according to GDP and forecast until 2032. This scenario will cover minor growth of passenger using port services, while the growth rate is perceived on the basis of tourist destinations within the region.

3. Municipal and local oriented airports (pessimistic scenario - Worst)

   This scenario is not expected to be held within the large number of airports within the Adriatic region, but still some future trends should bring reductions in RPK or number of operations for some seasonal airports. Above all, some global economy drivers, Ukrainian crisis, etc. could provide reductions in larger airports but not more than 5% in the total RPK within the region.

5 CONCLUSION

The existing connectivity network and air transport frequencies within the Adriatic region are bellow growing needs and demands of the travelling public. While connections with main European destinations are dominant and all leading European air carriers already operate in the Adriatic region, presently less than 15% of all airlines commercial activities are realized within the Adriatic network.

It can be concluded that the air transport in the Adriatic region is evolving from year to year by application of EU legislation. However, the problem of intraregional connectivity prevails, where majority of destinations from and to the Adriatic airports are in the Western Europe and minor of all air transport operations in the region are realized within the Adriatic network. Underdeveloped connections between the Adriatic ports and major cities represent a barrier for fast and convenient travel within the region.

The following conclusions can be drawn from the present study:

- New air connections within the Adriatic region could considerably improve mobility and accelerate economic integrations and touristic potential of regional development.
- Small aircraft transport system in Europe/Adriatic region is a solution to improve transport infrastructure (accessibility).
- GA revitalization in Europe needs cooperation and support from ACARE, SESAR, FP7/Horizon 2020 funding.
- New lines between Adriatic region cities by sea and by air due to the easiest way of infrastructure establishment (road and rail should be connected by new infrastructure development).
- Heliports development (for SAR on sea and passenger traffic within the ports).
- Traffic with hydroplanes improvements (due to the easiest of infrastructure utilization).

Accordingly, new air transport connections within the Adriatic region could considerably improve mobility and accelerate economic integrations and cooperation processes. In that respect, this new mobility potential should be further considered and analyzed to answer whether a new optimized route network could be established.

ACKNOWLEDGMENT

This paper is based on the Europe Adriatic SEA-WAY project, co-financed by the European Union in the framework of the IPA Adriatic Cross-Border Cooperation Programme 2007-2013.

REFERENCES

[1] Bureau of Transport and Regional Economics, Working Paper 51. (2003). Regional Public Transport in Australia: Long Distance Services, Trends and Projections.

[2] CE Delft, INFR AS, & Fraunhofer ISI. (2011). External Costs of Transport in Europe, Update Study for 2008 Report, Delft, CE Delft.

[3] European Commission. (2010). Action plan to the European Union Strategy for the Danube Region. Brussels.

[4] European Commission. (2011). White Paper, Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system.

[5] European Commission. (2013). Annual Analysis of the EU Air Transport Market 2012.

[6] SEETO. (2014). SEETO Comprehensive Network Development Plan – Multi Annual Plan 2015, SEETO, Belgrade.

[7] Šimecki, A., Steiner, S., & Čokorilo, O. (2013). The Accessibility Assessment of Regional Transport Network in the South East Europe. International Journal for Traffic and Transport Engineering, 3(4), 351-364.

COMPRESSION OF IRIS IMAGES IN THE SAFETY OF MARINE SYSTEMS USING IMAGE PROCESSING METHODS AND CLASSIFIED VECTOR QUANTIZATION

Mirko Čorić, M.Eng.
Anita Gudelj, D.Sc.
University of Split
Faculty of Maritime Studies
Zrinsko-Frankopanska 38, Split, Croatia
mcoric@pfst.hr, anita@pfst.hr

ABSTRACT

Iris recognition system occupies a larger and larger place in biometric identification because of its reliability. Popularity of this type of identification is growing in maritime systems, such as port security, coast guard, etc. Iris images need to be stored in databases and often sent over communication channel in large variety of biometric identification systems used in marine. Consequently, iris images should be compressed while maintaining acceptable accuracy in identification process. This paper explores advantages of Classified Vector Quantization (CVQ) compression method combined with some standard image processing methods, such as contrast, brightness, etc. Compressed iris images should differ from original images as less as possible. Experiments presented in this paper show that processed iris images are less different from original images than unprocessed iris images at the same bit rate level.

Key words: Marine safety, iris recognition, classified vector quantization, image processing.

1 INTRODUCTION

Iris recognition has become one of the most popular biometric identification methods due to its stability and reliability in regards to other biometric methods such as face, voice and fingerprint recognition [1],[2],[3]. It is a method of identifying people based on unique patterns within the ring-shaped region surrounding the pupil of the individual's eye, and it is mostly used in security-related applications [1]. Iris biometric systems are increasingly implemented in different marine systems that include port and ship security, as well as in other areas of transport, such as airport and air traffic security, road transport security, border security, etc. [4],[15].

Iris recognition method requires individual's iris images to be taken and stored into databases. A large number of iris biometric applications do not contain actual iris images in their databases, but 512 byte binary files called IrisCode templates that represent unique patterns of each and every individual. As a standard, grayscale iris images of format 640x480 pixels and Daughmans algorithm are used in order to obtain IrisCode templates [1],[3]. Simplification of the process would be usage of real iris images instead of templates. Moreover, different policies even lobby that biometric data should be stored in image form, rather than in form of templates created with specific algorithms, in order to achieve interoperability and vendor neutrality [6]. Also, some of existing biometric systems use portable iris scanners that include iris image transmissions over different communication channels, e.g. Coast Guard is using portable iris scanners so that they can quickly identify smugglers or suspected migrants at sea

[16]. These operations require fast data transmission and identification process. As an answer to all these requirements, real compressed iris images can be used in the recognition procedure instead of IrisCode templates. Experiments from previous researches proved that this solution is possible, and that recognition accuracy is not significantly affected [8],[9]. It has already been proved that Vector Quantization (VQ) gives better results than Discrete Cosine Transform (DCT) method [10],[11]. DCT is generally accepted standard used in majority of video and image compression methods [12],[13].

A more advanced version of VQ called Classified Vector Quantization (CVQ) is used in this work along with the classification of blocks of pixels (vectors) which is based on edges [14]. One of the main goals of every data compression is to preserve the quality of compressed data as much as possible. Quality preservation is particularly important when referring to something sensitive and important as iris biometrics and iris images in marine safety, and safety of other systems as well. This work explores weather there are improvements in quality of compressed iris images if some of the standard image processing techniques are applied over original iris images before coding and compression via CVQ. Next section describes the CVQ compression method. Third section describes the methodology and results while the conclusion is given in the last section.

2 CVQ

Ordinary VQ involves replacement of the original block of pixels (vector) from the original image with a closest matching block of pixels (vector) from the single codebook – approximation is done. During VQ of the input vector, it is not necessary to search the entire codebook to find the most similar approximation vector. It is possible to select and consider only one subset of the codebook when choosing approximation vector. In other words, the input vector can be classified, i.e. determined to which subset of the total codebook it belongs. This process is called CVQ, and Figure 1 illustrates the method.

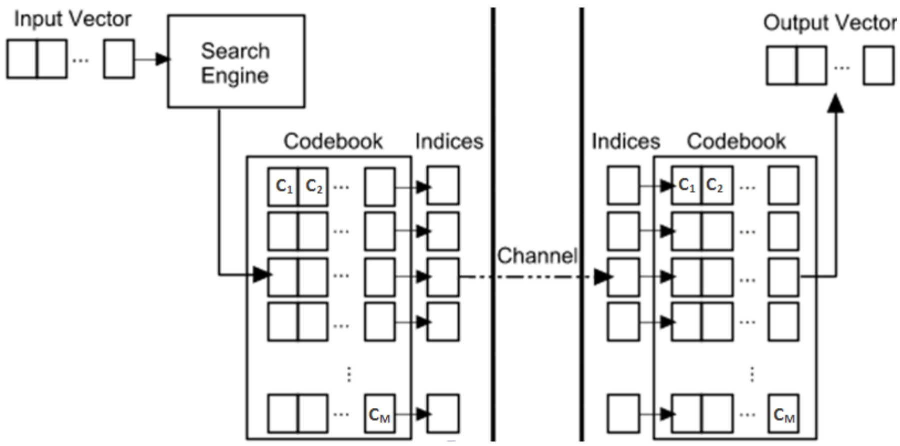


Figure 1: CVQ scheme

Source: Ramamurthi, B. & Gersho, A. (1986). Classified vector quantization of images. Communications, IEEE Transactions on (Vol. 34, 1105-1115).

Index, or the address of the vector from the codebook consists of two parts. The first part, generated by classificator, determines the codebook C_i in which the search for approximation vector is performed. The second part of the index is the address of the code vector within each codebook. Codebooks C_i are generated so that the overall training sequence T is divided into M subsequences $T_j\left(j=1,2,3,\ldots,M\right)$ after it passes through the classifier. Then, each codebook L_j of size $m_j\left(j=1,2,3,\ldots,M\right)$ is generated using one of the algorithms (LBG algorithm [5] is used in this work) for the appropriate subsequence only. Overall codebook is composed from all codebooks L_j.

Different properties can be considered in order to perform classification of vectors from the original image. Classification based on edges is most commonly used when it comes to compression of images. In this work, classification of image vectors is performed using a method called comparison of locally thresholded image vectors with a predefined set of binary edge templates [7].

3 METHODOLOGY AND RESULTS

3.1 Background idea

Generally speaking, main idea of any variation of VQ is replacement of original image's vectors with the most similar vectors from the codebook. It means that the vectors (blocks of pixels) from the original image are replaced with vectors from the codebook, in other words, approximation is made (compressed image is composed of these approximation vectors). One of the main goals of CVQ is better approximation of edges since edges within the image play the most important role for the human visual impression. This means that outlines, curves and all the sudden jumps between neighboring pixel values are approximated better than the rest of the image. Logically, uniform areas within the image are not important as edges for the visual impression and resolution of details. Average images from everyday environment do not have tendency to contain as much as edges as iris images (iris image contains a dense network of edges). CVQ based on edges can use this property in order to get better results.

Generally, codebooks contain approximation vectors developed from training set of vectors collected from original images that represent the environment for which the images are related. In order to get compressed images of better quality, training set of vectors should contain as much as possible vectors that are as similar as they can be to an original images that will be coded and compressed. In CVQ, training vectors are first classified into different edge classes using the method [7] mentioned in the previous chapter, and the separate codebook is developed for each and every edge class of training vectors. If there is a lack of training vectors inside these classes (meaning that there is a lack of edges in the image), developed codebooks do not contain approximation vectors that are good enough. This problem is not an issue in the case of iris images, especially if CVQ is combined with some standard image processing techniques like contrast, midtones/darktones level adjustment, brightness, etc.

3.2 Methodology

Iris images from Phoenix database [17] were used for the purpose of this study. Six randomly selected gray iris images were taken as training images for extraction of training vectors of size 4x4 pixels. Images were cropped in order to get standard 640x480 pixels size, meaning that the total of 115 200 training vectors were used for codebook development (each of 6 images containing 19 200 training vectors). Two test cases were analyzed. In the first test case Microsoft Office Picture Management tool was used to apply some of the image processing methods i.e. contrast, midtones and darkcolors level manipulation. These methods were applied in order to obtain as many edge vectors as possible during the classification process. In this work, experiment showed that contrast ratio of 100:1, 20% increased input midtone level and 20% decreased darkcolor level applied to original training iris images resulted with the largest number of edge vectors during the classification. Images are shown in Figure 2.

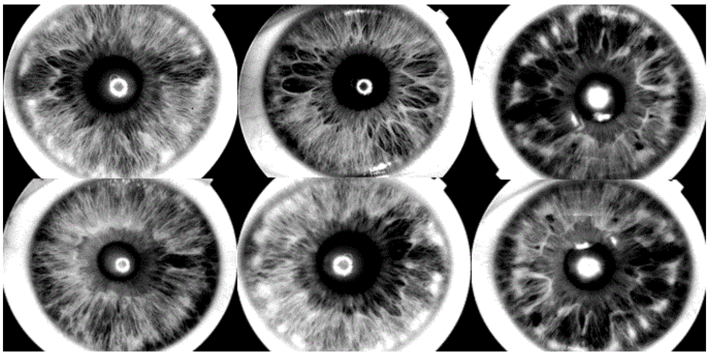


Figure 2: First test case training images

Source: http://phoenix.inf.upol.cz/iris/

After the extraction, training vectors obtained from these previously manipulated iris images were distributed among 30 different classes. 28 classes refer to edge classes, and each of these 28 classes represents one edge type. Two remaining classes refer to a mixed edge class (containing all the edge vectors that do not belong to any of these 28 classes) and to a non-edge class. LBG algorithm was used to develop separate codebooks for each of 30 classes. Codebooks of different sizes (64, 32, 16, 8, 4) were developed for each and every class, meaning that the input vectors from original iris images can be coded at different bit rates using CVQ (range from 0.43 – 0.68 bits per pixel). Finally, three randomly selected gray iris images from phoenix database were coded (i.e. compressed) at these bit rate levels. The same training images and the same methodology was used in the second test case, but without image processing methods applied (contrast, midtones and darkcolores manipulation). Images are shown in Figure 3.

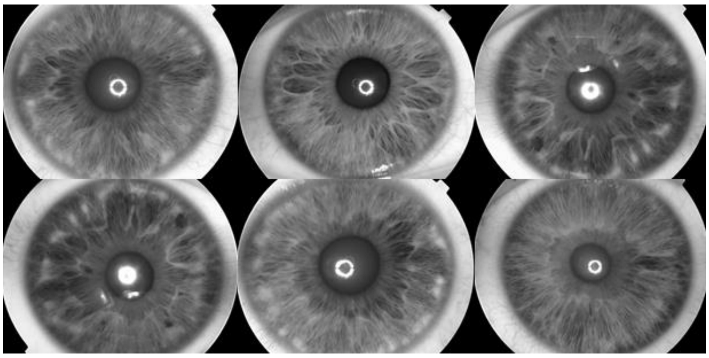


Figure 3: Second test case training images

Source: http://phoenix.inf.upol.cz/iris/

Again, same three iris images were coded at the same bit rate levels as in the first test case. Higher bit rates are of particular interest when compressing iris images because of the significant image quality degradation at lower bit rate levels, and significant loss of quality is not a desirable property when compressing biometric data such as iris images. Described methodology was performed using several Maltab scripts designed for this purpose. First script that is executed pulls training vectors (size 4x4 pixels) from input training images. Second script is used to classify these training vectors among 30 different classes based on edge types. Third script uses LBG algorithm in order to develop codebooks of different sizes. Fourth script codes original images that are selected for compression using one of the previously developed codebooks. Fifth script decodes these coded original images. And the last script measures the quality of coding (i.e. compression) using Mean Squared Error (MSE) [18].

3.3 Results

Statistic of extracted training vectors that are classified among 30 different classes is shown in Table 1 for both test cases.

Table 1: Classified vectors statistic for each test case

	First test case (applied image processing methods)		Second test case (no image processing methods)	
class	**number of vectors**	**% of vectors**	**number of vectors**	**% of vectors**
1	262	0.23	58	0.05
2	2937	2.55	652	0.57
3	3930	3.41	824	0.72
4	627	0.54	128	0.11
5	4588	3.98	1050	0.91
6	2251	1.95	497	0.43
7	186	0.16	54	0.05
8	3180	2.76	628	0.55
9	3133	2.72	817	0.71
10	606	0.53	295	0.26
11	4613	4.00	1156	1.00
12	2250	1.95	485	0.42
13	343	0.30	132	0.11
14	227	0.20	69	0.06
15	1447	1.26	283	0.25
16	5228	4.54	1568	1.36
17	283	0.25	153	0.13
18	292	0.25	129	0.11
19	1744	1.51	472	0.41
20	3473	3.01	906	0.79
21	496	0.43	153	0.13
22	1367	1.19	307	0.27
23	1935	1.68	516	0.45
24	1229	1.07	474	0.41
25	1238	1.07	477	0.41
26	2135	1.85	526	0.46
27	852	0.74	251	0.22
28	491	0.43	121	0.11
mixed	11835	10.27	2734	2.37
non-	52022	45.16	99285	86.18

In the first test case 54.84 % of vectors are classified as edges, while in the second case only 13.82 % of vectors are classified as edges. Therefore, codebooks from the first test case contain better approximation vectors, which ultimately results in better quality of compressed iris images in the first test case using the same bit rate levels. Coding results for both test cases are shown in Table 2.

Table 2: MSE for each test case

bpp	Iris 1		iris 2		iris 3	
	MSE - 1st test case	MSE - 2nd test case	MSE - 1st test case	MSE - 2nd test case	MSE - 1st test case	MSE - 2nd test case
0.437	41.11	47.13	44.20	50.23	39.72	44.65
0.5	27.24	32.15	28.87	34.16	26.66	30.82
0.562	16.35	21.03	18.05	24.17	17.51	21.09
0.625	10.01	15.54	13.21	18.02	12.07	16.72
0.687	8.42	13.94	11.60	16.22	11.01	15.13

Results show that iris images from the first test case (applied image processing methods) have reduced MSE compared to iris images from the second test case (no image processing methods applied). In other words, compressed iris images from the first test case are of better quality.

4 CONCLUSION

This paper presents advantage of CVQ combined with image processing techniques when compressing iris images in iris biometric security systems. Results show that iris images compressed with particular combination of CVQ and image processing techniques are of better quality than iris images compressed with CVQ only. Increased number of edge vectors within iris images when combining CVQ and image processing techniques is the reason of these results. Proposed approach can be applied in security of marine systems, as well as in security of other transport areas. It also has the potential to be applied in other biometric types (e.g. fingerprint biometrics). Improvements of this approach are possible as well, e.g. time required to develop codebooks can be reduced by increasing the size of the vectors that are observed within the overall process. Another example of improvement may relate to increased number of edge classes which would contribute to further quality increase of compressed iris images. Future research will focus on these improvements.

REFERENCES

[1] Jain, K., Flynn P., & Ross, A. (2007). Handbook of Biometrics. New York: Springer.

[2] Zuckerman, A. E., Moon, K. A., & Eaddy, K. (2002). Comparison of Fingerprint and Iris Biometric Authentication for Control of Digital Signatures. In Proceedings of the AMIA Symposium (p. 1208). American Medical Informatics Association.

[3] Daugman, J. (2004). How iris recognition works. Circuits and Systems for Video Technology, IEEE Transactions on (Vol. 14, pp. 21-30).

[4] McLaren, S. R. (2008). Reliability of iris recognition as a means of identity verification and future impact on transportation worker identification credential. Doctoral dissertation. Monterey, California: Naval Postgraduate School.

[5] Linde, Y., Buzo, A., & Gray, R. M. (1980). An algorithm for vector quantizer design. Communications, IEEE Transactions on (Vol. 28, 84-95).

[6] Chapman W, Hicklin A, Kiebuzinski G, Komarinski P, Mayer-Splain J, Taylor M, Wallner R. (2013 Jan). Latent Interoperability Transmission Specification. NIST Special Publication 1152. SAD: National Institute of Standards and Technology. U.S. Department of Commerce. (46 p).

[7] Quweider, M. K., & Salari, E. (1996). Efficient classification and codebook design for CVQ. IEE Proceedings-Vision, Image and Signal Processing (Vol. 143, 344-352).

[8] Ives, R. W., Bishop, D. A., Du, Y., & Belcher, C. (2010). Iris recognition: The consequences of image compression. EURASIP Journal on Advances in Signal Processing, 2010, 24.

[9] Daugman, J., & Downing, C. (2008). Effect of severe image compression on iris recognition performance. Information Forensics and Security, IEEE Transactions on (Vol. 3, pp. 52-61).

[10] Kekre, H. B., Sarode, T. K., Bharadi, V. A., Agrawal, A. A., Arora, R. J., & Nair, M. C. (2010). Performance comparison of DCT and VQ based techniques for Iris recognition. Journal of electronic science and technology., 8(3), 223-229.

[11] Čorić M. & Gudelj A. Application of the vector quantization compression method in the video supervision of maritime systems. Paper presented at: 6th International maritime science conference; 2014 April 28-29; Croatia, Solin.

[12] Chen, W.H., Smith C.H., & Fralick S.C. (1974). Discrete Cosine Transform. IEEE Transactions on Computers, IEEE Transactions on (Vol. 23, 90-93).

[13] Bhaskaran, V., & Konstantinides, K. (1997). Image and video compression standards: algorithms and arhitectures.2nd ed. SAD, Norwell, Massachusetts: Kluwer Academic Publishers.

[14] Ramamurthi, B. & Gersho, A. (1986). Classified vector quantization of images. Communications, IEEE Transactions on (Vol. 34, 1105-1115).

[15] http://en.wikipedia.org/wiki/Iris_recognition, February 2015, (Iris recognition).

[16] Stephanie Young LT. Securing our borders: Biometrics at sea. Coast Guard Compass: Official blog of the U.S. Coast Guard. 2011 Nov 21[cited 2015 Jan 17].

[17] http://phoenix.inf.upol.cz/iris/ , September 2014.

[18] http://en.wikipedia.org/wiki/Mean_squared_error , December 2014, (Mean squared error).

EMISSION INVENTORIES FROM SHIPS IN THE ADRIATIC'S URBAN REGIONS

Branislav Dragović, D.Sc.
University of Montenegro
Maritime Faculty
Dobrota 36, 85330 Kotor, Montenegro
branod@ac.me

Davorin Kofjač, D.Sc.
University of Maribor
Faculty of Organizational Sciences
Kidričeva cesta 55a, SI-4000 Kranj, Slovenia
davorin.kofjac@fov.uni-mb.si

Maja Škurić, M.Sc.
University of Montenegro
Maritime Faculty
Dobrota 36, 85330 Kotor, Montenegro
mskuric@ac.me

Andrej Škraba, D.Sc.
University of Maribor
Faculty of Organizational Sciences
Kidričeva cesta 55a, SI-4000 Kranj, Sloveniaandrej.skraba@fov.uni-mb.si

Tomislav Markolović, M.Sc.
AD Marina Bar
Obala 13 Jula, 85000 Bar, Montenegro
tmarkolovic@marinabar.org

ABSTRACT

This paper deals with the emission estimation analysis of three ports located in the east Adriatic, namely: Dubrovnik-Gruž (Croatia), Bar and Kotor (Montenegro). Here we specify the significant growth of cargo and cruise ships arrivals in the last few years related to the collected data from the ports, so these ports are very favorable for the measuring the level of emission from ships that affect local urban areas. The emission inventories are followed by the traffic analysis in mentioned ports and are consisted of presented distributions of ships' arrivals at the monthly basis from June 1 to September 1, 2012. A methodology for the emission estimation is reported. First, we specify the input parameters for calculating the emission inventories. Second, the seasonal effects of the ships' arrivals and emissions in ports are described with the comparative analysis of the reported ports. The output results will show the biggest and the lowest emitters with regards to the ship type. In order to reduce the level of emissions, some directions are proposed. It can serve as a report to the local port authorities to develop strategies and directions for more sustainable port model.

Key words: Emission from ships, Dubrovnik-Gruž, Bar, Kotor, estimation.

1 INTRODUCTION

Like in many studies of analyzing ship emission inventories, the national legislation has to be in accordance to the EU legislation especially to provide the actuality of the emissions and provide some limitations to preserve the local inhabitants. It is well known that the EU directive has made some headway in using lower sulphur content fuels. It imposes a 1,5% sulphur limit on all ships that travel in the North Sea, the English Channel, and the Baltic Sea. Some countries such as Montenegro recently ratified the Annex VI of MARPOL 73/78 Regulations for the Prevention of Air Pollution from Ships, but the fact is that emissions without system emission control have a greater effect on coastal residents than on the open sea. Therefore, this analysis like some before (cf. Dragović et al. (2014)) are directed to calculate and compare the emission inventories from ships in three Adriatic's urban regions such as Dubrovnik-Gruž (Croatia) and Bar and Kotor (Montenegro) in the period of three months in 2012.

This paper reports about the approach for calculating ship emission inventories and provide statistical analysis of traffic intensity inside three ports as well as discussion about the obtained results. The analysis is based primarily on the achieved methodologies from the literature specified in Table 1. This review served as a good foundation for investigating the level of ship emission inventories.

Table 1: Related literature on ship emission inventories (adapted from *Dragović et al.* (2014)**)**

Reference	Problem	Results
Schembari et al. (2012)	Discussion about the impact of European directive that considers emission inventories from ships in Mediterranean. Beside the theoretical part, it is reported the level of concentrations in ports.	After the use of monitoring station on one cruise ship, the output results indicate that the average decrease of mean concentrations in ports was 66%.
Vestreng et al. (2007)	The level of SO_2 is reported indicating to Longrange Transmission of Air Pollutants in Europe.	The results are related to the observations made for the three periods. First one from 1980-1989 is specified with the low annual emission reductions. In contrast, from 1990-1999 is presented the high annual emission reductions. Finally, observing the period from 2000-2004, it's characterized with medium to low reduction.
Trozzi et al. (1995)	The level of emission inventories inside Italian ports of Venice and Piombino is reported. Primarily, the maritime traffic is considered.	Two ship-based activities are recorded, i.e. maneuvering and berthing. The obtained results suggest on the difference inside the ports regarding the emission level from ships.
Saxe and Larsen (2004)	The problem to define the dispersion of air pollutants is described. The case study included three Danish ports.	Authors used operational meteorological air quality model. During the investigation the main point to be emphasized was with regards to the aerial emissions from ships - maneuvering and docking.
Corbett et al. (1999)	The study included the measuring of annual NOx and SO_2 emissions from ship.	Two approaches have been evaluated. First, emission test data and second fuel-based approach. The results are recorded for the ship emission.
De Meyer et al. (2008)	General approach included the emission inventories of merchant shipping in the Belgian part of the North Sea.	A comparative analysis has been done on the basis of obtained results for Dutch and EU ports, including Antwerp, Ghent, Ostend and Zeebrugge.

Reference	Problem	Results
Chang and Wang (2012)	Authors considered the reduction of pollutants and also estimated the emission.	Since the main objective of the study is employment of green port policy, the proposal of onshore power supply system is provided. Also, reducing the ship's speed to 12 knots definitely has a positive impact on minimizing fuel consumption.
Eyring et al. (2005)	Descriptive analysis of the international shipping in the last 50 years is provided.	The global approach of ship emissions is presented. The Vessel Rescue system is used to propose the emission scenarios.
Sanabra et al. (2014)	Provided the analysis of local air pollutions produced by ships and the impact on densely populated port areas. Concentration on activities at berth is of prime interest.	Four emitters are considered with their externalities ($PM_{2,5}$, SO_2, NOx, and VOCs). The more controlling activities should be provided at the berth.
Marmer et al. (2009)	A special atmospheric chemistry transport model is employed with regards to the Mediterranean.	The accent is to South European coast regarding air pollution from ships. The pollutants' contributions are still much presented.

2 TRAFFIC ANALYSIS

From the collected data of the ports (DPA, 2013; CTGT, 2013; PBAD, 2013; PKAD, 2012), in Figure 1 is given a distribution of a number of ships and port callings during the three-month period in 2012. First, it can be stated that in ports of Dubrovnik-Gruž and Kotor, we only took into the analysis cruise ships that visit these very attractive and UNESCO protected areas. On contrary, in regards to the Port of Bar, we reported the traffic analysis based on the arrivals of the following type of ships: bulk ships, container ships, general cargo ships, ferry ships, Ro-Ro ships and tankers.

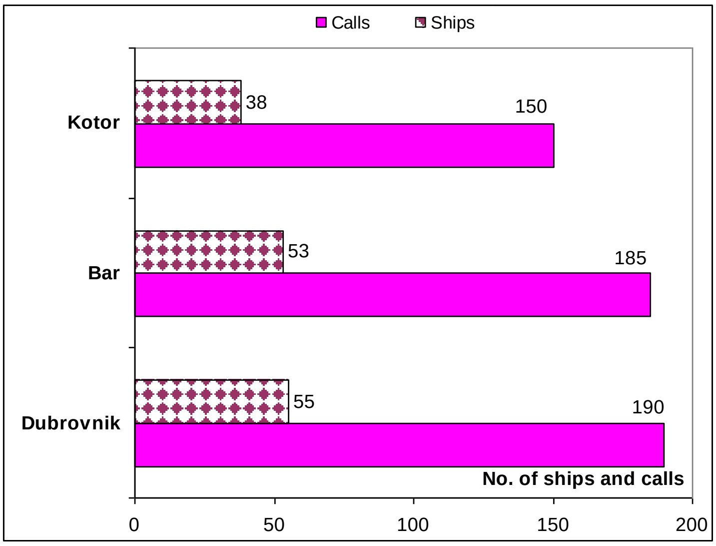


Figure 1: Number of ships and port callings in study period for reported ports

Generally speaking, from Figure 1 we can emphasize that 55 cruise ships made 190 port calls in Dubrovnik-Gruž, 53 different type of ships made 185 port calls in Bar while 38 cruise ships made 150 port calls in Kotor. Assuming the reported period, in Figure 2 is presented a distribution of number of port callings from June 1 to September 1, 2012. It is noticeable that almost the biggest throughput in ports was achieved during the August.

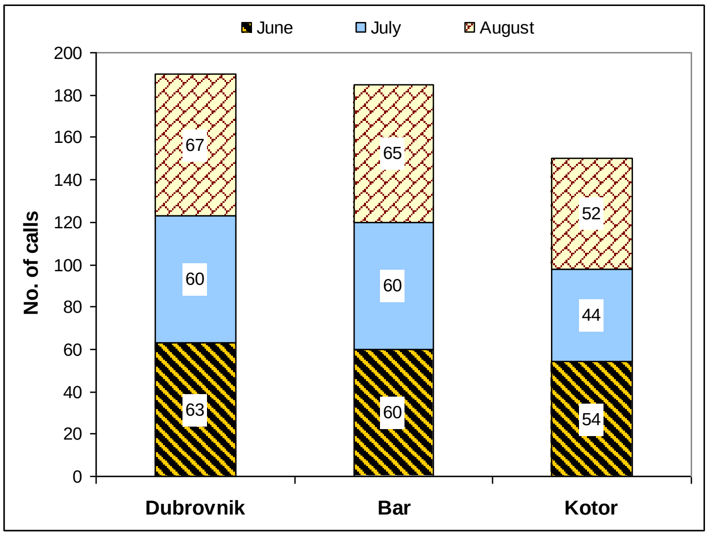


Figure 2: Distribution of number of port callings in study period for reported ports

3 METHODOLOGY

Perhaps the most convenient approach for our model is based on the calculation analysis specified in Tzannatos (2010a,b). In these papers, the author discuss about the Piraeus port which is characterized as the most frequent port calls by coastal passenger ships and cruise ships operating in the region. He emphasized that the analyses must be provided in order to estimate the main ship exhaust pollutants (NO_x, SO_2 and PM) like we will provide in this paper. To be more specific, in the first study (Tzannatos, 2010a), it was calculated that ship emissions reached 2600 tons annually and their estimated externalities were around 51 million Euros. On the other hand, but very similar approach like in the first paper, the second one (Tzannatos, 2010b) used fuel-based emission methodology for calculating ship exhaust emissions of CO_2, NOx, SO_2 and PM from 1984 to 2008 within Greek seas.

First we start with the level of sulphur content in fuel. According to the EU directive, ships burn fuel oil of 1,5% during sailing and maneuvering while maximally 1% sulphur content of fuel is used at berth. Therefore, the emission for each port call is the sum of the emissions in each ship activity phase (reduced speed zone (RSZ), maneuvering and hotelling (ships serviced at berth) for Dubrovnik-Gruž while slow cruise, reduced speed zone, maneuvering and hotelling (ships serviced at berth/anchorage) for Bar and Kotor).

In this analysis we applied main and auxiliary engine load factors during the various ship activity phases from the existing research literature on this issue (Tzannatos 2010a,b; ICF, 2009). The emission inventories are built through the application of a ship activity-based methodology. It means that emissions are estimated as a function of energy demand during a specific activity (expressed in kWh) multiplied by an emission factor, where the emission factor is expressed in terms of grams per kilowatt-hour (g/kWh). Regarding the selection of the NO_X, SO_2 and PM emission factors (like specified in Dragović et al., 2014; ICF, 2009), in view of the dominance of medium speed diesel engines in the powering of the cruise and other type of ships, it was considered appropriate to assume that all ships employ MSD engines (whether for mechanical or electric power generation) which burn fuel oil of 1,5% sulphur during sailing (incl. maneuvering) and 0,1% sulphur MDO/MGO at anchorage or at berth in the case of Dubrovnik-Gruž and Kotor. For cruise ports, the emission factors are: 12,8 and 12,4 for NO_X, 6,18 and 0,45 for SO_2, and 0,67 and 0,18 for PM. The emission coefficients are: 14,0 and 13,2 for NO_X, 11,24 and 4,75 for SO_2, and 1,43 and 0,42 for PM in the case of Port of Bar. In the case of ships that are serviced at the Port of Bar, it is assumed that those ships burn fuel oil of 2,7% while maximally 1% sulphur MDO at berth (ICF, 2009; Dragović et al., 2014).

4 EMISSION RESULTS

After applying the defined approach, in Figure 3 are presented the emission results in tons with regards to the three-month period in 2012.

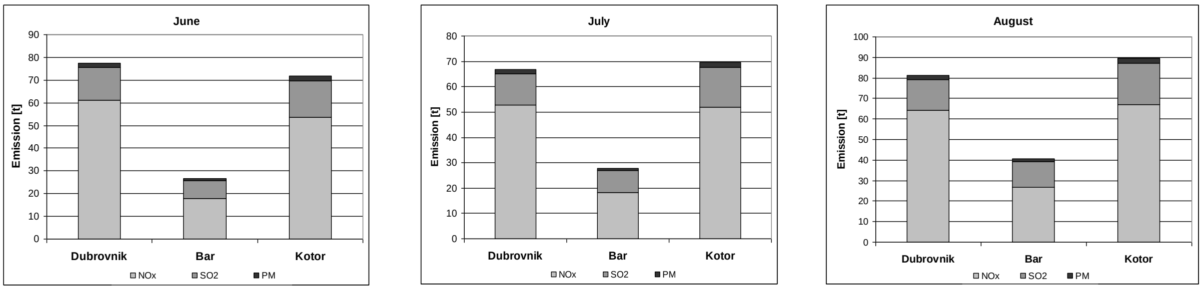


Figure 3: Emission results of NO_X, SO_2 and PM in tons for reported ports

In June, the biggest emission was produced in Dubrovnik-Gruž, in July this result was related to Kotor port as well as in August. The lowest level of emission was at the Port of Bar for all three months (see Table 2).

Table 2: Output results (emission in tons)

	June			July			August		
	NO_X	SO_2	PM	NO_X	SO_2	PM	NO_X	SO_2	PM
Dubrovnik-Gruž	61,304	14,181	1,903	52,887	12,337	1,650	64,353	14,826	1,992
Bar	17,746	7,946	0,812	18,277	8,590	0,901	26,845	12,367	1,284
Kotor	53,557	16,157	1,982	51,839	15,864	1,937	67,043	19,964	2,458

From the obtained results, it can be concluded that in these ports sustainable development concept should be of the prime interest. It means that all three ports have to determine the environmental policy in order to reduce the level of exhaust emission from ships in urban areas. The results indicate that ships at the Port of Dubrovnik-Gruž produced on average of 1,18 tons per call. In the case of ships at the Port of Bar, the emission per call was 0,51 tons while in the case of the Port of Kotor, the average emission per call was 1,54 tons. These results and especially for the Port of Kotor indicate that the port authority needs to propose some solution in order to prevent the increase of emission inventories in the port for the future period where number of cruise ships are announced to be increasing.

5 CONCLUSION

This paper describes the approach for calculating emission inventories in Adriatic's urban regions. We presented the results of emission in three ports, namely Dubrovnik-Gruž, Bar and Kotor for the period of three months in 2012. The results that are based on the reported traffic analysis showed that all three ports should follow the EU and international standards to improve the environmental national legislation inside the state. But, on the other hand, the port authority policies have to be more precise and to offer some measuring instruments in order to follow the level of ship emissions. Moreover, this approach has its own advantages and disadvantage. Advantages are related to the emission analysis in these ports that is very interesting to obtain, but the disadvantages lie in the fact that the complete methodology is approximate but on the other hand, can be improved by some simulation models as well as dispersion models.

The results and complete analysis is especially important for the Port of Kotor, since it is a cruise port and city of Kotor is UNESCO protected area, to provide more accurate information for the level of emission inventories from the ships. This study serves to the local port authorities to develop strategies and directions for more sustainable port concept which is the target point of the mentioned investigation. Further researches of this theme should lie in the fact to develop a more accurate model in order to prevent the increase of air pollutants from the cruise ships. It represents an important input for the local port authorities and municipalities in these reported regions.

ACKNOWLEDGEMENT

The study was carried out within the Project MNE-HERIC-81180, "Applying and promoting the concept of sustainable development to A.D. Marina Bar (SUST-MARINA)", financed within the scope of "Higher Education and Research for Innovation and Competitiveness in Montenegro" – ("HERIC") project, from the International Bank for Reconstruction and Development loan, in accordance with the Decision of the Ministry of Science of Montenegro on awarding the grant: Number: 01-1062 from 29th May 2014.

Also, this investigation is partially supported by the Ministry of Science of Montenegro through bilateral project "Green port development in supply chain based on mathematical modeling and simulation (Case study: Port systems in Slovenia and Montenegro)" (Grant no. 01-684, item 2).

REFERENCES

[1] Chang, C.-C., & Wang, C.-M. (2012). Evaluating the effects of green port policy: Case study of Kaohsiung harbor in Taiwan. *Transportation Research Part D*, *17*, 185-189.

[2] Corbett, J. J., Fischbeck, P. S., & Pandi, S. N. (1999). Global nitrogen and sulfur inventories for oceangoing ships. *Journal of Geophysical Research*, *104*(d3), 3457-3470.

[3] CTGT, Container terminal and general cargo Bar, Date of access: 05/09/2013. Retrieved from http://www.ctgc.me

[4] De Meyer, P., Maes, F., & Volckaert, A. (2008). Emissions from international shipping in the Belgian part of the North Sea and the Belgian seaports. *Atmospheric Environment*, *42*, 196-206.

[5] Dragović, B., Škurić, M., Kofjač, D., & Škraba, A. (2014). The Impact of Estimating Ship Emission on Green Port Policy. *IAME 2014 Conference Norfolk VA USA* (1-20).

[6] Dubrovnik Port Authority (DPA). Report and prediction analysis for 2013, 2013.

[7] Eyring, V., Kohler, H. W., Van Aardenne, J., & Lauer, A. (2005). Emissions from international shipping: 1. The last 50 years. *Journal of Geophysical Research*, *110*(D17305), doi:10.1029/2004JD005619.

[8] ICF, (2009). Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories. Final Report, Prepared for US EPA by ICF International, April.

[9] Marmer, E., Dentener, F., Aardenne, J. V., Cavalli, F., Vignati, E., Velchev, K., Hjorth, J., Boersma, F., Mihalopoulos, N., & Raes, F. (2009). What can we learn about ship emission

inventories from measurements of air pollutants over the Mediterranean Sea?. *Atmos. Chem. Phys.*, *9*, 6815–6831.

[10] PBAD (Port of Bar A.D.), (2013). Financial sector - Business results' report for the Port of Bar in 2012. Report of the joint-stock company Port of Bar.

[11] PKAD (Port of Kotor A.D.), (2012). Port of Kotor A.D. Reports of 2012. Kotor.

[12] Sanabra, M. C., Santamaría, J. J. U., & De Osés, F. X. M. (2014). Manoeuvring and hotelling external costs: enough for alternative energy sources?. *Maritime Policy and Management*, *41*(1), 42-60.

[13] Saxe, H., & Larsen, T. (2004). Air pollution from ships in three Danish ports. *Atmospheric Environment*, *38*, 4057–4067.

[14] Schembari, S., Cavalli, F., Cuccia, E., Hjorth, J., Calzolai, G., Pey, J., Prati, P., & Raes, F. (2012). Impact of a European directive on ship emissions on air quality in Mediterranean Harbours. *Atmospheric Environment*, *61*, 661-669.

[15] Trozzi, C., Vaccaro, R., & Nicolo, L. (1995). Air pollutants emissions estimate from maritime traffic in the Italian harbours of Venice and Piombino. *The Science of the Total Environment*, *169*, 257-263.

[16] Tzannatos, E. (2010a). Ship emissions and their externalities for the port of Piraeus e Greece. *Atmospheric Environment*, *44*, 400-407.

[17] Tzannatos, E. (2010b). Ship emissions and their externalities for Greece. *Atmospheric Environment*, *44*(18), 2194–2202.

[18] Vestreng, V., Myhre, G., Fagerli, H., Reis, S., & Tarrason, L. (2007). Twenty-five years of continuous sulphur dioxide emission reduction in Europe. *Atmos. Chem. Phys.*, *7*, 3663–3681.

KEY FINDINGS FROM LITERATURE REVIEW ON TRAFFIC INCIDENT MANAGEMENT

Ramadan Duraku, M.Eng
University of Prishtina ”Hasan Prishtina”
Faculty of Mechanical Engineering
Sunny Hill,10000, Prishtina, Republic of Kosovo
ramadan.duraku@uni-pr.edu

Kristi Bombol, D.Sc
St. Kliment Ohridski University
Faculty of Technical Sciences
POB, 99, 7 000, Bitola, Republic of Macedonia
kristi.bombol@tfb.uklo.edu.mk

ABSTRACT

Traffic incident presents any non-recurring event that causes a reduction of a roadway capacity or an abnormal increase in demand. Traffic management involves the application of traffic control measures in areas affected by an incident. Traffic Incident Management (TIM) is a critically important part of every transportation network management program. TIM comprises planning and coordination of people and resources to safely address and quickly clear disruptions and disturbances to the flow of traffic. TIM involves coordinated interactions of multiple public agencies and private-sector partners. It should be considered in all stages of development and implementation of network management and operations program as a key to reducing congestion. The objective of this paper is related to the literature review of all aspects of TIM. Recent findings in incident management which are pertinent for the state of the art have been presented. The elements of successful TIM programs have also been described. From this perspective, the attempt was to draw the key issues from literature findings as seen by different researchers. The concluding remarks address the differences between various TIM techniques from technological and modelling point of view.

Key words: Traffic management, traffic incident, technology, modelling.

1 INTRODUCTION

The congestion is one of the most significant negative impacts in the road traffic which is everyday concern in the road transport network. It may appear like recurrent and non-recurrent. Recurrent congestion is considered as the result of factors which occurs periodically in the road traffic system, whereas non-recurrent congestion is considered to be as the result of unpredictable events which could not be foreseen in advance. It is too difficult to analyse handling and modelling of non-recurrent as well as its increasing impact. Its causations are various and unpredictable and some of them are as follows: traffic incident, road works, weather, special events. According to literature [1] it is assessed that Traffic Incident (TI) causing significant number of negative impacts such as: travel delays, increased pollutant emissions, wasted fuel, and higher risks of secondary incidents. According to research conducted [2] in 85 major centres in USA from 1982 to 2003, it was clear that non-recurrent congestion contributed with 60%, and TIs contributed with 25% to the general figures of congestion. Taking into account that congestion and in particular TIs in the recent years have been increased in many directions, various initiatives are initiated in order to begin with their effective treatment and management so that given impacts are reduced. As consequence of this TIM model became integral part of Traffic Management (TM). In general TIM is initially dealt with by practitioners and later stage particular attention is placed also by other responsible bodies and university authorities. Certainly this contributes to the rapid development of technology, applications of different strategies/techniques and methodologies known until now as well as coordination between them.

2 INCIDENT MANAGEMENT

2.1 Problem Statements

Incident may be qualified as local because it appears only in some parts of road network and system-wide in which its impacts occur in the road network and wider. As the result of occurance of those incidents, TIs strategies have been prepared to deal with them and which is considered as programs for Incident Management (IM). Currently these programs are used in many cities. Nevertheless it is obvious that their bigger focus is in urbane zones as well as in some parts of road network, tunnels, bridges etc. In the literature there are several versions defining IM. According to literature [3] IM is defined like "the systematic, planned, and coordinated use of human, institutional, mechanical, and technical resources to reduce the duration and impact of incidents, and improve the safety of motorists, crash victims, and incident responders".

By application of those programs and their update it was made possible to increase efficiency, safety of participants and in paralell with this period to detection is reduced, verification and suitable response, safe cleaning and its restore to the normal situation for the traffic flow [4]. Looking this through the wider picture the main aim of IM is to reduce traffic congestion.

2.2 Inter-Agency Coordination and Involved

Considering that TIs is a complex issue, there is no doubt that for the right management of it, various stakeholders both from state authorities as well as private stakeholders need to be involved. Based on [4] the most significant stakeholders are: law enforcement agencies, fire and rescue, emergency medical services, transportation agencies, traffic information media, towing and recovery providers. Dominant role in this area is played by legislation which governs the role, obligations and responsibilities of each involved participant. The fact should not be forgotten about specifics of various countries. Coordination between stakeholders is an important aspect which may be achieved by appropriate training sessions. Often involved agencies use assessment procedures for their performance level.

2.3 Incident Types

In order to determine the type of incident there is necessity to clearly understand the most significant elements of Incident Types both from the point of view of severity level depending on the place of occurrence, its impact and the duration of it. Based on [5] such classification is reflected in Table 1.

Table 1: Typical Incident types/classifications

	Level 1	Level 2	Level 3	Level 4	Level 5
Type of Incident	Vehicle on shoulder	Vehicle in lane	Minor crash (no injury) Minor debris	Serious crash (injury) Debris Fire	Major injury crash Hazmat Fires
Estimated Duration	Nil	0-30 mins	30-60 mins	1-2 hrs	>2 hrs

Source: Charles, P. (2007). Traffic Incident Management: Best Practices

2.4 Impact of Traffic Incidents

TIs is playing important role in application of transport system expressed by congestion, increasing discharge of road congestions and which is resulting in reducing lost of vehicle hours etc. Apart from direct impact such that: injuries, fatalities, property damage as well as other road safety effects for participants, this is also very important to traffic mobility. There are certain criterions by which TIs impact is assessed but the one which is used frequently is incident rating which takes into account number of lanes and shoulders blocked, and delays. In [6] this is the best explained by Figure 1, which as the basis is taking the incident type, severity and durations.

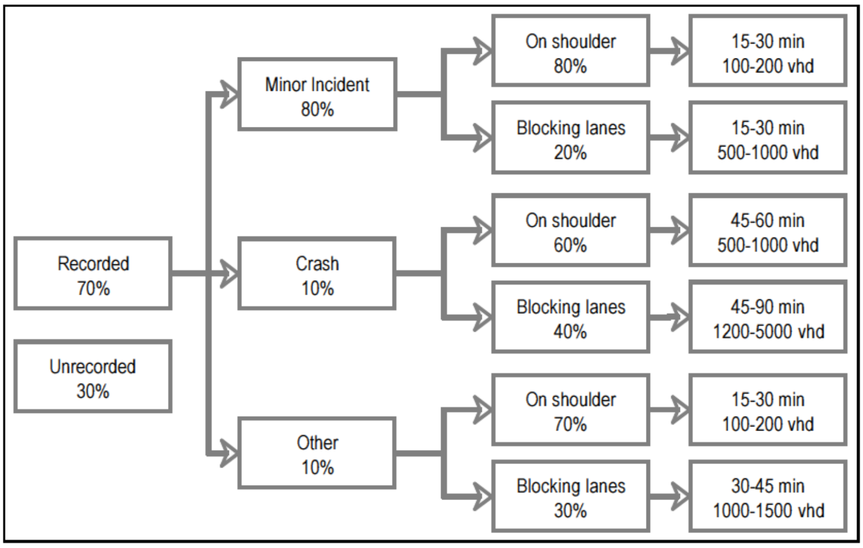


Figure 1: Composition Profile of Reported Incidents by Type

Source: Cambridge Systematic Inc, (1990)

According to [7] classification of incidents is done considering their severity, nature of incident, time of occurrence and the number of agencies needed to respond and clear incidents. Also, taking into account duration by literature [8], TIs are categorized into three general classes: 1) Major TIs, 2) Intermediate TIs, and 3) Minor TIs.

2.5 Benefits of Traffic Incident Management

By [8] effective management of TIM program is done by quantity and quality data. It has been proven that in order to decrease duration of TIs, benefitions should be identified through TIM program. Often benefitions identified by National Traffic Incident Management Coalition (NTIMC 2006) [9], are listed as follows: congestion relief, personnel savings, fuel savings, economic savings, crash and secondary crash reductions, emissions reductions, faster incident detection, verification, dispatch and response time, increased responder safety, reduce morbidity, reduced mortality, increased customer satisfaction.

3 TRAFFIC INCIDENT MANAGEMENT COMPONENTS

IM include but is not limited only to identify activities, services conducted by the personnel of various organizations and agencies. Some activities are not necessary to be completed always by predetermined cycle. IM process may be described by number of activities consisted of five key components: 1) Detection and Verification, 2) Response,
3) Site Management, Investigation and Clearance, 4) Traffic Management and 5) Traveller Information. Demonstration of those activities is done in the Figure 2. Component which is paid more attention in the context of this paper is the Traffic Management (TM). TM covers: Site investigation, Clearance and Recovery.

So, TM means application of control system of traffic in the zones in which an incident occurred. Based on [5] in the wider context TM means establishment of control sites, management of road space with intention to minimize the impact of traffic flow, engagement of personnel, management of resources for traffic control which consist of traffic signal control, ways of designing and their programming as well as selection of alternative roads.

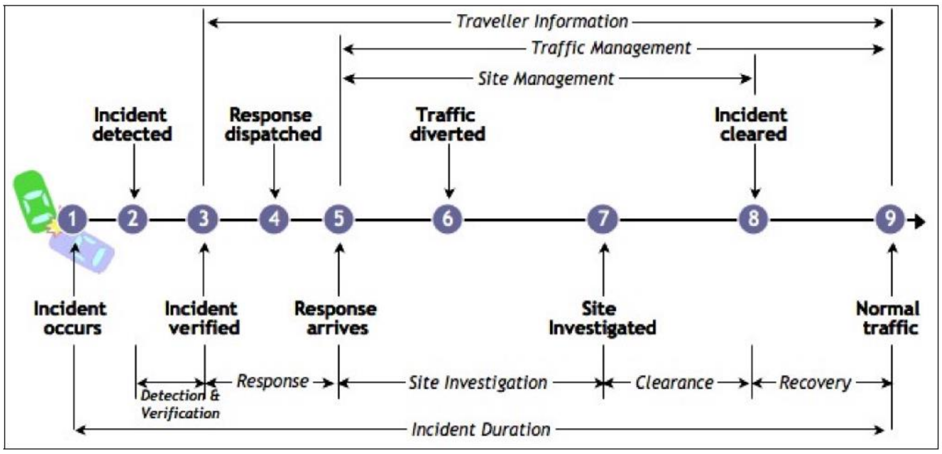


Figure 2: Timeline of Traffic Incident Management

Source: Charles P., (2007). Traffic Incident Management: Best Practices

3.1 Traffic Incident Delay Polygon

By the literature [6] the most significant features of TIM are expressed through incident delay polygon for various versions of IM. In Figure 3, departures and time is presented in horizontal axis while in vertical axis is presented cumulative arrivals of vehicles. Limited space between two constitutes zone with irregular shape in the diagram which is recognized by delay polygon and is expressed in “vehicle-hr” per incident. In the beginning of incident the rate of arrival of vehicles is very low compared to the peak rate and as the result this cumulative arrivals are equal with cumulative departures. After an incident occurred, the departure rate declines significantly or is blocked completely and consequently it differs from arrival rate.

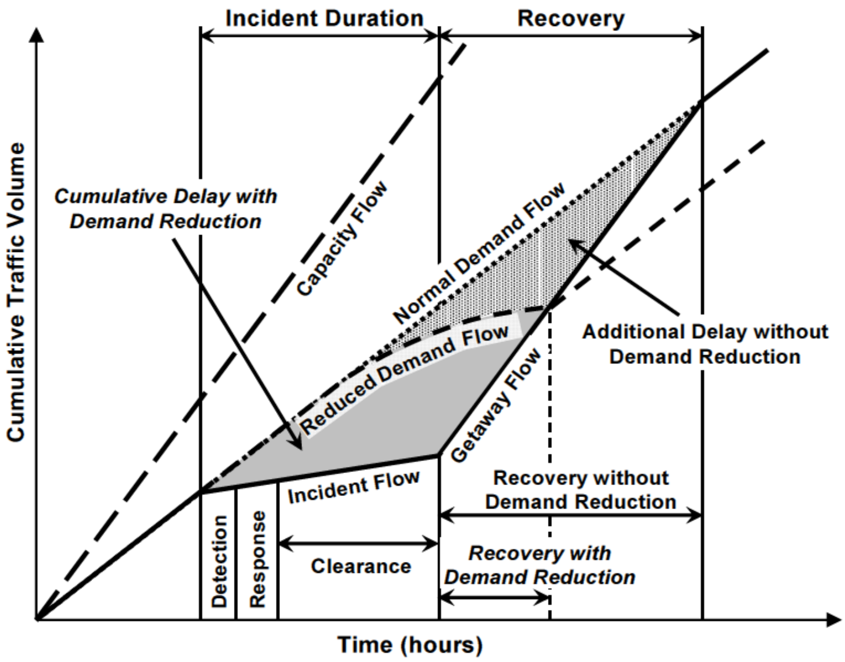


Figure 3: Delay Caused by Incidents

Source: Cambridge Systematic Inc., (1990). Incident Management

This causes delay in the traffic flow. These delays can be reduced immediately after detection and undertaking appropriate measures for intervention in each component. As soon as incident site is cleaned the departure rate can reach the maximum or the peak and there is time demand to restore the situation back to normal condition.

This diagram will face modification if appropriate measures are taken applying management programs for incident management, respectively application of models, known strategies, techniques, tools, new artificial intelligence techniques etc. This will reduce period for every component. An important role is played in informing drivers on time which will be facilitated in using alternative roads and ultimately in reducing cumulative arrivals. Values in key points of delay polygon can be determined numerically and graphically and be expressed in vehicle delays, queue length and travel time savings.

4 TRAFFIC INCIDENT MODELS

Many research papers are conducted by various experts in drafting TIM models for delay incident models and duration incident models. Particular emphasize of this paper is dedicated to delay incident models. Once incident occurred in road transport network, travel time reliability is impacted by number of factors and the most important are considered to be duration of incident and incident delay. These factors need to be measurable as regards their impact to TIs.

There are three components which need to take into account and which have an impact in Travel Time Reliability (TTR) and Travel Time Variability (TTV), such as: 1) duration, 2) delay, and 3) extent as presented in Figure 4.

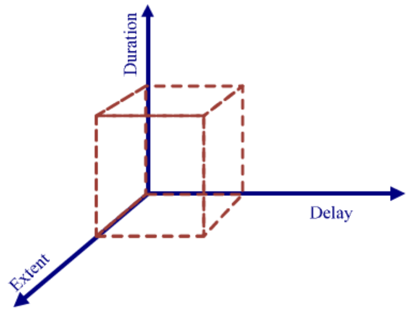


Figure 4: Components of Travel Time Reliability of a System due to Traffic Incidents

Source: Cambridge Systematic Inc. et al., (2008)

According to [10] duration means period in which TIs cause differences in travel time, while delay refer to total delays and extent means general number of vehicles which are affected by TIs. Variation in the reliability of the system is expressed by differences caused in the cube volume in Figure 4. During the literature review it is found that there are two types of models: 1) Analytical models and 2) Simulation models.

4.1 Analytical Models

The duration of incidents is dependant on various factors, such as: incident type, incident severity, geometric characteristics, weather conditions, temporal characteristics, and operational factors. Since this is not the subject of treatment, we did not give any description of these models. Here we consider only analytical delay models.

According to [10] the most representative approaches for incident delay models can be categorized into the following four groups as presented in Table 2.

Table 2: Analytical incident delay models

No.	Model approach	References	Characteristics
Analytical delay models			
1	Deterministic queuing model	Li et al. (2006) Qi et al. (2009)	Assumes demand and capacity are constant Assumes linear trend for flow rate ignores the network characteristics
2	Traffic shockwave analysis	Al-Deek et al. (1995) Knoop et al. (2010)	Assumes some information is deterministic, such as traffic demand, reduced capacity, and incident duration Ignores the network characteristics
3	Heuristic analysis	Skabardonis et al. (2003) Chung and Recker (2012)	Capable of distinguishing between recurrent and non-recurrent congestion Requires good historical traffic and incident data
4	Other Approaches	Dowling et al. (2004) Abdel-Aty and Pande (2005)	Unrealistic assumptions such as linear relationship between incident duration and delay

Source: Hojati, A.T., (2014). Modelling the Impact of Traffic Incidents on Travel Time Reliability

4.2 Simulation Models

According to [11] there is another possibility to assess the impact of traffic congestion in transport network respectively in calculating traffic incident delay which is distinguished like simulation models. These models provide a powerful base and are used for assessing complex traffic situations. Nowadays we find much software traffic engineering programe which apply to visualise or simulate the real traffic situations in the road network. The most often used software, are: AIMSUN, PARAMICS, CORSIM, VISSIM, TRANSIT-7F, EMME 2, SATURN etc. In [12] it is stated that use of simulations is very important to generate real scenario which describe actual traffic flow. It should be noted that apart from advantages offered by them, there are also limits in their use to simulate features of traffic of real-life scenarios [13]. By the literature [14] existing traffic simulation models, categorised into three levels: 1) macroscopic, 2) mesoscopic, and 3) microscopic as presented in Table 3.

Table 3: Summary of estimation models on incident delay

No.	Model approach	References	Characteristics
Simulation models			
1	Macroscopic	Lam and Wong (2003) Khattak et al. (2004)	Capable of relaxing some of the simplifying assumptions and limitations of the analytical process Computational costs of simulation models Time-consuming and costly depending on the level of simulation
2	Microscopic	Chien et al. (2002) Dia and Gondwe (2008)	
3	Mesoscopic	Boyles and Waller (2007) Kamga et al. (2011)	

Source: Hojati, A.T., (2014). Modelling the Impact of Traffic Incidents on Travel Time Reliability

5 TRAFFIC INCIDENT MANAGEMENT STRATEGIES AND TECHNIQUES

5.1 Strategies and techniques for improving Traffic Management

Efforts for mitigation of congestion raised the need to use strategies and various techniques for many subsequent years and some of them have been updated continuously. Analysing and studying congestion, mitigation strategies and their comparison resulted in selection of strategies and techniques which ultimately had an impact in reduction of congestion. It is of relevance to recognize advantages and disadvantages offered by each strategy and techniques for real situations and to find optimal elements, significant to decision makers. Based on [15] we are focusing on a summary reviewing in existing congestion mitigations strategies and techniques with their advantages and disadvantages as given in Table 4.

Table 4: Strategies and Techniques for Improving Traffic Management

Strategies and Techniques	Advantages	Disadvantages
Alternate Route Plans	Removal of traffic demand from impacted roadway Permits easier access to site by emergency response personnel Develops collectively and cooperatively with other stakeholders Diverts traffic to routes that can accommodate demands Detours traffic around sensitive areas (such as schools, hospitals, etc.)	Alternate routing for incidents may already be utilized around construction project Requires extensive pre-planning to execute Requires agencies to have resources available to implement Secondary alternate routes may be required to provide detouring of primary construction alternate route

Strategies and Techniques	**Advantages**	**Disadvantages**
		Applies to long-term incidents only
Emergency Turnarounds / Access Gates	Allows incident responders to access incident scene from opposite direction Shortens travel time of responders to scene May permit removal of incident debris to inside construction area for later removal	Non-emergency traffic may be tempted to use if no physical barrier is provided May slow initial responders if they have to remove physical barrier or gate to access site
Alternative Emergency Response Access Routes	Allows emergency vehicles to access to scene quickly	May require real-time adjustment if alternate route is congested
Predefined Staging Areas	Provides a common area or “rally point” for responders Provides a safe waiting area for storing response vehicles Can be used to separate media from the emergency response areas and can be used to keep media clear of the incident scene to ensure their safety and the safety of the responders. Can be located outside of construction area or off roadway facility	May be difficult to locate staging area in some tight construction zones Used only with large scale incidents
Refuge Areas	Provides a safe refuge out of travel lane where minor repairs can be performed Provides refuge area where disabled vehicles can be pushed to Important when the shoulders are used as travel lanes through the construction area.	May require construction of all-weather surface May be difficult to locate in limited work zone area May be difficult to access at high traffic speeds
Accident Investigation Sites	Provides an established area for relocating damaged or disabled vehicles Could potentially serve as staging area of other incident responders	May require construction of improved area Area must be large enough to accommodate 3 to 4 vehicles Requires installation of signs directing motorists to site
Shoulder Usage Policies	Maximizes the utilization of paved surfaces to move traffic Increases roadway capacity	May not always be possible when work zones utilize shoulders as travel lanes Operational problems may exist at ramps and interchanges Shoulders are no longer available as refuge areas for disabled vehicles
Incremental Lane Opening Guidelines	Keeps duration of lane closures to minimum required to complete response activity Maintains traffic flow past incident scene	Some incident responders may be hesitant to open and close lanes multiple times May increase tendency for secondary incidents
Reopening Work Zone Lanes	Restores roadway capacity potential to pre-construction levels	Only feasible when temporary lane closures have been deployed as part of construction activity Depends on the type of work activity Agency may need to perform an additional lane closures at another time to complete work activity
Equipment Storage Sites	Equipment readily accessible to responders Results in quicker response times to incident scene within construction area	May result in longer response times if equipment needed at incident scene is NOT in close proximity to work zone Requires a secure storage area in close proximity to work zone

Strategies and Techniques	**Advantages**	**Disadvantages**
Traffic Responsive Signal Control Plans	Signal timing plans adjust automatically to changing traffic conditions Reduces the need for law enforcement officers to manually operate traffic signals at intersections	Requires surveillance technologies on alternate routes Signal plan may not fully cover total range of potential incident conditions May require upgrade of existing traffic signal control equipment
Restrictive Ramp Metering Timings	Reduces traffic demands on the freeway Controls access to the freeway Ramp meters infrastructure may already be in place to address recurring congestion problems	Construction may alter ramp geometrics, making it undesirable or unsafe to use ramp metering Ramp queues may block local arterial streets Traffic may divert to an undesirable alternate route (unless acceptable alternate route clearly defined) Requires that TOC have communications with ramp controllers

Source: FHWA. (2009), Traffic Incident Management in Construction and Maintenance Work Zones

5.2 Traffic Incident Management Tools

According to literature review, respectively according to [16] there is wide range of tools used in Traffic Management. They can be grouped into two main categories: 1) hard engineering tools and 2) soft engineering tools. The cycle of their implementation can be fixed through the short to medium term and some of them long term and all this is depended from the topic of application. They have been presented in Figure 5, since the hard engineering tools are placed in Boxes 1 and 2, whereas soft engineering tools are placed in half below part of figure. Undoubtedly, some of tools can be combined with each other supported also by Information and Communication Technology which enables them to perform also in dynamic environment.

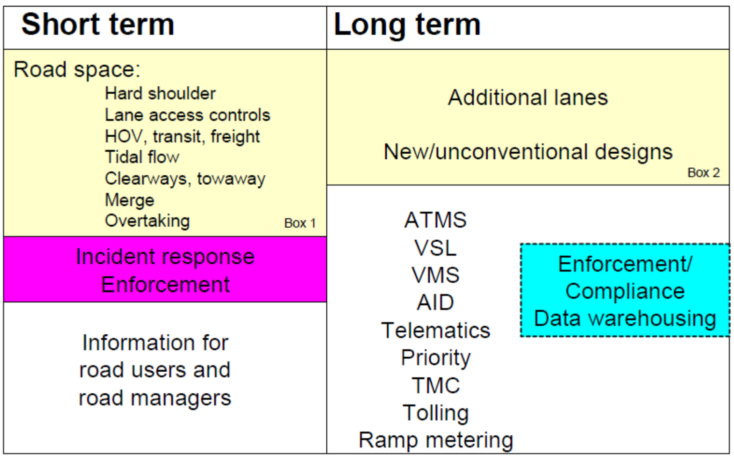


Figure 5: Tools for Improving Network Performances

Source: Charles K., (2007). Tools that Impact Network Performance: Integrated Tools

5.3 Artificial Intelligence Techniques – Agent Based Technology

Nowadays, in the field of road Traffic Management and control applications, the concept of using intelleget agents became very attractive.

Artificial intellegence (AI) means the capability of system to adapt the environment when changing external conditions as well as the possibility to get knowledge from data gained by given environment so that decision makers will have easier job in taking daily decision with regard to Road Traffic Management. Following intelligent techniques are included: knowledge-based, case-based reasoning, fuzzy logic, genetic algorithms, artificial neutral networks, and intelligent agents which are used widely to Traffic Management in the last decade [17]. The domain of AI is wider. Undoubtedly, they are considered like new techniques which are in the process of upgrade applied as well by academic research. There are such advantages of given methods compared to old fashion methods which makes them irreplaceable and applicable in many scientific and technology areas certainly also in the Traffic Management field.

Agent technology marked significant increase in AI research. According to [18] the agent is defined as “a computer system that is situated in the same environment, and that is capable of autonomous action in this environment in order to meet its design objectives”. In order to establish complex systems based on [19] it is not enough sole action of an independent agent but there is requirement for multiple agents which need to be coordinated with each other and which are recognized like Multi-Agent Systems (MAS).

An important part of AI implemented in adaptive traffic signal control as well as in TM is Reinforcement Learning (RL). Main aspects for improvement of control in which there is general impact like AI and Intelligent Agent (IA) defined according to [20] are listed: 1) The capability of dealing with multiple problems and conflicting objectives, 2) The capability of making decisions on the basis of temporal analysis and developments, 3) The ability of managing, learning, and responding to non-recurrent and unexpected events, 4) Self adjustability is an integral part of IA based units, 5) More flexible control unit can proactively optimise while operating.

6 CONCLUSIONS

Considering literature review about TIM one can clearly notice that this topic is dealt with initially by practitioners and consultants, whereas with technology issues in the later stage are dealt with by research institutes and university bodies.

In general, TIM is the policy through which certain measures may be undertaken permanently to reduce negative impacts in many dimensions where in a specific way following issues can be addressed, such as: travel delay and congestion, energy savings, public health and safety, public safety resources and responders’ safety etc.

Once TIM program has been applied, appropriate benefits to national and regional economy are multiple, which are expressed in reduction of travel delay, fuel consumption, emissions, and secondary incidents.

This paper put efforts in providing a clear picture in regard to the relevance of traffic congestion, its types, the role and significance of incident management, their impact, benefits of them, coordination between various agencies involved, components etc. Exploration of traffic delay polygon, shifting afterwards to the models explored so far, application of known strategies/techniques, use of tools and ultimately finalizing the role and relevance of artificial intelligence in general and intelligent agents in particular.

As conclusion, we may recognize the fact that this is broad field with wide range of stakeholders from different research backgrounds and the future researches in this area remain imperative for every country in all levels.

REFERENCES

[1] Steenbruggen, J. (2013). Road Traffic Incident Management and Situational Awareness, Faculty of Spatial Economics, Vrije Universiteit, Dissertation.

[2] Cambridge Systematics Inc. & Texas Transportation Institute (2005). Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation Federal Highway Administration, Washington, DC.

[3] Tasic, I. (2012). Using Micro-simulation to Evaluate Traffic Incident Responses for Traffic Operations Centre Decision Making. Master of Science Thesis, Department of Civil and Environmental Engineering, University of Utah.

[4] Charles, Ph. (2007). Review of Current Traffic Incident Management Practices. The University of Queensland, Austroads Publication No. AP–R297/07.

[5] Charles, Ph. (2007), Traffic Incident Management: Best Practice, Austroads Publication No.AP-R304/07. The University of Queensland 7 Adelaide, Australia.

[6] Cambridge Systematics, Inc. in association with JHK & Associates Transmode Consultants, Inc. Sydec, Inc. (1990). Incident Management Prepared, Final report.

[7] Lopez, J.J. (2008). Development of a Freeway Incident Rating System, University of Texas at Arlington.

[8] MUTCD. (2003). Manual of Uniform Control Devices, FHWA, U.S Department of Transportation.

[9] NTIMC. (2006). National Traffic Incident Management Coalition, Quick, Safe, Clearance.

[10] Hojati, A.T. (2014). Modelling the Impact of Traffic Incidents on Travel Time Reliability, School of Civil Engineering.The University of Queesland.

[11] TRB. (2010). Traffic Incident Management Handbook Update. FHWA, U.S Department of Transportation.

[12] Charles, K. (2007). Tools that Impact Network Performance: Summary report, Austroads Publication No.AP-R313/07.

[13] Boxill, S. A., and L. Yu. (2000). An Evaluation of Traffic Simulation Models for Supporting ITS Development. Center for Transportation Training and Research, Texas Southern University.

[14] Sommer et al., (2011). Bidirectionally Coupled Network and Road Traffic Simulation for Improved IVC Analysis. Mobile Computing, IEEE Transactions on, 10(1), 3-15.

[15] FHWA. (2009). Traffic Incident Management in Construction and Maintenance Work Zones.

[16] Charles, K. (2007). Tools that Impact Network Performance: Integrated Tools, Austroads Publication No.AP-R309/07.

[17] Chen, G. and Pham, T.T. (2001). Introduction to Fuzzy Logic and Fuzzy Control Systems.

[18] Wooldridge, M. (2002). An Introduction to Multiagent Systems. 1st ed. Jon Wiley &Sons.

[19] Stuart J. Rusell and Peter Norvig. (2010). Artificial Intelligence -A Modern Approach, Third Edition, Prentice Hall.

[20] Bielli, M., Ambrosino, G., Boero, M. (1994). Artificial Intelligence, Applications to Traffic Engineering. VSP International Science Publishers.

MODELS FOR THE INTRODUCTION OF ALTERNATIVE FUELS IN THE REPUBLIC OF SLOVENIA

Elvis Fičur, M. Sc.
elvis.ficur@omv.com

Robert Muha, D. Sc
University of Ljubljana
Faculty of Maritime Studies and Transport
Pot pomorščakov 4, SI-6320 Portorož, Slovenia
robert.muha@fpp.uni-lj.si

ABSTRACT

Road transport, a key factor in the modern world economy at the global level, is facing global energy and environmental crisis. In addition to the use of fossil fuels, their increasing price and limited resources, road vehicles have a significant impact on the global pollution and the green-house effect.

It is the environmental impact that calls for immediate measures and transition to vehicles using alternative fuels.

Market penetration of alternative fuels in Slovenia provides the opportunity for zero-emission mobility. However, it also brings some threats that should be overcome, such as: increasing demand for new fuels, high investment cost in distribution and transport infrastructure, adoption of new technology and change in travel habits. The economical, technical and environmental aspects shall be taken into account, as well as natural conditions, capabilities and applicable law provisions. Consideration should also be given to dynamical aspect and time horizon in relation with the progress of research and development, changing economic conditions, time limits, the development of transport and constantly changing needs.

The article deals with the interaction among these complex factors and integrates research findings into economically efficient business models that are suitable for economic and social conditions in Slovenia.

Key words: Alternative fuels, sustainable development, electric vehicles, liquefied petroleum gas, biofuels, natural gas, hydrogen and fuel cells.

1 INTRODUCTION

Much has been undertaken lately, both in science and in economy, aiming to develop an adequate, clean, renewable and cheap energy product to replace fossil fuels. An ideal fuel has to be neutral to the environment over the entire exploitation process (from extraction or production to consumption). Such fuels, the potential of which was assessed by numerous research studies, include natural gas and liquefied petroleum gas, biofuels, electrical energy, and hydrogen.

Fuels and energy product differ in their physical and chemical properties, in extraction methods, storage and handling techniques, in safety requirements and in developmental potential. Therefore, fuels need to be viewed from a user-specific angle, so the choice of an adequate fuel is quite a complex decision.

In international environment, we can find numerous business models, either tested or in their pilot stage, for introducing alternative fuels. Perujo, Thiel, and Nemry (2011) concentrated their attention to electric vehicles in an urban context [1], Hadley and Tsvetkova (2008) studied potential impacts of plug-in hybrid EVs on regional power generation [2], Ramsden, Ruth, Diakov, Laffen and Timbario (2013) examined hydrogen pathways updated cost, well-to-wheels energy use and emissions of various hydrogen production [3], delivery and distribution scenarios, while Thomas, James, Lomax and Kuhn (2000) concentrated on various fuel options for the fuel cell vehicle [4]. Each research and project is placed within a specific national or economical field which varies considerably from one country to another.

However, the transition from an individual project into a particular country is a complex step.

2 IMPORTANT FACTORS IN INTRODUCING ALTERNATIVE FUELS

Average air temperature on the surface of the Earth has increased by ca. 0.6°C in the last 150 years, and it is forecast to heighten by additional 1.5–4.5°C over the next hundred years. The warming is strongly believed to be an outcome of man's activities and emissions causing the increased volumes of greenhouse gases in the atmosphere and generating the greenhouse effect [5].

In 2009, the European Union (EU) and the heads of states or governments of the G8 Group agreed that by the year 2050, the CO2 emissions are to be reduced by 80% and the global warming needs to be maintained below 2°C, which is considered as the safe level. The goal to reduce carbon emissions by 80% by the year 2050 implies that carbon emissions in road traffic need to be reduced by as much as 95%.

In Slovenia, the energy consumption in the year 2011 contributed more than 80% to total exhausts of greenhouse gases on the national level. Thereof, fuel consumption contributed 75%, which comprises traffic as the largest source. The road traffic sector uses by far the largest share of energy of all traffic segments. That share was 97 percent in 2011. Automobiles spent as many as 62 % of total energy used in traffic, and in commercial vehicles 33 percent.

In Slovenia, exhausts of greenhouse gases from traffic increased by 181 % between the years 1986 and 2011. Road traffic in particular remains one of major sources for air pollution compared with the year 1986 [6].

The concept of sustainable traffic is derived from the general term ‘sustainable development’. Sustainable transport can be approached by analysing the sustainability of transport system alone to examine the positive and negative external impacts on environment, public health, safety and reliability, use of land, traffic hold-ups, economic growth and social inclusion [7].

3 DEVELOPMENT OF MODELS FOR EFFECTIVE INTEGRATION OF CLEAN FUELS IN SLOVENIA

The requirements addressing the issue of energy use and environmental pollution will demand big changes in road traffic. New technologies in road traffic, which are envisioned to satisfy these requirements, comprise a wide spectrum of technological solutions.

In Slovenia, present-day trade and distribution of petroleum products is well regulated. It is determined by a business model that integrates the whole range of regulatory, economic, technical, safety and environmental requirements. That model regulates the entire distribution route from fuel import, distribution via central storage facilities and numerous retail service stations to end customers.

Also the distribution route of alternative fuels requires to build up an equally efficient business models from manufacturer to consumer. The speed and efficiency of introducing the alternative fuels and consequently, paving the way for clean vehicles, depend on effective planning of the underlying business models. Clean vehicles must assure both short and long-run economic development and aim to fulfil the expectations of the driving public. In addition to low price, the eligible energy product also has to be as user-friendly as conventional fuel, allow for the desired speed, efficiency, safety and availability of charging the vehicle.

As described above, the approach to a systematic introduction of alternative fuels integrates the underlying economic, social and environmental aspects. These are intertwined with scientific and technological development, conditions and capabilities given in a country and regulatory framework. Such a complex, integration-driven task presents a challenge that can be achieved by creating adequate business models.

The prospects of developing and integrating efficient models to introduce alternative fuels and as a follow-up, enable a free flow of clean vehicles onto Slovenian roads, will bring advantages and benefits to the driving audience and Slovenian society, which in fact stand for a contribution to clean environment, more favourable prices of fuel, increased mobility, achieving compliance with the EU and international commitments to environment, and last but not least, new opportunities for national economy.

This paper focuses on the design of unsophisticated models by which we can have an efficient way for introducing alternative fuels to Slovenia.

3.1 Road vehicle operation model

All self-propelled vehicles rely on a primary energy source that is available in the vehicle. The vehicle converts, under controlled conditions in an energy converter, the primary energy into mechanical work – i.e. kinetic energy necessary for drive or motion respectively.

Figure 1 shows the basic model of a conventional road vehicle that uses chemical energy from hydrocarbons derived from mineral oil and stored in a vehicle reservoir. Chemical or intrinsic energy is released in a combustion process generated within an internal combustion engine. The energy conversion is partly seen as thermal energy and partly as useful mechanical work – the motion, which is transferred to the drive wheels of a vehicle by a shaft mechanism and a mechanical transmission.

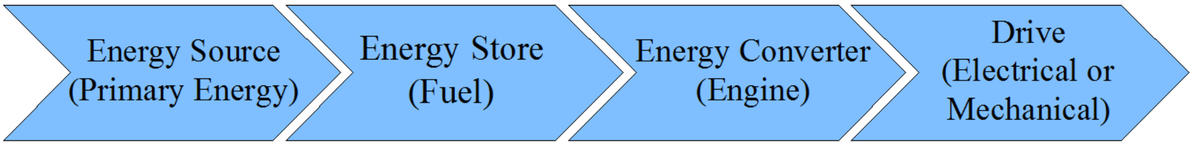


Figure 1: Basic model of how a road vehicle is driven

Source: (Lane, B. (2007). Road Vehicle Technology Options)

In road traffic, such a basic model uniformly describes the use of fossil fuels as well as of other alternative fuels. The essential operation is that the energy source is converted into the form that assures the desired autonomy of vehicle for a longer time, and there must exist an adequate mechanism (chemical, physical or electrical) to convert the energy from the fuel into kinetic energy, whenever necessary and in the necessary volume. In the broader sense, this business model separately deals with propellants, and the technologies used in a vehicle [8].

3.2 Methods for model design

The basic model described herein is used as underlying for design and further development of business models dealing with the introduction of individual alternative fuels. It has to be upgraded by the aspects that are vital for introducing clean fuels. Such aspects can be uniformly integrated and defined as “Prospects for development of technology and science”, covering the social aspects, “Prospects for new economic opportunities” standing for the economic aspect, and “Contribution to environmental protection, attraction and benefits for users derived from alternative fuel introduced”, which combines the factors of the environmental and social aspects [10].

To the three key aspects in this model, we added the pertaining quantities that can be schematically evaluated by colour and size. Red colour denotes a low potential, yellow medium potential, and green colour denotes a high potential. The arrow height level stands for the global contribution expected from the introduced alternative fuel onto the mass driving audience in Slovenia. The length of arrow shows the period of time in which the activities are bringing their effects.

3.3 Creating a basis for designing efficient models

The method described above can be used to design a business model; however, the method alone is not sufficient for that. Models must necessarily be based on detailed preliminary scientific research dealing with one or several alternative fuels and comprising all the factors applicable to international sphere, and to a national environment in particular. In addition to technological and non-technological factors, the models are also dependent on factors that have an indirect bearing on the penetration of an individual alternative fuel, or on the introduction of clean technology, respectively. An example of an indirect impact on the penetration of an alternative fuel is the environmental measure prohibiting traffic to vehicles driven by liquid fossil fuels in an urban environment. Consequently, the demand for clean vehicles has been rising. The second such measure can be the development and investment in public transport. As a result, automobiles might be losing their attraction. The same applies to cases of investing in telecommunications, which renders work from the home possible, or to cases of laying out cycling routes.

To sum up, there are two vital aspects for designing our models: a thorough research in the first place, and an appropriate method under which our model can be constructed as described herein.

3.3.1 Model of introducing Liquefied Petroleum Gas in Slovenia

Based on the data obtained from preliminary research, the following factors can be resumed for the introduction of liquefied petroleum gas [9]: The prospects of technological development of LPG are primarily focused on improving the utilization rates and to reducing the emissions of internal combustion engines. Further improvements are possible in distribution processes and logistics of fuel, as well as in the applicable quality standards.

Due to only recent occurrence of serial filling stations in Slovenia, it is possible to observe a low level of familiarity with technological processes of distribution and charging of vehicles.

The main problem is the gasification of fuel in the course of handling process and variance in the quality of gas at each filling (proportion of butane, propane and other admixtures). In the economic sector, the interest in expanding and building up the retail distribution network is limited to current distributors who are already operating in the segments of imports and distribution of fossil fuels.

Expansion is foreseen for the range of vehicles for sale and for the after-sale service network. Acceptance of new technology on the part of users is tied to the price of fuel and availability of charging network. In the eyes of users, the quality of travel does not change essentially whether there is a diesel or a petrol-operated engine in the vehicle [10].

Based on these data, the business model in Figure 2 was created.

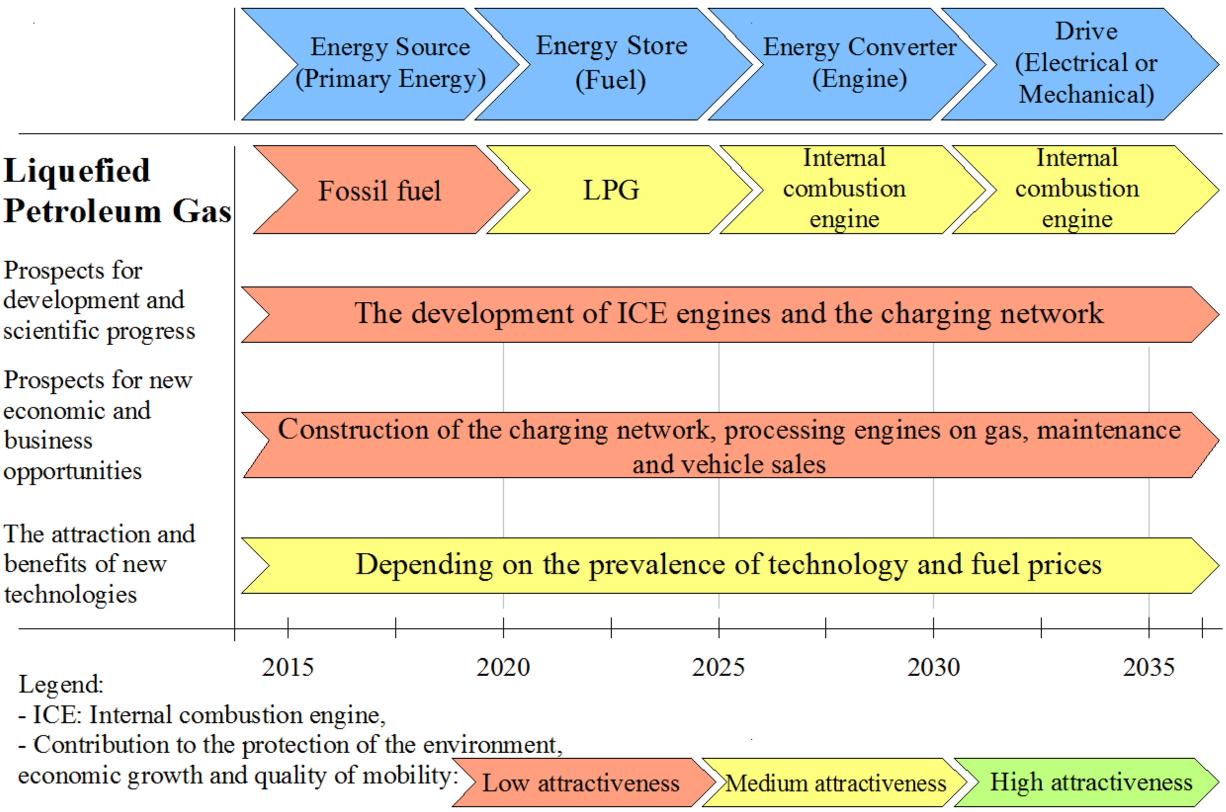


Figure 2: Model of introducing Liquefied Petroleum Gas (LPG) in Slovenia

Source: (Fičur, E. (2014). Business Models of introducing alternative fuels in Slovenia)

The model shows that prospects for scientific, technological and economic development for that type of fuel in the coming twenty years are minimal (red and low arrow). There is a minimal number of national companies that take interest in that segment. The fuel is of fossil origin, national procurement entirely depends on imports. As regards the acceptance of new technology, this model shows a medium potential (yellow and low arrow). For the user, it is demonstrated in a low retail price of fuel, provided that the price will not undergo an essential change in the course of time.

3.3.2 Model of introducing electric vehicles in Slovenia

Figure 3 shows one of the models of integrating the Plug-in battery electric vehicle (PBEV) in the country. This model is based on data obtained from research on the effects of implementation of passenger electric vehicles on the Slovenian transport network and energy grid (Fičur, E., 2012) which showed a high potential for the PBEV in Slovenia [9]. It is evident that the prospects for scientific, technological and economic development of the PBVE for the next twenty years are high (green and high arrow). There is a large number of national companies and scientists who are interested in this segment. That applies to all areas listed below: energy generation from renewable sources; development and manufacture of batteries; charging infrastructure; aggregates, and component groups for vehicles. The PBEV introduction is further interesting for stakeholders who are not directly involved in traffic, but rather in cooperation in developing smart electric grids, in providing the charging service at drivers' homes or offering free charging in large shopping centres, aiming to attract the visiting audience and increase the sales turnover [9].

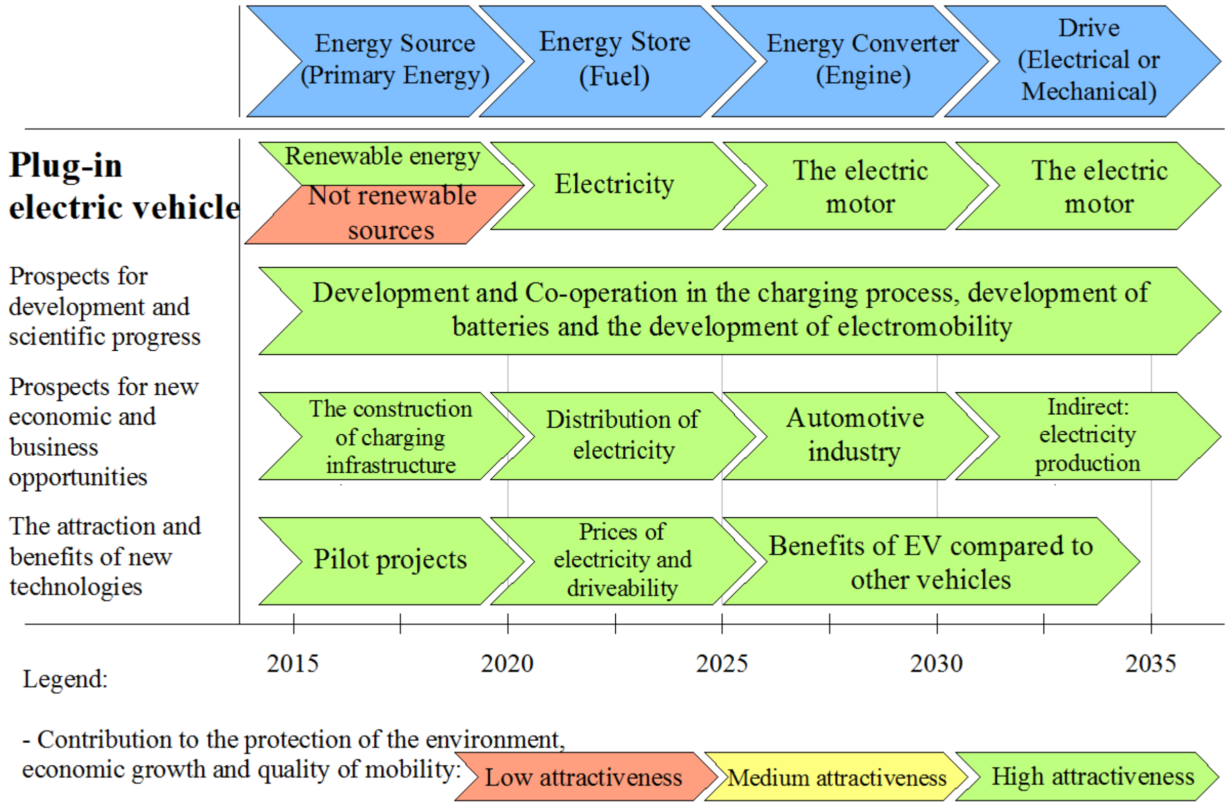


Figure 3: Model of introducing electric vehicles in Slovenia

Source: (Fičur, E. (2014). Business Models of introducing alternative fuels in Slovenia)

Electrical energy can be generated from renewable sources in the national territory. Short-termed supply relies both on non-renewable sources and on imports (green-red arrow). The BEV have a high potential for the acceptance of new technology they offer good performance (high torque, silent driving) to users, however, the initial phase will require much investing in promotional activities and presentations.

3.4 Comparison of business models presented herein

If equal procedures and criteria are applied, we can design uniform business models for all alternative fuels. Unification of business models offers transparency and comparability. The areas analysed herein can be compared and dealt with in detail, if necessary, they can be expanded or curtailed; a review of activities herein and of the strengths and threats of such activities can be determined. The business models can be supplemented by a financial plan. These business models allow for dynamics in monitoring in the course of time, and sufficient flexibility to adapt to new situations as they arise. Likewise, they also support a rapid implementation of corrections if needed to cope with newly emerged political and economic situation or to grasp a new economic opportunity (e.g. in case of notable progress of science and technology).

4 CONCLUSION

Introducing alternative fuels to the Republic of Slovenia is a challenge that is not only addressing the underlying research issue, but also closely embedded in the revival of national economy, reducing the emissions, looking for new possibilities for independence from fossil fuels, and improving the quality of mobility. All of these challenges are topical and demand immediate action. There is no ideal way or approach thereto, but there are numerous prospects and opportunities leading to accomplishment of the goals set.

The business models dealt with herein support the integration the detailed results of individual research studies into basic business models. These schematically determine the possibilities for introducing alternative fuels and the correlation between the activities falling within individual phases of implementation in the course of time. The goal of our research is accomplished: we have provided the business models that point to advantages and prospects in the processes introducing alternative fuels into Slovenia.

REFERENCES

[1] Perujo, A., Thiel, C., & Nemry F.. (2011). Electric Vehicles in an Urban Context: Environmental Benefits and Techno-Economic Barriers. Electric Vehicles - *The Benefits and Barriers*, 19-34.

[2] Hadley, S., W., & Tsvetkova, A.. (2008). Potential Impacts of Plug-in Hybrid Electric Vehicles on Regional Power Generation. Oak Ridge, Tennessee, U.S.A.: *Oak Ridge National Laboratory*.

[3] Ramsden, T., M., Ruth, V., Diakov, M., & Laffen, T.A. Timbario. (2013). Hydrogen Pathways Updated Cost, Well-to-Wheels Energy Use, and Emissions for the Current Technology Status of 10 Hydrogen Production. *National Renewable Energy Laboratory*. Available 7. April 2015 http://www.nrel.gov/docs/fy14osti/60528.pdf

[4] Thomas, C., E., Brian, D., James, Frank, D., Lomax, & Ira., F., Kuh. (2000). Fuel options for the fuel cell vehicle: hydrogen, methanol or gasoline? *International Journal of Hydrogen Energy 25 (2000), Elsevier Scienc Vol. 25, pp. 551-567.* Available 7. April 2015 on *http://www.sciencedirect.com*

[5] Wikipedia (2013). The greenhouse effect. Available 8. April 2014 on: http://sl.wikipedia. org/wiki/.

[6] Environmental Agency of the Republic of Slovenia (ARSO). (2013) Environmental indicators in Slovenia. Available 1. January 2014 on: http:// kazalci.arso.gov.si/.

[7] OECD. (2010). Sustainable Transport: futures, strategies and best practices. Synthesis Report of the International EST Conference, (str. 4–6). Vienna, Austria.

[8] Lane, B. (2007). Road Vehicle Technology Options. Available 3. April 2014 on: http://design. open.ac.uk/documents/LaneThesis/Chapter_2.pdf.

[9] Fičur, E. (2012) The effects of implementation of passenger electric vehicles on the Slovenian transport network and energy grid. *ICTS Conference*. Portorož, Slovenia.

[10] Fičur, E. (2014). Business Models introducing alternative fuels in Slovenia, *Master Thesis, Faculty of Maritime Studies and Transportation*, Portorož.

NAUTICAL TOURISM AND ANALYSIS OF MARINAS, BOAT AND YACHT TRAFFIC IN SPLIT-DALMATIA COUNTY

Stipe Galić, MEng
Zvonimir Lušić, PhD
University of Split
Faculty of Maritime Studies
Zrinsko Frankopanska 38, 21000 Split, Croatia
stipe.galic@pfst.hr, zvonimir.lusic@pfst.hr

Danijel Pušić, MEng
Hydrographic Institute of the Republic of Croatia – Split
Zrinsko Frankopanska 161, 21000 Split, Croatia
danijel.pusic@hhi.hr

ABSTRACT

Nautical tourism is one of the most competitive Croatian products. The development of nautical tourism ports in terms of macro-economic strategic plans are of significant national interest for Croatia. The nautical tourism in Croatia is becoming increasingly important, but it still does not achieve an adequate material profit considering its potential. The problem is that the current development does not have a clear concept, which leads to non-selectivity in the development and has negative environmental impacts. This article deals with statistical data referring to the selected area and the marina management in Split-Dalmatia County. Also, the analysis of boat and yacht traffic in nautical tourism within the specified area along the main and local navigation routes within Split-Dalmatia County will be presented. This article provides an overview on security measures, guidelines for listed nautical marinas as well as the implementation of the Blue Flag marina criteria.

Key words: Nautical tourism, competitiveness, marina capacity, marina management, boat and yacht traffic, Blue Flag.

1 INTRODUCTION

According to the broadest definition, a port is a naturally or artificially protected marine, river, canal or lake basin where the vessels can find shelter from waves, currents, tides, ice, and effects of enemy attacks. It is a place where vessels can be loaded with fuel, water and food, where people can repair the hull, machinery and equipment, clean parts, carry out safe and quick loading, unloading or reloading of cargo and passengers and where the crew can rest. [8]

Ports in Croatia can be divided into:

- The ports open to public traffic - are managed directly by state / county via the Port Authority and can be used by every legal and natural person.
- Special purpose ports - are managed by state / county, which transferred the management rights to the holder of the concession.

A nautical port is a tourist facility which in spatial, commercial, constructional and functional view forms a whole and which provides all the necessary conditions for nautical tourism and for meeting the needs of nautical tourists.

A marina is a special kind of a nautical port which, in addition to berth service and vessel accommodation, offers many other facilities and services related to nautical tourism. A dry marina features an area of land intended to provide accommodation for vessels and their transport from dry dock to sea and vice versa. If a nautical port wants to be declared as a marina, it must meet a number of technical requirements such as:

- connection of electricity 220 V per 20 berths,
- access to hygienic water every 20 berths,
- lifting device of at least 50 KN
- repair shop for interventions on vessels,
- grocery store maximum 500 m away,
- storage space for vessels on land,
- at least one toilet unit and shower with hot water every 50 berths,
- VHF marine radio station,
- equipment and accessories for first aid,
- restaurant not farther than 500 m,
- daily weather report,
- parking for cars for at least 50% of the number of berths,
- slipway for trailers,
- working boat,
- guarding service 0-24 hours,
- telephone for public use,
- equipment to prevent the spread of sea pollution,
- money exchange office,
- reception service,
- gas supply.

The role of marinas in nautical tourism is of great importance, and is characterized by a high share of investments per unit of capacity. The primary purpose of a marina is to ensure berth and safe shelter for boats. However, marinas often offer additional services such as: boat repair and maintenance service, administrative services, assistance with lifting and lowering boats into the water, electricity and water connections, garbage disposal, supply of spare parts, fuel, groceries and other necessities. Also, the marina can provide additional amenities such as entertainment, sports, recreation and so on. Thus it can be said that the marina is the special type of port in nautical tourism which offers berth services, shelter for boats and other facilities and services to meet the contemporary nautical tourism demand.

If a marina wants to meet minimum requirements, it must pass categorization. In Croatia, the categorizations of nautical ports are implemented on the basis of the Law on Tourism (Official Gazette / Narodne Novine, Nos. 8/96, 19/96 and 76/98) and the Regulation on Classification and Categorisation of Nautical Ports (NN, Nos. 142/99, 47/00, 121/00, 45/01 and 108/01).

Marinas are divided into three categories:

- The first category stands for marinas of the highest standard.
- The second one stands for marinas of medium standard.
- The third category stands for marinas of the lowest standards.

2 NAUTICAL TOURISM IN SPLIT-DALMATIA COUNTY

The difference between the nautical tourism and other forms of tourism lies in mobility. The term nautical tourist refers to frequent change of residence. Marine tourism has been experiencing a large expansion in the last few decades. Nautical tourism is such a kind of tourism that contains elements of nautical tourism product and nautical tourism service. The law on tourist activities in the Republic of Croatia defines nautical tourism as "sailing and staying of tourists-sailors on vessels, as well as staying in nautical ports for rest and recreation." [9]

Split-Dalmatia County has unique tourist potentials: the indented coastline, abundance of islands, clear sea, beautiful nature and a unique cultural and historical heritage. As such, it has great potential for development of nautical tourism. This potential should be recognized for the purpose of creating identity in nautical tourism service. Nautical tourism has three forms:

- Nautical ports: ports that provide accommodation and service boats and nautical tourists. This category is the most advanced form of business in marinas.
- Charter (chartering): business with vessels, in terms of their rental.
- Cruising: a form of nautical tourism which includes round trips by commercial boats.

Table 1: Statistics of nautical ports in Croatia, 2013

COUNTY	TOTAL	ANCHORAGE	MOORING	Land Marina	Marina 1st category	Marina 2nd category	Marina 3rd category	Marina, categorised and marked by anchors	Uncategorised nautical ports
Republic of Croatia	106	22	13	14	6	24	17	6	4
Primorje-Gorski kotar	32	10	5	7	1	3	3	3	-
Zadar	23	9	3	3	-	4	4	-	-
Šibenik-Knin	14	1	-	1	2	4	5	-	1
Split-Dalmatia	17	2	2	2	-	5	3	2	1
Istria	14	-	2	-	3	6	2	1	-
Dubrovnik-Neretva	6	-	1	1	-	2	-	-	2

Source: Central Bureau of Statistics, Republic of Croatia, March 2014.

Table 2: Capacity of nautical ports, situation on 31 August 2013

County of Split-Dalmatia	
Water surface area (m2)	258810
Moorings, total	2021
Number of dry berths	503
Total surface area on land (m2)	77760

Source: Central Bureau of Statistics, Republic of Croatia, March 2014.

The city of Split, as an important nautical, administrative, economic and tourist centre of Split-Dalmatia County, located in the central part of the Adriatic coast. Nautical tourism is the most promising form of maritime tourism, which is especially notable in the Mediterranean coasts, and on water surfaces of almost all European countries. All developed countries indicate that nautical tourism is growing faster than the total tourist traffic and that it has an increasing share in the domestic and international tourism. This fact has opened up new processes for construction and adaptation of specialized ports and harbours on the sea coasts, but also on the inland waters of developed countries around the world. Production of vessels for sport and tourism is rapidly growing. The development of nautical tourism in the world is going through a phase of expansion.

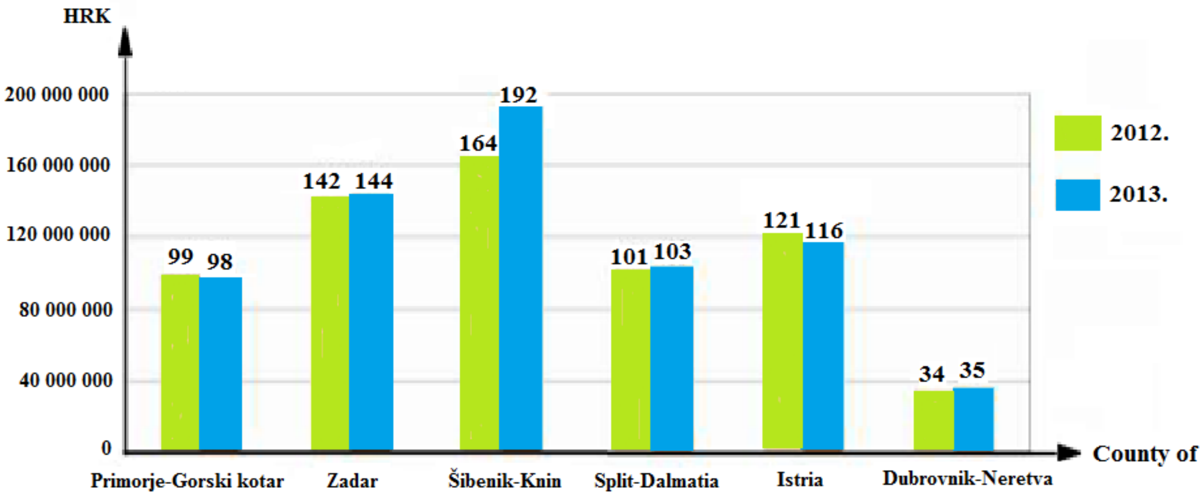


Figure 1: The profit of nautical ports in the Republic of Croatia (without VAT)

Source: Central Bureau of Statistics, Republic of Croatia, March 2014.

The development of nautical tourism lies on a natural basis. Croatia's Adriatic Sea features a very indented coastline that is 6176 km long, of which 4398 km refer to the coastlines of the islands. There are 1244 islands, islets and rocks, 50 islands are inhabited. The most attractive areas for nautical tourists are areas under various categories of protection as prominent natural values because of specific environmental value and biodiversity. According to the latest survey in 2013, Split-Dalmatia County has a total of 17 nautical ports: 12 marinas (5 second and 3 third category marinas, 2 dry marinas and 2 categorized and marked as anchorages), 2 berthing ports, 2 anchorages and 1 unclassified port.

Table 3: Number of vessels in nautical ports, situation on 31 December 2013

	Vessels, permanently moored				
	Total	**Motor yachts**	**Sailboats**	**Other**	**Total indices I.-XII.2013. I.-XII.2012.**
County of Split-Dalmatia	1441	474	904	63	107.8
Vessels using sea moorings	1172	295	840	37	99.0
Vessels using only land (dry) berths	269	179	64	26	175.8

Source: Central Bureau of Statistics, Republic of Croatia, March 2014.

According to statistics performed in 2013, Split-Dalmatia County has a sea area of 258.810 m² suitable for nautical tourism, with a total of 2021 berths, and 503 dry berths. The total area of land is 77.760 m². According to the spatial plan of Split-Dalmatia County, another 55 nautical ports - marinas with about 10.200 berths are planned [6].

Table4: Number of vessels in nautical ports in 2013

	Vessels in transit				
	Total	Motor yachts	Sailboats	Other	Total indices I.-XII.2013. I.-XII.2012.
County of Split-Dalmatia	44649	7853	34633	2163	106,4
Vessels using sea moorings	44621	7830	34628	2163	106,5
Vessels using dry berths	28	23	5	-	65,1

Source: Central Bureau of Statistics, Republic of Croatia, March 2014.

3 MARINAS IN SPLIT-DALMATIA COUNTY

There are 106 ports of nautical tourism in the Republic of Croatia. 6 of them are 1st category marinas, 24 are 2nd category marinas and 17 are 3rd category marinas. [5] Croatian marinas have 16.000 sea berths and 8.500 dry berths. In addition, there are 30.000 berths in ports and sports ports. [11]

Table 5: List of marinas in Split-Dalmatia county

Name	Place	Position	Sea berths	Dry berths
ACI Marina Milna	Brač	P (φ = 43° 19,7´N λ = 016° 27,6´E)	144	15
ACI Marina Palmižana	Hvar	P (φ = 43° 10,6´N λ = 016° 26,4´E)	211	
ACI Marina Split	Split	P (φ = 43° 30,3´N λ = 016° 25,8´E)	364	60
ACI Marina Trogir	Trogir	P (φ = 43° 30,8´N λ = 016° 14,9´E)	162	35
ACI Marina Vrboska	Hvar	P (φ = 43° 10,8´N λ = 016° 40,3´E)	125	17
Marina Agana	Marina	P (φ = 43° 30,6´N λ = 016° 07,0´E)	134	70
Marina Baotić	Seget Donji	P (φ = 43° 31,0´N λ = 016° 14,0´E)	300	
Marina Baška Voda	Baška Voda	P (φ = 43° 21,5´N λ = 016° 56,8´E)	30	
Marina Frapa	Rogoznica	P (φ = 43° 31,9´N λ = 015° 57,7´E)	450	150
Marina Kaštela	Kaštel Gomilica	P (φ = 43° 32,8´N λ = 016° 24,4´E)	420	200
Marina Kremik	Primošten	P (φ = 43° 34,3'N λ = 015° 56,5'E)	393	150
Marina Lav	Podstrana	P (φ = 43° 29,5´N λ = 016° 32,3´E)	75	
Marina Podgora	Podgora	P (φ = 43° 15.0'N λ = 017° 05.0'E)	220	
Marina Ramova	Krvavica	P (φ = 43° 19,4´N λ = 016° 58,9´E)		
Marina Tučepi	Tučepi	P (φ = 43° 15,8´N λ = 016° 03,5´E)	50	
Marina Vlaška	Brač	P (φ = 43° 18,9´N λ = 016° 26,1´E)	75	
Marina Zirona	Drvenik Veli	P (φ = 43° 27,0´N λ = 016° 09,1´E)	15 (150)	

Source: author

Apart from basic services such as water and power supply, many ports of nautical tourism in Croatia provide additional amenities such as traditional cuisine, primary health care, charters, apartments, video surveillance, security service, etc. There are 17 marinas in Split-Dalmatia County (Table 5).

4 MAIN AND LOCAL NAVIGATION ROUTES IN SPLIT-DALMATIA COUNTY

The County's major navigation routes are directed towards the Port of Split. International routes, i.e. transit routes, mainly extend across the margins of the County. The largest part of the international transit takes place in the area between Palagruža Island, Pianosa Island and Point Gargano, whereas a smaller share of the traffic takes place around Vis Island. The most important transverse international route is the passage connecting Split and Ancona in Italy. Other transverse routes run along the coast, connecting Split with Rijeka, Dubrovnik and other ports in the eastern Adriatic. Local navigation routes in Split-Dalmatia County connect the Port of Split with the neighbouring islands of Brač, Šolta, Drvenik, Hvar, Vis and Korčula. Generally speaking, the densest maritime traffic occurs on the approaching routes toward the City of Split.

The areas of increased risk to navigation may appear due to navigation obstacles, unfavourable weather conditions and intensive traffic. With regard to Split-Dalmatia County, such areas may include Splitska Vrata (Split Strait between the islands of Brač and Šolta), Drvenik Channel, Šolta Channel, Pakleni Islands and Pakleni Channel, areas of approach to the Port of Split and other major County ports, Vis Channel, area covering the outer chain of islands and the areas used by hydroplanes.

4.1 Traffic of yachts

In nautical tourism, 10 to 15 m long yachts make the predominant group of vessels. Yachts of this size represent two thirds of the overall number of vessels. The sail boats and power boats equally contribute to these figures.

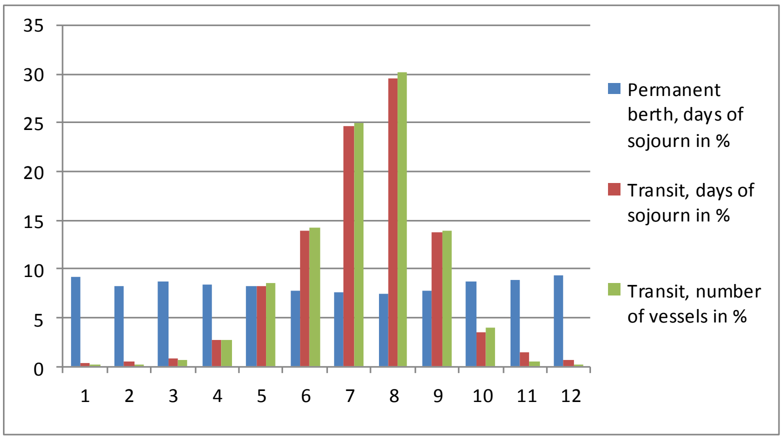


Figure 2: Monthly dynamics (%) of the number of vessels and their sojourn days in the ports of nautical tourism in 2013

The traffic of yachts has some specific features. For instance, except for professionally crewed large yachts, such vessels usually do not navigate at night. During night, most of these vessels remain in marinas, ports, anchorages or other shelters. Of all accommodation options, staying in marinas is their most frequent preference. They usually leave marinas early in the morning and enter them late in the afternoon. The average daily navigation of yachts rarely exceeds several hours. High performance power boats spend even less time at sea. However, they travel at higher speeds. The densest yacht traffic occurs during summer season. Their traffic features (data referring to speed and duration of navigation) is almost impossible to analyse due to the variety of navigation speeds and destinations (marinas, anchorages, large and small ports, bays and coves, etc.).

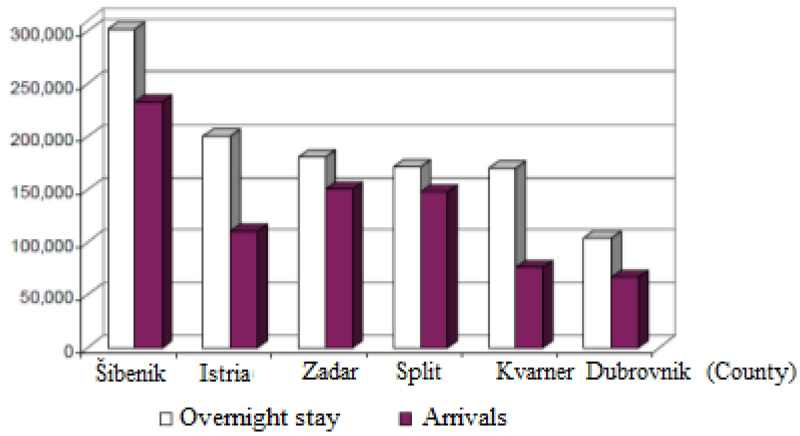


Figure 3: Traffic of boaters by Croatia's regions in 2004, according to the Study of development of nautical tourism in the Republic of Croatia (2006)

*In 2004, in the Republic of Croatia there were 198124 vessels in transit and 11598 at permanent sea berths (In 2013, there were 177254 vessels in transit and 11605 at permanent sea berths).

4.2 Traffic of boats

One of the inherent characteristics of boat traffic is that these vessels rarely leave the area of their registration, so that the data on boat number present a rather accurate portrayal of the area in which the boats move.

Table 6: Number of boats registered at Harbor master's offices in Croatia's central Adriatic

Boats in central Adriatic – Split area	
Fishing boats	151
Trawlers	139
Purse seiners	12
Commercial boats	3641
Trawlers	35
Purse seiners	29
Others	1485
Boats for particular needs	20090
Boats – total	22969
Yachts	736
Commercial yachts	674
Yachts for personal needs	62

Source: Traffic-Navigation Study of Split, Ploče and Dubrovnik sailing areas, Rijeka 2014.

Boats predominantly sail close inshore during daylight and are mainly used for sports and recreational fishing activities and for entertainment in summer months. The effect of boats – particularly the privately owned ones – on the safety of navigation is irrelevant from the statistical viewpoint. Their impact can be discussed from the aspect of their safety but from the aspect of the maritime traffic modelling. As the nautical tourism industry has been steadily growing over the years, it can be expected that the number of yachts and boats engaged in nautical tourism will gradually rise and so will the intensity of sea traffic immediately before and after the main tourist season. The intensity of inshore traffic is not likely to grow during winter. It is expected that the traffic on the Adriatic's major navigation routes running towards northern ports will remain unchanged in the terms of quantity and characteristics. On the other hand, in the near future there may be an increase in traffic of new types of vessels such as hydroplanes, vessels designed for underwater tourist trips, vessels supplying the diving teams, etc.

5 IMPLEMENTATION OF THE BLUE FLAG CRITERIA IN CROATIAN MARINAS

An important instrument in promotion of sustainable development of nautical tourism is the Blue Flag. It is granted to the marinas and beaches that meet the criteria of ecological quality. The criteria include continuing care for the environment by the owner of a concession, personnel training aimed at environment preservation, informing the public on environment condition, safety and services provided on beaches and in marinas, and environment management in compliance with basic ecological principles. Nowadays, the Blue Flag is globally recognised and represents one of the most important factors for choosing a nautical destination.

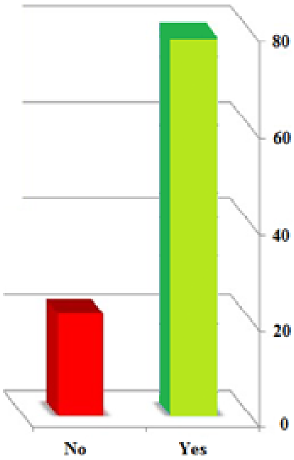


Figure 4: Marina visitors' awareness, according to 2013 statistics: Have you ever heard for the Blue Flag?

Source: http://www.lijepa-nasa.hr/images/datoteke/pz2013_bilten_4.pdf

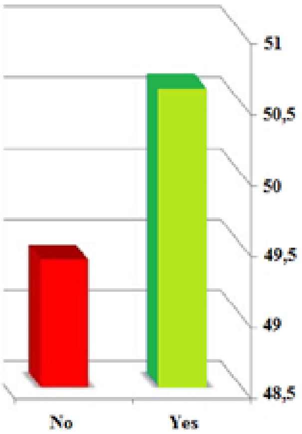


Figure 5: Survey on the importance of the Blue Flag in nautical tourism: Has the Blue Flag affected your choice of destination for vacation?

Source: http://www.lijepa-nasa.hr/images/datoteke/pz2013_bilten_4.pdf

Entitled to a Blue Flag are the marinas that have pontoons or piers for accommodating boats and yachts, as well as all other relevant facilities, including properly designed systems of sewage and drains, systems for dealing with solid and fluid waste, etc. The marinas have to be accessible to inspection and there must be a designated person in charge in each marina flying the Blue Flag. A marina may form a part of a larger port engaged in other activities, but only under the condition that the Blue Flag area is clearly separated from the port's activities.

The Blue Flag is granted for a period of one year. During that period the marinas and beaches are audited by Blue Flag inspectors. At the end of the season, an analysis of the implementation of the relevant Blue Flag criteria is made. These criteria are divided into four groups: 1. Personnel training aimed at environment preservation and informing the public on environment condition, 2. Water quality, 3. Environment management in compliance with basic ecological principles, 4. Safety and services. [29]

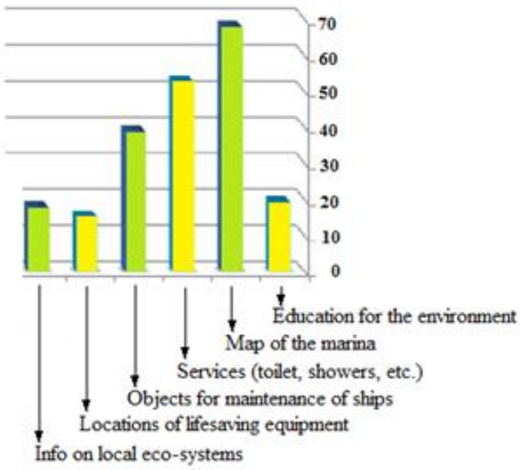


Figure 6: Type of information searched by marina customers, according to the survey conducted in 2013: What information were you looking for at the notice board?

Source: http://www.lijepa-nasa.hr/images/datoteke/pz2013_bilten_4.pdf

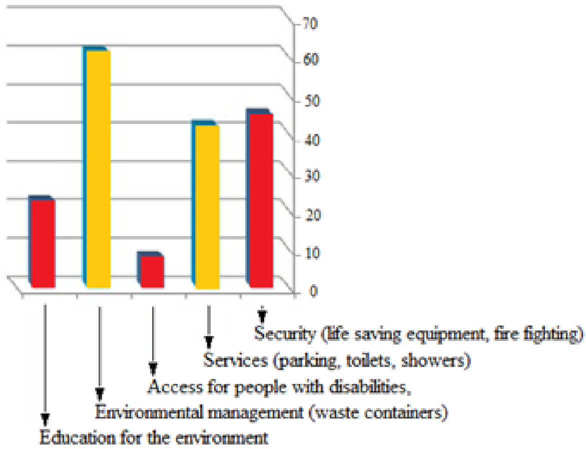


Figure 7: Importance of the Blue Flag, according to the respondents surveyed at Croatia's marinas and beaches in 2013: What does the Blue Flag mean to you?

Source: http://www.lijepa-nasa.hr/images/datoteke/pz2013_bilten_4.pdf

According to the statistics performed in 2013, there were 128 inspections of the beaches and marinas. The major identified imperfections included insufficient information on nearby environmentally sensitive areas, lack of training and education aimed at environment preservation, lack of information on the bathing water quality and insufficient information on the individual Blue Flag. However, according to the data gathered in 2014, there were 135 inspections. Most of the beaches and marinas had but minor difficulties in meeting the Blue Flag criteria (36%), while as many as 16% of the marinas and beaches had major problems in complying with the standards. According to the Blue Flag Survey which was conducted at Croatia's marinas and beaches in 2013, 39% of the respondents stated that they were spending holidays with their families, whereas 35% of them were with their partners. The questionnaire was completed by 101 marina customers, of which 54 men and 47 women. The share of foreigners was around 75.3%, mostly aged 25-44 (40.6%), and 45-64 (37.6%).

6 CONCLUSION

Marinas have a very important role in nautical tourism and are characterized by a high proportion of investment per unit of capacity. In the last few decades marine tourism is experiencing a large expansion. Split-Dalmatian County has great potential for development of nautical tourism. This potential should be recognized for the purpose of creating identity in nautical tourism offer. The development of nautical tourism in the world is going through a phase of expansion, and the production of boats for sport and tourism is rapidly growing. The development of nautical tourism in Croatia lies on a natural basis, where the Adriatic Sea with his indented coast, natural values, specific landscapes and biological diversity is the most attractive area for nautical tourists. As for the traffic, in Split-Dalmatian County the main navigational routes are directed to the port of Split, and international routes are mainly stretched through the edges of the county. Some areas of increased danger for navigation may occur because of navigational obstacles, weather conditions and intense traffic. Such areas of increased danger for navigation within the Split-Dalmatia County are: Splitska vrata, Drvenički kanal, Šoltanski kanal, Pakleni otoci i Pakleni kanal, entrance to city port, access to larger county ports, Vis Channel, an area outside the edge of the island and the area of navigation for hydro-planes. In nautical tourism the largest group of yachts are those from 10 to 15 meters. The yachts of such lengths are representing two-thirds of the total vessels, and the yacht traffic is most in the summer season, and their movement (daily navigation and speed) is almost impossible to reliably process. The problem is that the speeds of such vessels are various and destinations are numerous (marinas, anchorages, ports, harbours, bays, etc.). The small boats traffic is characteristic in a way that they rarely leave the area in which they are registered and therefore numbers data of small boats give a fairly good picture of the areas in which they move. Traffic of small boats is occurring only during the day along the coast and they are mainly used for sports and recreational fishing and entertainment during the summer months. Their impact on the safety of navigation is statistically very small, especially privately owned boats. Given the increase in nautical tourism, we can expect a gradual increase in the number of yachts and boats intended for nautical tourism, the greater the intensity of navigation in the period immediately before and after the peak tourist season. The intensity of coastal traffic during the winter period will not change. In marinas the Blue Flag is very important, because they are given to beaches and marinas that meet strict environmental criteria at the initiative of the European Union. According to the research, the biggest shortcomings in marinas make the lack of information on the nearby natural sensitive areas, lack of education activities for the environment, the lack of information on the sanitary quality of bathing water and the lack of information on the Individual Blue Flag. These things need to change, because the Blue Flag is a certification of sea protection and marine environment and thus raises the quality of nautical tourism in Croatia.

REFERENCES

[1] Croatian Bureau of Statistics (2014). Nautical Tourism Capacity and Turnover of Ports, 2013, Zagreb, ISSN 1330-0350

[2] Institute of Tourism(2014). Plan of Institute for Tourism in 2014., Zagreb

[3] Kirinčić, J.(1991). Luke i terminali, Školska knjiga, Zagreb.

[4] Luković. T, Bilić. M (2007). The Ports of Nautical Tourism in Croatia and Strategy of Local Development, Naše more 54(3-4), Review

[5] Luković. T.(2007) Nautical Tourism – Definitions and Dilemmas, "Naše more" 54(1-2), Preliminary communication

[6] Luković. T (2007). Nautički turizam, definiranje i razvrstavanje. Ekonomski pregled N, 58 (11) 689-708, JEL Classification L83, Pregledni rad.

[7] Strategija razvoja nautičkog turizma Republike Hrvatske za razdoblje 2009.-2019. (2008). Ministarstvo pomorstva, prometa i infrastrukture, Zagreb.

[8] Traffic - Navigation study in navigable areas of Split, Ploče and Dubrovnik (2014). University of Rijeka, Rijeka.

[9] Zelenika. R, Vidučić. V (2007). Model razvitka nautičkog turizma u Republici Hrvatskoj do godine 2015. Zagreb (9-10), 522-544, Ekonomski pregled.

[10] http://www.lijepa-nasa.hr/images/datoteke/pz2013_bilten_4.pdf

[11] http://www.kaiseryachting.hr/ponuda/marine_na_jadranu-56.html

[12] http://www.aci-marinas.com/aci_marina/aci-milna/

[13] http://www.aci-marinas.com/aci_marina/aci-palmizana

[14] http://www.aci-marinas.com/aci_marina/?aci_marina=aci-split&lang=hr

[15] http://www.aci-marinas.com/aci_marina/?aci_marina=aci-trogir&lang=hr

[16] http://www.aci-marinas.com/aci_marina/?aci_marina=aci-vrboska&lang=hr

[17] http://www.marina-agana.hr

[18] http://www.marinabaotic.com

[19] http://yacht-charter-croatia.eu/marine/hrvatska/marina-baska-voda

[20] http://www.taxi-zadar.com.hr/marina-frapa/
[21] http://www.ultra-sailing.hr/hr/Charter-baza-Kastela
[22] http://www.hrvatska-charter-jedrenje.com.hr/marina-kremik.html
[23] http://www.marinalav.hr/hr/index.php
[24] http://www.croatiacharter.com/hr/marina-podgora.asp
[25] http://www.ramova.hr
[26] http://www.marinatucepi.com/
[27] http://www.marinavlaska.nl/hrvatski/home/
[28] http://www.croatia-yachting-charter.com/en/Marinas%20in%20Croatia/Marina%20Zirona.aspx
[29] http://www.lijepa-nasa.hr/plava-zastava.html

OPERATIONAL AND CONSTRUCTION PROBLEMS OF THE FIREFIGHTING INSTALATION ON NAVAL VESSELS

Andrzej Grządziela D.Sc.
Bogdan Szturomski D.Sc.
Polish Naval Academy
Smidowicza Str 69, Gdynia, Poland
a.grzadziela@amw.gdynia.pl, b.szturomski@amw.gdynia.pl

ABSTRACT

Fire protection engineering structures is a well-known topic. There are number of publications founded on the theoretical analysis of the combustion process, the causes of the phenomenon, organizational and technical methods to fight fires, processes, training etc. The specificity of warships fire protection primarily due to the reasons for and consequences of the threat posed by a fire crew, cargo and the environment. Due to the tasks, warships are exposed not only to the occurrence a fire characteristic of commercial vessels, ie. the effects of crew negligence, accidents or damage of installations but also to the effects of use enemies weapons. Another argument emphasizes the thematic diversity can be a fire on the submarine, which in addition to the typical submerged hazards associated with fire is exposed to oxygen depletion for the crew and respiratory toxicity of combustion products resulting from the lack of ventilation capabilities. The impact of enemy weapons brings not only a fire hazard but also detonation. Temperatures fires occurring on warships are significantly higher, the rate of propagation of fire is also a greater risk of detonation of warfare agents stored on board.

Key words: Firefighting, organization, operation, construction, naval vessel.

1 INTRODUCTION

Fire protection engineering structures is a well-known topic. It is possible to find many publications on the theoretical analysis of the combustion process, the causes of the phenomenon, organizational and technical methods to fight fires, processes, training etc. The specificity of warships fire protection primarily due to the reasons for and consequences of the threat posed by a fire crew, cargo and the environment .

Warships are exposed not only to the creation of a fire characteristic of commercial vessels, ie. the effects of crew negligence, accidents or damage to offshore marine installations but also to the effects of enemy weapons. Another argument emphasizes the thematic diversity can be a fire on the submarine, which in addition to the typical submerged hazards associated with fire is exposed to oxygen depletion for the crew and respiratory toxicity of combustion products resulting from the lack of ventilation capabilities.

The impact of enemy weapons brings not only a fire hazard but also detonation. Temperatures fires occurring on warships are significantly higher, the rate of propagation of fire is also a greater risk of detonation of munitions stored applies to both the crew and the surrounding marine environment.

2 FIREFIGHTING REGULATIONS

Warships in the world are built according to defense standards, regulations and shipbuilding experience. Principles of design does not require the use of the provisions of SOLAS although the rule is that designers usually use them in some aspects significantly increase the structural requirements. The Polish Navy approved the internal rules for fighting fires and prepared regulations Classification and Construction of Warships. PRS, part V, Fire Protection in 2008 [1]. PRS provisions are not mandatory for shipbuilding, however, during the design process in the field of fire protection systems are widely used. These provisions relate to the following aspects:

- general provisions relating to the scope of applicability,
- structural fire resistance in design-oriented,
- requirements for fire-extinguishing systems,
- requirements for fire detection and fire alarm systems on the ship,
- fire protection of marine spaces,
- requirements for installation and equipment posing a fire hazard to the ship,
- requirements for portable fire-fighting equipment on the ship,
- specific additional requirements for certain types of ships.

Regarding the activities regulated by separate internal regulations of the Navy there are not just a set of rules relating to fire-fighting equipment as well as maintenance and training activities. Currently, firefighting training activity is one of the priority directions of training on Navy vessels. The problem, however, is that most of them are only focused to the fire fighting activities. Currently, other navies extend the three areas performed simultaneously, ie. against fire, medical security and defense of an emergency team cooperation.

3 STRUCTURAL FIRE PROTECTIOS

The main issue is the occurrence of so-called. water and gas-tight bulkheads. They allow the isolation of the individual compartments of the hull ship during a fire. The principle is the use of non-combustible materials indoors or slowly spreading flames. In the case of living spaces is permitted to use combustible materials with the heat of combustion Q does not exceed the value of 45 MJ / m^2. These calculations are performed using the following formula [1]:

$$Q = Q_s \cdot \rho \cdot s, \ [{}^{MJ}/_{m^2}] \tag{1}$$

where:

Q - heat of combustion for the thickness of the material, [MJ / m^2],

Qs - specific heat of combustion of the material, defined by ISO 1716, [MJ / m^2],

ρ - density of the material, [kg / m^3],

s - material thickness [m].

In addition, depending on the role of compartment regulations specify the maximum mass of combustible material per 1 m^2 of space. The rule is that the premises with an area of less than 50 m^2 no obligation to sprinkler assembly they are equipped with signaling systems only. This rule does not apply to special compartments that affect the life of the ship, its commanding processes or are warehouses of ammunition. For these reasons, the hull design provides three classes fire resist partitions A, B and C, and 14 categories of compartments/spaces.

The size and purpose of the room determines the type and number of fixed fire-extinguishing system used, the number of escape hatches and pop hardware. Particular attention is paid to the premises where are stored fuel, oils, workshops, ammunition compartment and a kitchen. These rooms are equipped with temperature sensors associated with global fire protection system focused on:

- 30^0 C, to start automatic ventilation system in order to lower the temperature in the room,
- 50^0 C, to start the automatic sprinkler wall of the room,
- 70^0 C, to start the automatic sprinkler horizontal surfaces of the room.

It should be noted that if the installation does not flood the whole capacity of the room within 30 minutes the room should be equipped with an additional installation of the flooding. In terms of design attaches important role also for the construction and used materials for doors, hatches, stairs, ladders and escape scuttles.

4 FIRE SYSTEMS

Marine fire protection can be divided into stationary and portable. Fixed installations should comply with the requirement of constant readiness for use. The basic installation of fire on the ships is due to the fire main installation is not inexhaustible supply of extinguishing agent which is seawater. Installation is internally divided into hydrates, which works by using a hose-usually on the open deck and sprinkler system, which protects the interior spaces - Figure 1.

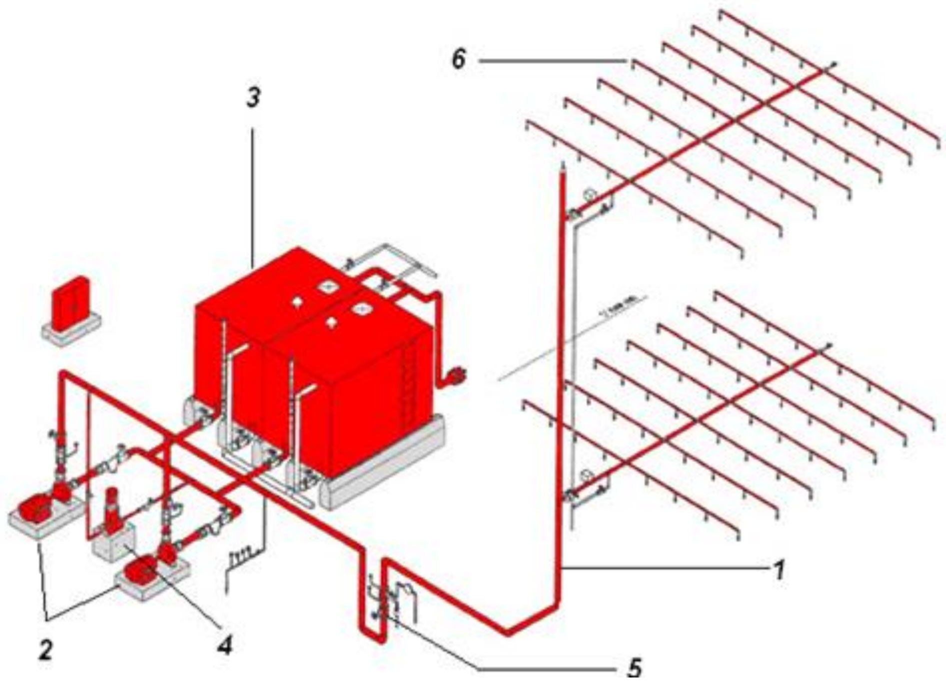


Figure 1: Sea water sprikler installation, where: 1 water main, 2 feed pumps, 3 - intermediate tank, 4 - pump, 5 - automatic valves, 6 - sprinkler network [2]

Source: http://www.supo.com.p

Depending on the size of the ship in the selected expense pressure water pumps and their distribution in the hull whereas the principle of redundancy system. Pumps obviously must satisfy the condition self-sucking and one of them acts as a principal and another emergency. The rule is that one of the pumps should have an independent power supply to the emergency pump flow cannot be less than 25 m^3 per hour, regardless of the type of ship. Also the distribution of water pipes should have a ring structure with the piping on both sides should be symmetrically arranged above and below the waterline. Selection diameter pipelines, hydrants and fire hoses should allow mutual supply in the event of fire from land to ship or ship to shore fire-extinguishing system.

Sprinkler system should be in permanent readiness to run without the crew. The installation is divided into sections, each of which should not be more than 200 sprinklers. Installation of automatic operation can be carried out by independent temperature sensors or sensors integrated into the sprinkler - Figure 2.

Figure 2: Sprinkler nozzles so. automatic sprinkler [2, 3]

Sources: http://www.supo.com.pl, http://www.fire-fighter.pl

Operation of the system should be accompanied by a system of visual and acoustic alarm and the selection of sprinklers should take into account the condition that the water flow from one of the sprinkler not be less than 5 dm^3/min per area of 1 m^2 (24 dm^3/min per 1 m^2 ammunitions chambers).

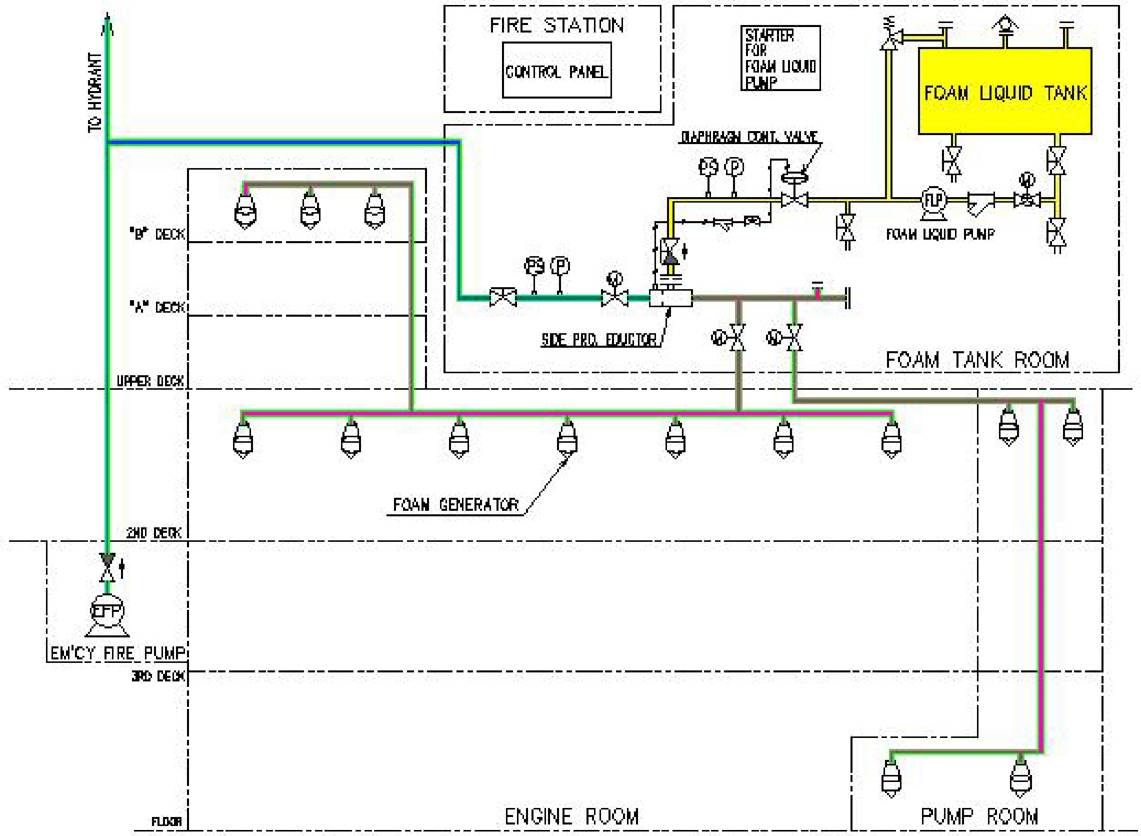


Figure 3: Diagram of foam system [4]

Source: http://www.langemachinery.com

Fire foam systems have become for many years the standard equipment of naval vessels. Their main purpose is to ensure fire safety in machinery spaces of ships. Extinguishing foam is usually heavy type and difficult for the calculation but it is accept that the installation should have a minimum productivity of 5 dm^3 / min per 1 m^2 of surface area covered by the fire during the operation of not less than 5 minutes. Diagram of a typical foam system is shown in Figure 3. Sometimes a high expansion foam system wherein the condition of its applicability is less than the number of foam 1000. These systems are also used to secure the helicopter landing sites, the requirement of a minimum volume of the tank of 0,4 m^3, and depending on the category landing H1 ..H3 expense of from 250 to 800 dm^3/min.

Due to the possibility of a very rapid spread of fire inside the ship and taking into account the structural conditions compartments are commonly used in marine CO2 extinguishing systems. Load weight of carbon dioxide for protected spaces is calculated using the following formula:

$$G = 1{,}79 \cdot V \cdot \varphi, \ [kg] \qquad (2)$$

where:

V - volume of the protected space, [m^3]

φ - the filling factor, [kg/m^3]

φ = 0.3 for cargo spaces,

φ = 0.35 for the machinery which adopted the gross volume including the volume of wells,

φ = 0.4 for the machinery which adopted the gross volume without taking into account the volume of wells].

An additional requirement is that the installation has fulfilled 85% of the volume of the space protected for time 2 minutes for machinery spaces and for other compartments in the course 10 minutes. Starting station of carbon dioxide can be implemented in automatic or remote option. Due to the safety of the crew, which may be in the range normally protected remote control installation is a decision about its use shall commander of the ship after confirmation of information about the crew evacuation from the affected compartment. This procedure does not apply to submarines where good not threaten the life of the crew and the ship safety is a priority task. View of the ship's CO_2 station is shown in Figure 4.

Figure 4: Diagram of CO_2 system [5]

Source: http://www.freepatentsonline.com

Depending on the size of the ship powder systems can be installed as a stationary or portable. The rule is that the powder was a carrier of an inert gas, but often you can meet power systems with compressed air for technical purposes. In the shipbuilding industry rule of thumb is to plant powder provide continuous operation for 45 seconds at the expense of 3.5 kg/s and a powder-range penalty of not less than 8 meters. Firefighting positions in machinery spaces are normally higher requirements for standard ready to run no longer than 30 seconds. All fire-extinguishing systems, stationary and portable, are subject to periodical, military supervision.

5 FIRE TRAINNIG SYSTEMS

The ship's crew A fire fighting trainer is now a three-stage, ie .:

- Theoretical training,
- Practical training at the training ground fire - Figure 5,
- Practical training during whole vessels exercises.

Figure 5: Training on the firefighting range [8]

Source: http://morska.edu.pl/szkola/baza-dydaktyczna/poligony/poligon-pozarowy

Theoretical training is typical, and refers to the fight against fire and risks of detonation. The training program on the fire range is the most common two-*level* and includes such issues as:

- theory of the fire formation - the fire triangle,
- sources of ignition and fire hazard,
- characteristics of combustible materials,
- causes of fires on the ship,
- fire detection,
- construction, use and distribution of fire-fighting equipment,
- construction and operation of stationary fire installation,
- combat organization fighting a fire on the ship,
- extinguishing agents.

The training program also includes practical exercises on the training ground from the scope of fire extinguishing small fires extinguishers (CO_2 snow, light powder and water), expand and collapse and linking of fire hose and nozzles, water currents workout - compact and diffuse currents and the use of foam - hard, medium and light. On the model of the ship performs the task in a smoky room with breathing apparatus and evacuation dummy. All exercises are meant to training of practical habits, to test the degree of acquired knowledge and the identification of people with claustrophobia or other psychophysical deviations preventing them from serving on ships.

Simultaneously with the process of training of crews marine research and development centers carry out research for the implementation of new, innovative technologies. Institution are focused on automation and robotics. The first area of research is the identification systems indoors fire source and then automatically directing high pressure multi-directional flow of firefighting. Such action should identify and eliminate fire from the identification of the thermal system of supervision no later than 3 seconds. The second area studies is focused on the use of fire-fighting robots - Figure 6.

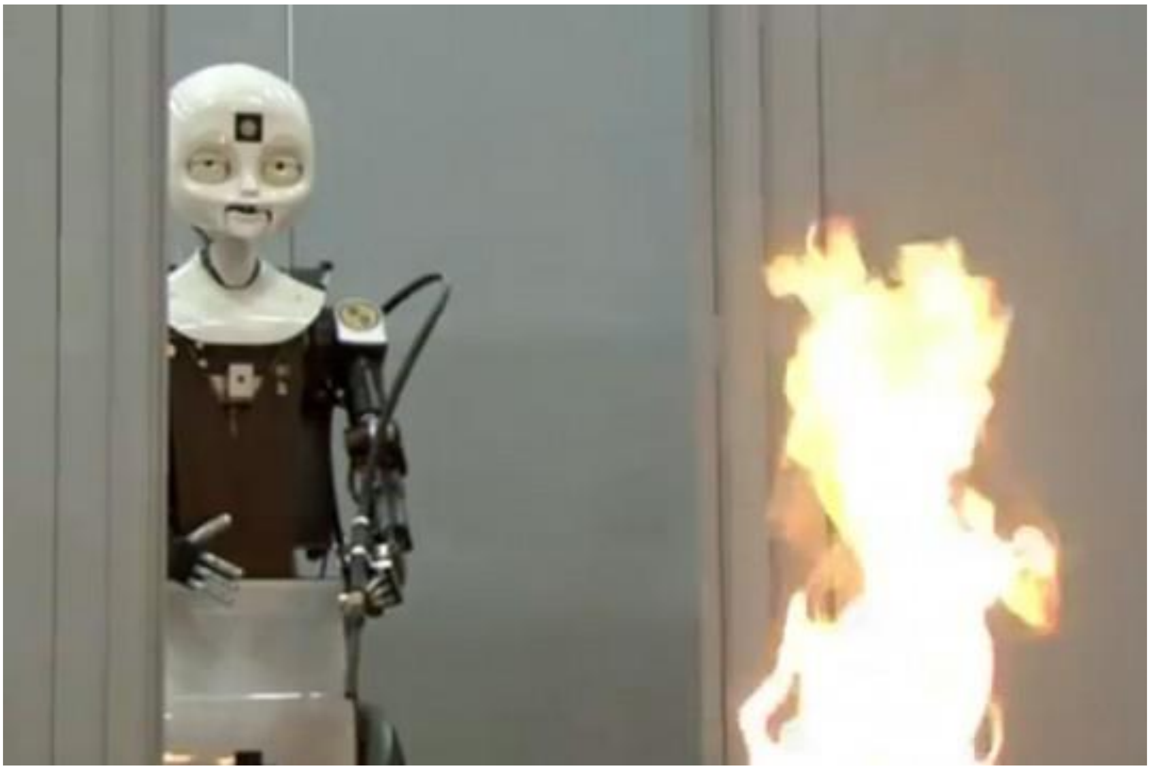


Figure 6: Example firefighting robot during the simulation studies [6]

Source: http://morska.edu.pl/szkola/baza-dydaktyczna/poligony/poligon-pozarowy

The task of the robot is to be to identify the source of the fire and its self-extinguishing system using a portable fire extinguisher. Such works were to be applied mainly on ships where there is risk of the chemical or radioactive contamination.

6 CONCLUSIONS

Constructional safety issues warships are multithreaded and include areas of materials engineering, construction and operation of machinery, shipbuilding, automation, control systems and even robotics. The correctness of fire-resistant construction is essentially the result of not only fulfillment of the standards and regulations but also the imagination of designers and consultants with great maritime experience. All the "shortcuts" in the form of savings on materials, redundant systems, etc. usually bring disgrace of the design office or death of crew members. Ship equipment intelligent fire alarm systems are standard and not the unnecessary gadget. The real problem is only the cost of installation in the military version, which requires adequate resistance to impact shock loads.

Regardless of the degree of automation and robotics it should be emphasized that man is most likely to cause a fire occurs as the fact that man is the most effective factor in his extinguish the fire. This is the reason that fire training combined with medical training are the most desirable from the point of view of safety.

REFERENCES

[1] Przepisy Klasyfikacji i Budowy Okrętów Wojennych. PRS, część V, Ochrona przeciwpożarowa, Gdańsk 2008

[2] http://www.supo.com.pl

[3] http://www.fire-fighter.pl

[4] http://www.langemachinery.com

[5] http://www.freepatentsonline.com

[6] http://inhabitat.com/firefighters-might-soon-be-fighting-blazes-with-electrical-wands

[7] http://www.novencogroup.com

[8] http://morska.edu.pl/szkola/baza-dydaktyczna/poligony/poligon-pozarowy

STOCHASTIC MODEL OF SHIPS TRAFFIC AS A TOOL OF WATERWAY DESIGN IN RESPECT TO DIFFERENT TRAFFIC SOLUTIONS IN ŚWINOUNJŚCIE – SZCZECIN WATERWAY

Lucjan Gucma, PhD.
Andrzej Bąk, PhD.
Maritime University of Szczecin
Wały Chrobrego 1-2, 70-500 Szczecin, Poland
l.gucma@am.szczecin.pl

ABSTRACT

The paper presents stages of stochastic ships traffic stream model creation which was applied for optimization of different solutions of Świnoujście-Szczecin waterway design. The model is based on Monte Carlo methodology and is microscopic which means that each ship's model is treated as separate object possessing given attributes. The main output from the model is sum of delay time of waiting ships and distribution of ships queue. Two alternative waterway traffic solutions with different passing places for ships were analysed in this study and compared with each other. The model was used for the first time for optimization of modernized Szczecin-Świnoujście waterway in respect of two different solutions of passing places for ships.

Key words: Ship traffic stream model, waterway capacity, ship intensity.

1 INTRODUCTION AND STATE OF THE ART

The increase of traffic in port area demands new tools for traffic optimization assessment of different marine traffic engineering solutions and developing traffic control methods needs especially within VTS. The analytical models used for capacity estimation are based on ship domain theory are static and does not reflect stochastic nature of ships traffic process. To overcome this stochastic models are created [Groenveld&Hoek 2000]. Some models of capacity take into consideration alternative passing [Bačkalić&Škiljaica, 1998]. Model for traffic optimization with use of discrete optimization for Kiel Canal have been developed by [Mohring et all. 2005] Several models have been developed with use queue theory [Mou et all 2005] and cellular automata [Feng 2013]. Usually domain models are applied [Zhou H. et all 2013] where domain is defined as area where navigator intentionally keep free from the other ships.

Usually two criterions are applied for assessing marine traffic systems in scope of traffic streams parameters:

1. time of ships delay and its distribution;
2. mean queue of ships waiting with its distribution.

It is much easier to draw conclusions from model researches when the relative measures are applied like in this study where two alternatives were compared. In presented researches the area of Świnoujście-Szczecin waterway (fig. 1) is analysed and two alternatives of modernisation are compared.

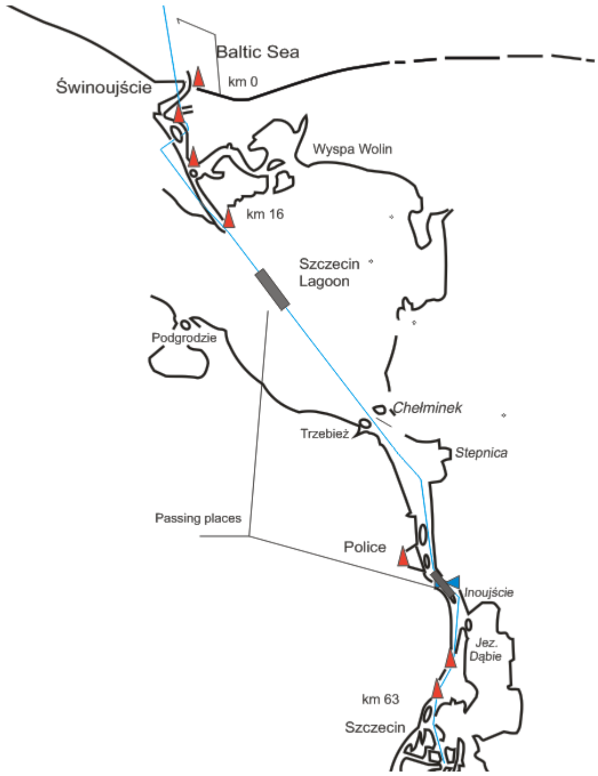


Figure 1: Layout of Świnoujście-Szczecin waterway with planned passing places for Alternative II and localisations of VTS radar stations

2 MICROSCOPIC STOCHASTIC MODEL OF SHIPS TRAFFIC

The created simulation model of ships traffic on the waterway for need of presented study has following features:

1. is microscopic, that means that every ship is considered separately as an object;
2. is domain based (the distances of following ships are based on ships domain theory);
3. is stochastic, where some parameters like ships generators, ship length, draught, speed are modelled as random variables generated from its distributions mostly by Monte Carlo principle;
4. is one dimensional – the movement of ships is modelled in one dimension only (along the waterway);
5. is kinematic – the ships are modelled as line interval (of length L) moving with uniform speed along the given section of waterway, speed changes (if any) are immediate.

The main algorithm of the model is presented in fig. 2. The model has several outputs, where the main are as follows:

1. time of delay in respect to ideal situation without delays,
2. queue parameters in respect to ship categories and number of ships waiting,
3. passing and overtaking points with the ships categories.

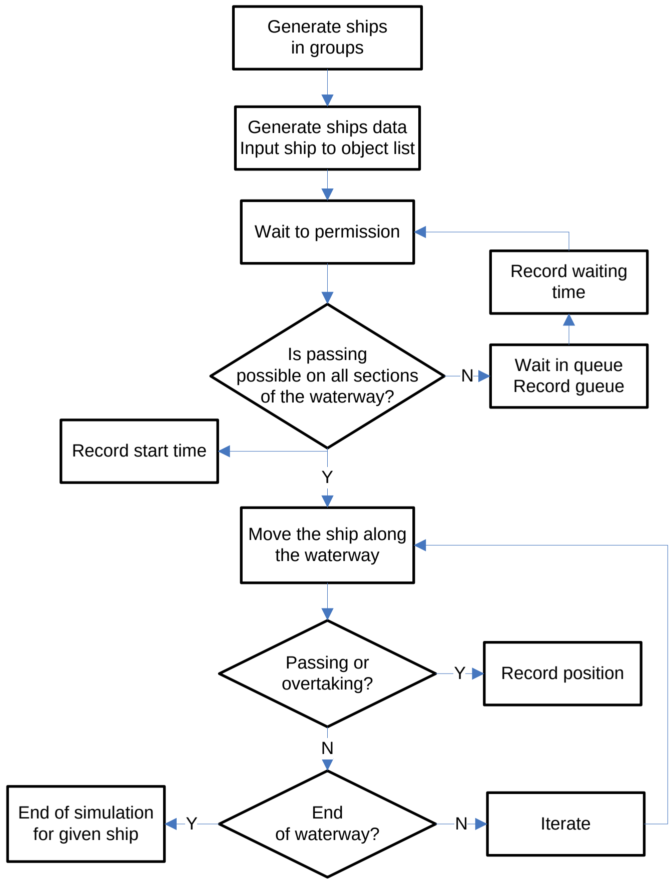


Figure 2: Stochastic microscopic simulation model of ships traffic in Świnoujście-Szczecin waterway

The model is written in Object Pascal language and *Lazarus* compiler distributed by Open GPL licence Model has very simplify graphical interface the data are stored in text files.

The verification of internal consistence and errorless of the model was done on the simplify properly chosen input data.

2.1 Dynamic domain approach

The ship domain dimensions on such very narrow waterways when the port regulation are playing major role are dependant of the section of the waterway (x). The length of domain $D_L(x)$ could be defined as (fig. 3):

$$D_L(x) = L + D_F(x) + D_A(x) + \delta_L \quad (1)$$

where:

L – ships length,
$D_F(x)$ – domain length forward (from zero to minimal following distance),
$D_A(x)$ – domain length aft (assumed as 0),
δ_L – domain variability.

Similar formula can be used for width $D_B(x)$ of ships domain:

$$D_B(x) = B + D_S(x) + D_P(x) + \delta_B \qquad (2)$$

where:

B– ships length,
$D_s(x)$ – domain width port,
$D_p(x)$ – domain width starboard,
δ_B – domain variability.

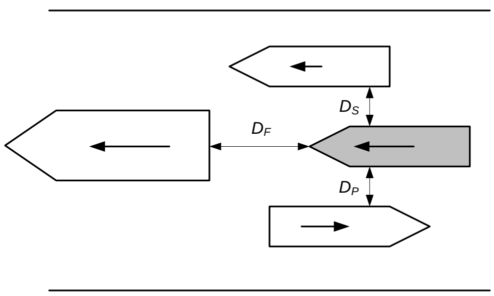


Figure 3: Ships domain parameters in narrow waterway

In presented study when 1-dimensional model is applied the $D_B(x)$ could be defined as two state variable: $D_B(x) = \{o(x) = (1{,}0); p(x) = (0{,}1)\}$ where $o(x)$ and $p(x)$ are logical variables defining if passing or overtaking of given ships is permitted on given section of waterway (0-passing/overtaking possible, 1-passing/overtaking prohibited).

Navigator has very limited influence to adjust the length of domain on the aft (D_A) and the following ships adjust this domain size according to ship dimensions, port regulations and intentions, so it is set to zero. The dependence of domain dimensions of x is the reason of variability of waterway sections and regulations inside the sections and ships speed variability in given sections. The domain variability (error) is changed according to navigators behaviour. It is possible to model the risky, conservative behaviour or violating the regulations. This effect was neglected in this study.

The most important dimension of domain in this study is D_F. The length before the ship which navigator intend to keep free is important when one ship follows the other due to overtaking prohibition. This distance is set by regulations or by navigator itself, taking into account possibility of accidental stopping of the own ship. The accidental stopping in narrow waterway is usually made by so called step-manoeuvre which depends of ships manoeuvring characteristics. The step-manoeuvre is usually performed in steps changing set to engine in order to avoid grounding of own ship. Usually in the first phase of step-manoeuvre the “Full Astern” is set on engine then when ship start to considerably change her course (usually to starboard) the speed telegraph is set to “Stop” and rudder is set to “hard to port” (or starboard depending on the ships reverse turning ability). Then the procedure is repeated. In the last step usually the anchor is dropped when it is possible. Study on step manoeuvres have been carried in [Report 1980] for different ships size, passing the waterway with different speeds and setting on engine (fig.4). In presented study the dimension of domain D_F has been set on the base of stoping distance (fig.3) as D_F=$Sd(Hah, DWT)$.

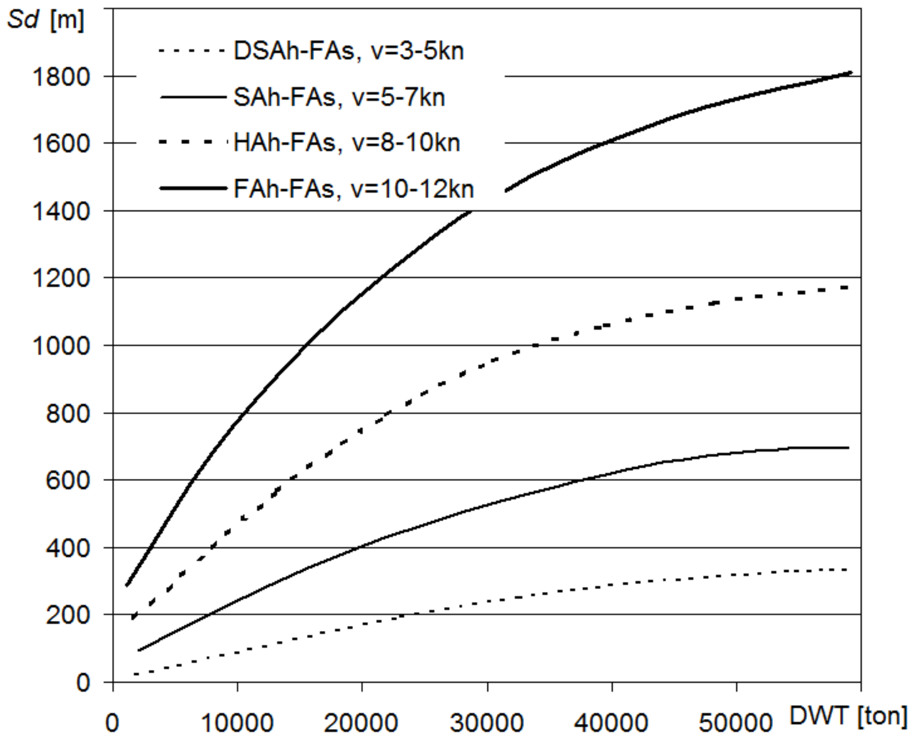


Figure 4: Stopping distance (*Sd*) in case of accident of followed-by ship in step-manoeuvre through narrow waterway for general cargo ships (based on results of [Report 1980])

Due to model level of abstraction some approximations and conditions have been applied to the model divided in following groups:

A. Ships generators

The model used ships generated by the Poisson distribution in 9 groups with given intensities. The Poisson model is adequate and how good statistical consistence for under-critical intensities such as exist in analysed waterway [Kasyk 2014, Gucma&Schefs 2007]. Computer Poisson generator used in this study was created on the basis of [Zieliński&Wieczorkowski 1997]. Length of ships in groups were generated by uniform distribution with parameters: [L_{max}, L_{min}]. Speed of ships was generated by normal right side cut distribution where cutting distance was set as maximum regulation speed in given section. Extended studies over the speed distribution in this area was done by author in this area [Gucma&Schefs 2007]. The same intensities has been set to inbound and outbound ships (the choose of direction by ship was modelled by Bernoulli distribution). Main elements of the algorithm of the model are 3 loops realized by computer programme in different time intervals:

1. The loop of ships generation and the recording of their main parameters (time interval =1h);
2. The loop of the updating of the position of ships and the record of their passage (time interval =1min);
3. The decision loop of the check of the possibility of letting in ships on the waterway or to the queue (time interval =10min).

B. Waterway characteristics

Described by *n* sections, defined by (X_i, X_{i+1}), each contain width of waterway, admissible speed, and matrix of passing/overtaking possibility as boolean matrix of dimension 5x5 (i.e. number of ships in classes).

C. Traffic control measures

Traffic control is mostly neglected in this study except keeping the ships in queue in case the waterway is busy. In practical situation sometimes the speed reduction is applied as traffic control measure by VTS operators.

3 PRACTICAL APPLICATION OF CREATED TRAFFIC MODEL FOR ASSESSING TWO ALTERNATIVES OF ŚWINOUJŚCIE-SZCZECIN WATERWAY MODERNISATION

The planned modernisation from 16km to 63km (so called project "12.5m") of waterway from Świnouście to Szczecin will cover:

1. deepening the depth from 10.5 to 12.5 (max ship draught from 9.15m to 10.5m);
2. widening the waterway depending of the area for two different alternatives I and II (fig. 4.);

For the traffic modelling purpose the ships was divided on 9 types and 5 classes (tab.1). The possibility of ships passing and overtaking is depended of the width of waterway and was different for given section in Alternative I (14 sections) and Alternative II (16 sections).

Table 1: Applied division of ships in Świnoujście-Szczecin waterway

Class/Type	Name	L [m]	B [m]	T [m]
I **Very large ships**				
1	Cruiser	200-260	28.0-33.0	7.0-9.0
2	Container	180-240	28.0-32.3	9.0-11.0
3	Bulk	180-220	26.0-32.3	9. 0-11.0
II **Large ships**				
4	Cruiser	140-200	20.0-28.0	6.0-8.0
5	Container	140-180	20.0-28.0	6.0-9.0
6	Bulk/General	140-180	20.0-26.0	6.0-9.0
III **Medium ships**				
7	All kinds	120 -140	< 20.0	< 8.0
IV **Small ships**				
8	All kinds	< 120 (100-120)	< 18.0	< 7.0 m
V **Very small ships**				
9	All kinds	< 120 (70-100)	< 18.0	< 5.0 m

Alternative I assumes widening the waterway in Szczecin Lagoon to 130m in section from 16,5 km ÷ 41,0 km and allowing for passing the following classes of ships: (3, 4, 5) with (3, 4, 5). Alternative II assumes narrower waterway in this area (100m) but creating long passing place of 250m width on Szczecin Lagoon from 23,8 km ÷ 28,8 km which will allow to passing of ships in following classes: (2, 3, 4, 5) with (1, 2, 3, 4, 5) i.e. only maximal (class 1) with maximal cannot pass each other.

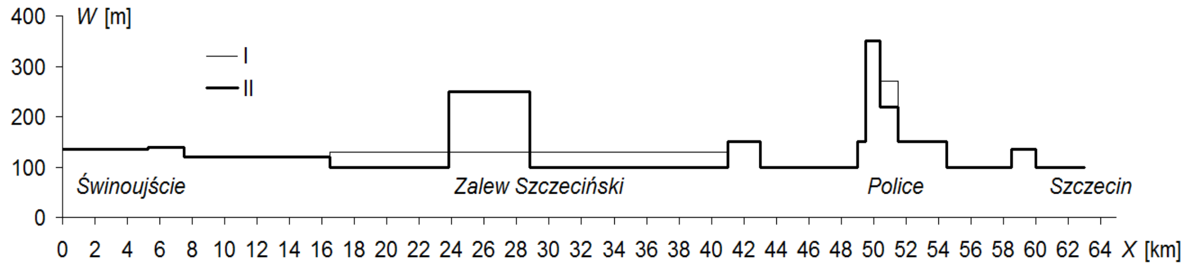


Figure 5: Width of the waterway (*W*) in function of its length (*X*) for two analysed Alternatives I and II

3.1 Determining the future ship traffic intensities in Świnoujście-Szczecin waterway

Port of Szczecin does not show significant dynamics of changes of the ships traffic, which is below 3000 ships entering per year. It is presented in data form Polish Statistical Office [GUS 2013] presented in table 2.

Table 2: Ship traffic in Szczecin and Police ports

Year	Szczecin	Police	Sum
2009	2775	173	2948
2010	3185	349	3534
2011	3084	306	3390
2012	2822	276	3098

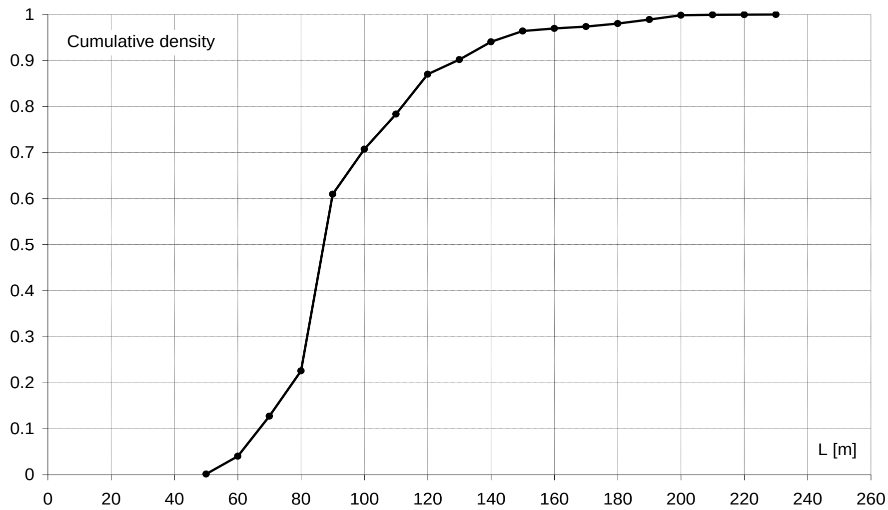


Figure 6: Cumulative distribution of length of ships entering to Szczecin in 2011

Analysis and forecast of ships traffic was done for the so called project "12.5m" based on previous studies [Report 2008] and authors previous works such as [Gucma&Sokołowska 2012]. In 2011 there was 2680 entrances of ships above 50m to Szczecin. The cumulative distribution (tab.2) of its length show very high concentration of ships 80m to 10m (small ships).

On the basis of detailed size groups analyses in 2011 and economic forecasts for container and cruise ships the intensities and yearly dynamic of ships in groups were determined and final forecast intensities for 2021 were applied as input data for traffic model.

Table 3: Forecast of ships traffic in 2021 and intensities for given types of ships Szczecin and Police

Type	Class for waterway	Kind	No of ships in 2011	Yearly dynamic of traffic increase for "12.5m" [%]	Forecast of ships entrance in year 2021	Intensity of ships applied in the study [ship/h]	Double intensity of biggest ships [ships/h]
1	1	Cruise	2	100	20	0.005	0.009
2	1	Cont.	10	25	25	0.006	0.011
3	1	Bulk	60	15	90	0.021	0.041
4	2	Cruise	5	100	50	0.011	0.023
5	2	Cont.	20	30	60	0.014	0.027
6	2	Bulk	181	15	272	0.062	0.124
7	3	General	421	15	632	0.144	0.144
8	4	General	466	15	699	0.160	0.160
9	5	General	1634	15	2451	0.560	0.560
Sum			2799		4298	0.981	1.099

4 RESULTS OF TRAFFIC SIMULATIONS FOR TWO ANALYSED ALTERNATIVES

The simulation researches were carried out in 4 scenarios (2 waterway alternatives in two traffic conditions):

- Alternative I – traffic forecasted on 2021 (tab.2);
- Alternative II – traffic forecasted on 2021;
- Alternative Ix2 - traffic for 2021 with double increased traffic in groups 1 and 2 (sensivity analysis of for biggest ships due to expected passing problems);
- Alternative IIx2 - traffic for 2021 with double increased traffic in groups 1 and 2 (as above);

Duration time of simulations was 365 days (1 year). Single scenario consumes approximately 1min of simulation time for standard PC computer.

The recorded output data from simulation were analysed under several parameters of traffic streams such as:

1. Distribution of ingoing ships queue in classes.
2. Distribution of outgoing ships queue in classes.
3. Time of passage without delays (ideal).
4. Sum of delay time in classes and types.
5. Number of ships generated in classes and types.
6. Mean delay time in classes and ships types.

Table 4 presents results of the annual simulation for forecasted data for the year 2021 for two Alternatives. There are visible differences between time of delay of large ships which are equal approx. 1h more per one ship of 1 class and 0.5h per one ship of class 2.

Table 4: Results of yearly simulations for Alternative I and II for traffic intensity of 2021 year

Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Sum**
Class	1	1	1	2	2	2	3	4	5	
Alternative I										
Time without delay [h]	159	176	704	317	452	1808	3902	4523	13124	
Time with delay [h]	255	349	1310	608	768	3252	6570	5565	15892	
Total ships generated	46	51	204	92	131	525	1132	1313	3806	7300
Sum of delays [h]	97	174	606	291	316	1444	2669	1042	2768	9407
Delay per 1 ship [h]	2.1	3.4	3.0	3.2	2.4	2.8	2.4	0.8	0.7	1.3
Alternative II										
Time without delay [h]	155	155	604	283	424	1756	4030	4454	13317	
Time with delay [h]	275	263	967	453	664	2749	6130	5416	16104	
Total ships generated	45	45	175	82	123	509	1168	1292	3862	7301
Sum of delays [h]	120	107	364	171	239	993	2100	962	2787	7843
Delay per 1 ship [h]	2.7	2.4	2.1	2.1	1.9	2.0	1.8	0.7	0.7	1.1

In table 5 the sensivity analysis is presented where sensivity factor was the influence of largest ship intensity increase (applied double traffic increase). The reason of such approach was the fact that the largest ships are the main waterway blocking factor. It could be observed large influence of large ships especially for the waterway in Alternative I. In compare to the previous results, Alternative II is more robust on increasing large ship intensity in class 1 and 2 because differences are much smaller then primary simulation without traffic increase.

Table 5: Results of yearly simulations for Alternative I and II for traffic intensity of 2021 year and double traffic in ship class 1 and 2

Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Sum**
Class	1	1	1	2	2	2	3	4	5	
Alternative Ix2										
Time without delay [h]	311	335	1180	735	835	3443	4005	4337	13283	
Time with delay [h]	566	616	2416	1402	1403	6292	7037	5603	16943	
Total ships generated	90	97	342	213	242	999	1162	1257	3851	8253
Sum of delays [h]	256	281	1236	667	568	2849	3031	1266	3660	13814
Delay per 1 ship [h]	2.8	2.9	3.6	3.1	2.3	2.9	2.6	1.0	1.0	1.7
Alternative IIx2										
Time without delay [h]	221	293	1194	725	883	3519	3978	4495	13245	
Time with delay [h]	378	505	1965	1206	1453	5880	6231	5603	16668	
Total ships generated	64	85	346	210	256	1022	1154	1304	3839	8280
Sum of delays [h]	158	211	772	481	570	2361	2254	1108	3423	11337
Delay per 1 ship [h]	2.5	2.5	2.2	2.3	2.2	2.3	2.0	0.8	0.9	1.4

Histograms of ships queue length and probability of queue on entrance (at Świnoujście approach) and departure (in Szczecin Port) are presented in fig. 6 (for Alternative I and II) for classes 3, 4 and 5 (ships with highest intensity). In ships of classes 1 and 2 the queues are minimal due to small intensity.

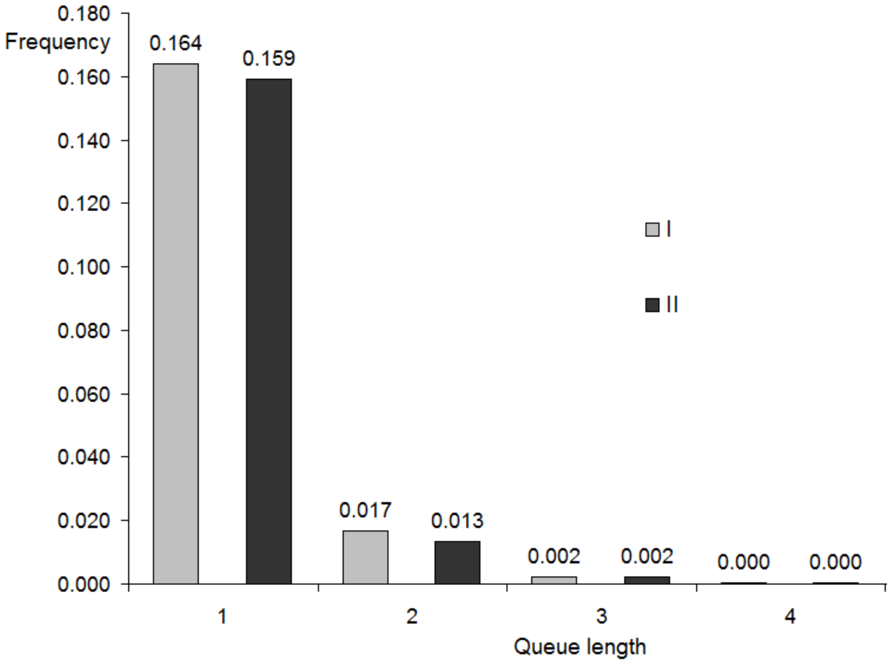


Figure 7: Probability of queue in ships classes 3, 4 and 5 for Alternative I and II

5 CONCLUSIONS

The following conclusions could be drawn from presented studies:

- The created for needs of this study stochastic model of ship traffic flow is stable and its parameters such as queue length and number of ships are stabilising in time for different input data.
- Much better solution in respect of total ships delay is Alternative II. This alternative saves about 65 waiting days per year in compare to Alternative I. Most advantages appear in delays of ships of 2nd and 3rd class where cost of ship delay is highest.
- The sensivity analysis showed that Alternative II is less sensitive for traffic increase in biggest ships group which are the factor of waterway blockage.
- The queue of ships stabilises in time and probability of queue for class 3, 4 and 5 is about 16%. Probability of queue is slightly less in Alternative II. Length of the queue is less then 5 ships for both alternatives.
- The application of intelligent traffic control should optimize the ships traffic parameters in these area.

REFERENCES

[1] Bačkalić T. and Škiljaica V. (1998). Modelling of Vessel Traffic Process in One-Way Straits at Alternating Passing, Proceedings of the "MARIND '98" Bulgaria.

[2] Feng H. (2013). Cellular Automata Ship Traffic Flow Model Considering Integrated Bridge System. International Journal of Service, Science and Technology Vol.6.

[3] Gucma L. & Schefs S. (2007). Studium prędkości statków na torze wodnym Świnoujście-Szczecin: Wydawnictwo AM Szczecin.

[4] Gucma L. & Sokołowska S. (2012) The ships entering to Szczecin port dimensions analysis with over-normative vessels consideration. EXPLO-SHIP 2012.

[5] GUS (2013). Rocznik statystyczny gospodarki morskiej 2013. GUS Warszawa-Szczecin.

[6] Groenveld R. & Hoek C.V.A. (2000). A simulation tool to assess nautical safety in port approaches, Seminar of the Permanent Commission for Development and Cooperation of PIANC, Argentina.

[7] Kasyk L. (2014). Probabilistyczne metody modelowania parametrów strumienia ruchu statków na akwenach ograniczonych: Wydawnicwo AM Szczecin.

[8] Mohring R. et all. (2005). Conflict-free real-time AGV routing. Operations Research Proceedings 2004, Berlin: Springer-Verlag.

[9] Mou. J.M. et all (2005). Research on application of queuing theory in communication engineering, Journal of Wuhan Institute of Shipbuilding Technology.

[10] Report (1980). Zastosowanie naukowych metod określania przepustowości portów morskich dla celów prognostycznych, koncepcyjnych oraz przygotowawczo – inwestycyjnych. Instytut Nawigacji Morskiej Wyższej Szkoły Morskiej w Szczecinie, Szczecin 1980r.

[11] Report (2008). Określanie docelowych bezpiecznych parametrów toru wodnego Świnoujście-Szczecin. Akademia Morska w Szczecinie.

[12] Zhou H. et all (2013). Nanjing Yangtze River Bridge Transit Capacity Based on Queuing Theory 13th COTA International Conference of Transportation Professionals.

[13] Zieliński R. & Wieczorkowski R. (1997). Komputerowe generatory liczb losowych. WNT, Warszawa.

METAL COMPOSITE FOAMS – SELECTED PROPERTIES

Maciej Gucma, PhD
Katarzyna Gawdzińska, PhD
Barbara Kwiecińska, M.Eng
Maritime University of Szczecin
Wały Chrobrego 1-2, 70-500 Szczecin, Poland
m.gucma@am.szczecin.pl, k.gawdzinska@am.szczecin.pl, b.kwiecinska@am.szczecin.pl

ABSTRACT

The Department of Marine Materials Engineering, Maritime University of Szczecin, has carried out research into metal composites technologies, focusing on composite aluminium foams stabilized with ceramic particles. The tested foams were made by the method of gas blowing into liquid metal. The paper presents selected properties of metal composite foams – their strength and high temperature resistance. These material can be used in maritime transport. Shipbuilding is another potential area for a wide use of metal foams. Merchant vessels and warships are objects where powerful machines generate vibrations and noise, radiate huge amounts of heat, some spaces require good thermal insulation, and risk of fire or explosion is relatively high. Besides, electromagnetic waves are generated, while some shipboard instruments have to be protected against electromagnetism. Naturally, whether metal foams will be widely used in ships and to what extent will depend on their price.

Key words: Composite foams, strength and high temperature resistance, maritime transport.

1 INTRODUCTION

Metal foams may be used to reduce consequences of collisions at sea, to reduce consequences of impact and other forms of undesired contact with the quay or pier during berthing, or to minimize effects of exceedingly dynamic interaction of vessel hull in heavy weather conditions (waves, wind). Very high static and dynamic loads occur in the area of the bow, on both forward sides of the hull, the sides in way of the engine room, collision bulkhead and stern bulkhead. Particular attention is always paid to the forward part, as it is more susceptible to hit bottom obstructions, floating objects or the quay.Cellular materials have many unique properties that make them suitable as machine components. Thanks to low density, metal foams are an ideal filler material for layered structures of high rigidity, low thermal conductivity makes them good insulators, while the ability to damp vibration suggests applications as vibration and noise absorbing layers. When under load, foams are liable to substantial deformations, so they are used in systems absorbing impact energy or reducing the effects of explosion. The proper method of making metal foams from pure metals or their alloys leads to a rather restricted scope of changes in foam properties. The range of functional properties of foams and the capability of controlling these properties may be extended by using multiphase materials. These include composite materials made by combining at least two physically and chemically different materials in such a manner that, as per definition [1-4] – "with good mutual connection, there should be a visible boundary between them and the distribution of the reinforcement phase should be possibly homogeneous across the whole volume of the matrix". Metal-ceramic composites, with wide ranges of components, may be used for making foams of specific properties, which, satisfying the principles of material engineering, broaden design opportunities. The Department of Marine Materials Engineering, Maritime University of Szczecin, has carried out research into metal composites technologies, focusing on composite aluminium foams stabilized with ceramic particles. Composite metal foams, thanks to their high thermal insulation capacity, geometric shape stability and different properties can have various usage in many industries.

2 METAL COMPOSITE FOAMS – DESCRIPTION OF THE ISSUE

The blowing of varying amounts of gas into liquid composite may lead to varied effects in the foam making process. Gas moves in the form of bubbles rising to the surface. The bubbles either break and release gas or remain in the metal keeping gas closed by thin layers (walls) of initially liquid, then solidified metal, making up a layer of foam. To produce foam, the created physical and chemical conditions should be such that gas bubbles flowing up to the surface of liquid metal will not be breaking up. The basic parameter that affects physical and chemical properties of the system is the temperature-dependent viscosity of liquid being foamed. When the temperature is lowered, the liquid viscosity increases, which stabilizes bubbles remaining at the boundary of the two phases. By selecting geometrical parameters and those referring to liquid metal properties of the system, and parameters of the injected gas, we can affect the size and distribution of gaseous bubbles (pores in the solid state) in produced foams. The chosen method of foaming a liquid metal broadens the capability of changing properties of the produced foam by varying the foam structure. The ranges of parameters describing the structure depend on physical and chemical properties of the system, technological parameters and the geometry of the foaming device elements. Functional properties of foams result from: type and properties of the material being foamed (metal); spatial geometrical structure, effect of foaming; possibility of modifying the produced metal foam. This is described in a flow chart (Figure 1).

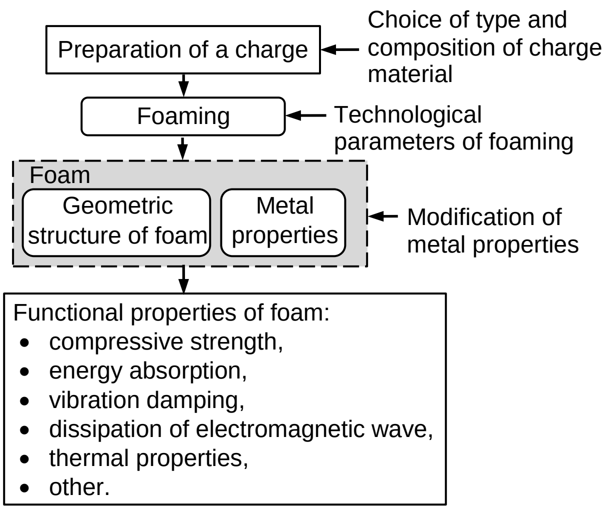


Figure 1: Possibilities of controlling foam properties at various stages of the technological process [2]

The discussed method comprises a wide spectrum of factors that can affect practically functional properties of foams and have an impact on some of their properties – e.g. their strength and high temperature resistance.

3 STRENGTH AND HIGH TEMPERATURE RESISTANCE PROPERTIES OF METAL COMPOSITE FOAMS

Strength researches were made on four types of foam, each made of a different material, denoted, respectively: H – aluminium alloy AlSi9, A, B and C – composite foams with AlSi9 matrix and SiC particles as reinforcement, 15 % by weight, differing in pore size. Three samples were chosen from each group, and the results were averaged. The different size pores are displayed in Figure 2. The tested foams were made by the method of gas blowing into liquid metal [2– 4].

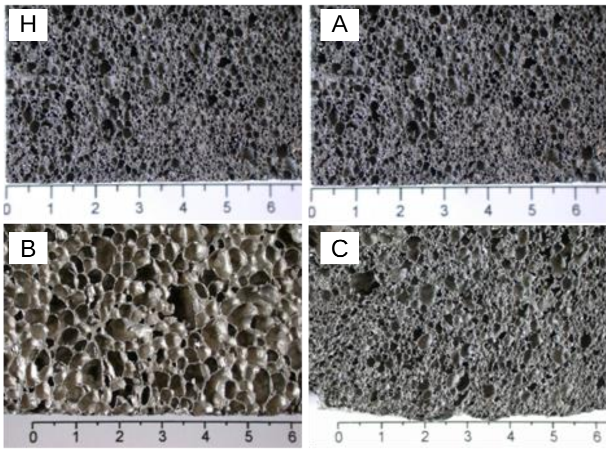


Figure 2: Metal foams with different pore sizes used for tests described in this study (notations explained in the text)

Foam H had a density 0,228 g/cm^3, while the respective densities of the composite foams were as follows: A – 0,455; B – 0,250; C – 0,301 g/cm^3. Assuming the true density of AlSi9 alloy as 2,65 g/cm^3, the density of SiC being 3,21 g/cm^3, we could calculate the true density of composite material of foam: 2,72 g/cm^3. These data allow to calculate apparent densities and porosities of all tested foams. The calculated results are given in Table 1.

Table 1Densities and porosities of the tested materials (metal foam H and metal composite foams A, B, C)

Material	**Apparent density / g/cm^3**	**True density / g/cm^3**	**Relative density / % theoretical**	**Porosity / %**
H	0,228	2,65	8,60	91,60
A	0,455	2,72	16,73	83,27
B	0,250	2,72	9,19	90,81
C	0,301	2,72	11,07	88,93

The foam was tested for static load by axial compression to examine how the geometry of bubbles affects the stress in foamed composite. The tests of cuboidal samples of foams, sized 40 × 40 × 20 **cm** were performed using an H10K-T strength testing machine [4]. The results are shown in Figure 3.

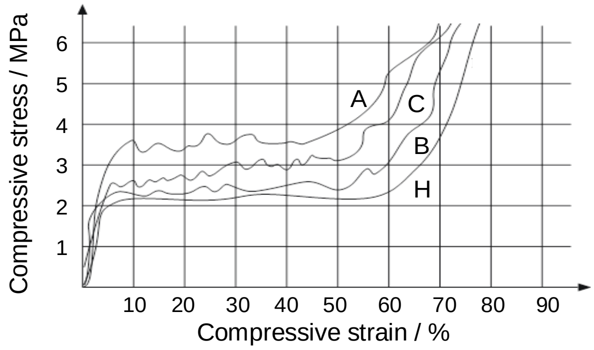


Figure 3: Values of compressive stress dependent on compressive strain for all types of foam: H, A, B, C

The examined samples differed in pore sizes and average porosity, which had to affect the results of strength tests [6]. Nevertheless, analyzing the changes in the strain-stress relationship recorded during the tests of all materials, we can make a qualitative comparison. All curves have a roughly similar shape, in which three stages can be distinguished, related to the progress of destruction of foam microstructures during the test. The first stage represents a single figure percentage of strain, a range in which the strain-stress relation is linear. Then the strain increases up to 50 – 60 %, within which the average stress remains steady or slightly rises. In the final stage, upon reaching a substantial degree of strain, over 60 %, the stress also rises significantly with smaller changes of strain.

This is confirmed by the foregoing considerations and the literature [2– 3]. Values of strain read out from the examined curves in Figure 3 clearly show that the lower total porosity is, the higher stress is necessary for strain to occur. However, another difference can be noticed in how the curves run. In the second stage the curve illustrating the strain of aluminium foam is relatively “smooth”, while those for composite foams have considerable fluctuations of stress. This is most probably due to a retarding effect of inclusions that block the plastic strain in metal, causing a local accumulation of stresses. The amplitude of the fluctuations is related to foam density – the greater the density, the larger fluctuations of stress occur during strain.

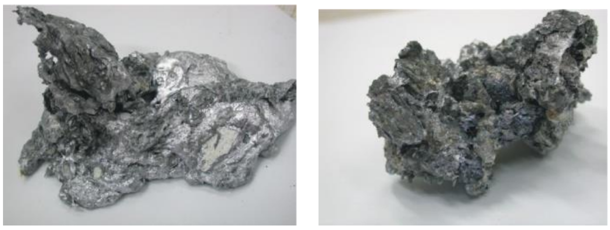
Apart from typical resistance properties making metal foams useful in various engineering areas, fire resistance is an essential factor justifying the use of these materials in shipbuilding. This property means that metallic foams maintain their cellular structure in high temperatures, and do not emit smoke or toxic chemical compounds (organic insulating foams traditionally used in ships emit phosgene and other gases. Metal foams keep their insulating properties even if the humidity of the environment is high. Such properties have been found in composite metal-ceramic foam based on aluminium alloy and carbide or oxide ceramics with specific gravity ranging from 0.25–0.40 g/cm^3.

Initial tests of melting aluminium-based foams and composites with Al-alloy matrix have shown that heating foam samples to a temperature higher than the liquidus temperature of the alloy or composite (even to 1000°C) does not result in obtaining a homogenous liquid metal. The effects were as follows:

- for a foam made of aluminium using titanium hydride the result was a semi-fluid suspension in some places changing into a solid phase with powder consistency (Fig. 4a),

- for a foam obtained by blowing gas into liquid composite with Al-alloy matrix reinforced with SiC grains (15% of metal mass) – the result was that the foam did not change its form (Fig. 4b).

Figure 4 shows samples of the above mentioned foams after annealing them at a temperature of 1000°C. This is an important observation indicating fire resistance of the examined material making it useful in aircraft, passenger ship and other constructions [1].



a) b)

Figure: 4 Samples of aluminium foams (a) and foam made of AlSi7Mg composite + 15% SiC (b) after annealing at a temperature of 1000°C

4 CONCLUSIONS

Pointing out composite metal foams as highly fire resistant materials is also important in view of consequences of a fire aboard ship at sea[5-7]. A fire breakout is considered as particularly dangerous on a passenger vessel whose construction required a lot of finishing materials: wood, fabrics, polymer carpeting etc. Most frequent scenes of fire are engine room spaces, accommodating main engines and generating sets (Fig.5). A risk of explosion also exists in these rooms due to the presence of fuel and lubricating oils. Fire risks in engine rooms are due to many installations with flammable substances, and possibility of uncontrolled temperature increase or sparking in some of engine room machines or devices. Besides, once a fire breaks out, steel walls transfer fire to adjacent spaces, initiating flames through contact heating of flammable insulating materials, or wall covering materials, or cause ignition of objects at a distance through heat radiation. It goes without saying that effective fire protection onboard a ship requires proper thermal insulation of separations, namely bulkheads and decks.

a) b)

Figure 5: Conditions for fire spread: a) through steel bulkheads b) through steel bulkheads with thermal insulation of composite metal foam

ACKNOWLEDGEMENTS

Article has been preaperd under REP SAIL project in ERANET Initative.

REFERENCES

[1] J. Banhart, J. Baumeister, Proceedings, Materials Research Society Symposium, San Francisco, 1998, D.S. Schwartz, D.S. Shih, A.G. Evans, H.N.G. Wadley (ed.), vol. 521, MRS, Warrendale, 1998, pp. 121–132.

[2] K. Gawdzińska, M. Gucma: Two-criteria analysis of casting technologies of metal and composite foams, Archives of Metallugy and Materials, 2015, Vol. 60, issue 1

[3] K.F. Wall, S.H. Bhavnani, R.A. Overfelt, D.S. Sheldon, K. Williams: Metall. Mater. Trans. B. **34** (2003), 843–851

[4] K. Gawdzińska, J. Grabian, M. Szweycer, W. Przetakiewicz: Foaming the Structure of Composite Metallic Foams, Archives of Metallugy and Materials, 2014, Vol. 59, issue 2, 771-773

[5] L. Bonaccorsi, E. Proverbio, Advanced Engineering Materials, **8** (2006) 9, 864–869.

[6] K. Gawdzińska, J. Grabian, Z. Pędzich, W. Przetakiewicz, Archive of Foundry Engineering, **11** (2011), Special issue 1, 11–14.

[7] P.A. Karnezis, G. Durrant, B. Cantor: Mater. Charact. **40** (1998), 97–109.

LEASE CONTRACT

Blanka Ivančić-Kačer, PhD
Frane Mitrović, PhD
University of Split
Faculty of Maritime Studies
Zrinsko Frankopanska 38, 21000 Split, Croatia
bkacer@pfst.hr

ABSTRACT

In this paper the legal problem of solving relationhip between the two laws has been researched- the Civil Obligations Act and the Maritime Code, on the very specific issue of the lease agreement (COA) as a general law and contract of affreightment (Maritime Code) as a special law.

Conclusions are drawn and based on them according to the criterion of specialty (which is usually considered the most important criterion) the absolute advantage has Maritime Law in a number of cases which that particular- special law deals with, regardless of whether it is the matter of mitigation or aggravation of solutions from the COA. However, it is pointed out that this applies only to that part that regulates Maritime Code, and in regard to that part which is not concerned, COA is applied to the contract of affreightment.

Key words: Contract, lease, ship, special law.

1 INTRODUCTION

Long time has passed when everything in law was simple, when there was one basic division of private and public law, when a number of legal brances was simply incomparable to today's situation when specialization (as a need, certainly not as a fad) has become *conditio sine qua non* of progress and prosperity. It is inevitable that this general trend applies to individual legal brances as well.

This paper deals with a classic civil law institute – lease contract, but not any lease contract, not the one in which the subject of the lease can be anything (the one that is regulated by teh COA[1]), but, on the contact of the affreightment (which is edited in Maritime Code[2]) and regarding the so-called general lease agreement, meaning the one in which it does not matter what the subject is . If there would be no special code that would in its regulations contain deviations from the general solutions for a lease contract everything would be very easyand simple- the one and the same legal text would be applied to all situations, no matter how specific they are. The fact it would be easy and simple does not mean that it would be good, because the specifics of a particular subject of lease , especially if it reasches the so-called critical point, simply call for specific regulations.

[1] Civil Obligations Act, NN35/05., 41/08.,125/11-further COA or Civil Obligations Act.
Previously the law of the same name was effective which was adopted 08.10.1991, and originally was adopted in 1978 in the former state - Službeni list SFRJ no. 29/78., 39/85., 57/89., NN53/91., 73/91., 111/93., 3/94., 7/96., 91/96., 112/99., 88/01. - further COA78/91. or Civil Obligations Act 78/91.
[2] Maritime Code, NN 181/04., 76/07., 145/08, 61/11., 56/13. - further MC or Maritime Code. Previously the law of the same name was effective- Maritime Code, NN 17/94., 74/94., 43/96. - further MC or Maritime Code 94.

Given the fact that the Republic of Croatia not only has no civil Code, but does not have in its plan to make one, the COA is its replacement or substitute, with all the disadvantages and disadvantages of such a solution. That law, as its integral part, has not only general regulations relating to each contract (Art.1-375), but also a special section dealing with the particular designated contracts (**among other lease contract as well in Art. 519-549**). Accepting COA as a surrogate of the civil Code, the subject of this paper a relationship of that Acta and Maritime Code, on the very specific issue, the issue of the lease contract which was arranged by the Maritime Code(Art.658-672, while Art.673 defines the question of the limitation period in the case of contracts of affreightment), but not in a way that excludes the application of all relevant regulations of the COA. This means that the text deals with the relationship of these regulations in the two mentioned laws, but in a way that it includes everything that arises from the so-called nature of things, therefore is nowhere explicitly formally and precisely regulated, but the nature of things is what decisevely influences the conclusion of the application or inapplicability. It is the application of the rules of interpretation, solving, both, the antimony and legal gaps.

2 LEGAL SOURCES

Civil Obligations Act[3] is one of the most important laws in Croatian applicable law. This in no case means that there are unimportant laws, but only emphasizes its objectively great significance, which is formally confirmed by the fact it is one of the laws that contain the largest number of articles (1163 in the basic text) in Croatian applicable law[4]. Very similar is with Maritime Code [5](1032 articles in the basic text).

Given the subject of this paper, legal sources are all those which more or less directly, deal with contracts and in particular lease contract , both, those general from the COA and the contract of affraightment from the Maritime Code as one of maritime contracts. Of course, the most legal source is the Croatian Constitution[6] and all laws and bylaws must comply with it. International agreements have legal power superior to the Constitution. There is an extremely large number of international conventions, which under terms of ratification and publication (as well as any other international agreement), acquire the satus of overlaw. Just as an example we can mention in the field of sea transport Convention of the Equalization of Certain Rules Relating to Bills of Lading (Hague Rules), 1924, with the changes of protocol 1968 (Visbyska rules) and in 1979.,the United Nations Convention on the transport of Goods

[3] Civil Obligations Act, NN35/05., 41/08.,125/11-further COA or Civil Obligations Act.
Previously the law of the same name was effective which was adopted 08.10.1991, and originally was adopted in 1978 in the former state- Službeni list SFRJ no. 29/78,39/85, 57/89., NN53/91.,73/91.,111/93.,3/94.,7/96.,91/96.,112/99, 88/01- further COA78/91 or Civil Obligations Act 78/91.

[4] Despite the fact that the scope itself is not and will not be the decisive criterion (and a number of articles even less, because a particular article may consist of one paragraph with one short sentence, or of more paragraphs and subparagraphs with many sentences), it has particular meaning.

[5] Maritime Code, NN 181/04.,76/07.,145/08, 61/11.,56/13-further MC or Maritime Code. Previously the law of the same name was effective- Maritime Code, NN 17/94.,74/94.,43/96 - further MC or Maritime Code 94.

[6] Croatian Contitution, NN 56/90.,135/97.,8/98-consolidated text, 113/2000, 124/2000-consolidated text, 28/2001, 41/2001, 55/2001- correction and the change of Croatian Constitution published in NN no.76/201, 85/10- Constitution.

by sea (Hamburg Rules) in 1978, the United Nations Convention on the contract for the international transport of goods by sea or things in their entirety (Roterdam Rules) 2009.[7]

Legal sources are rules that were effective prior to the above COA and MC, especiallyregarding the rules that a particular situation should apply regulations that were valid at that (earlier) time of acquisition, and even despite the fact that it is always possible that subsequent regulation brings changes, whether to convalidate somethingthat initially was not valid, or to differently arrange something that was valid at the beginning with the effect to that earlier acquisitions.

The meaning of legal sources also have traditions, particulary on the basis of very clear and very explicit regulation in Art.12 of the COA, which greatly complements special laws, including Maritime Code. According to this Article, it is necessary to distinguish commercial and legal traditions and customs, all with certain aatributes, but without questioning that all three fall under the legal sources which are prior to dispositive legal norms.[8]

The meaning of legal sources have as well by-laws that directly or indirectly deal with issues addressed in this text.

It is common to class judicial practice and legal science under legal sources. Ater Republic of Croatia has gained full membership in the EU (01.07.2013), a Europian judicial practice (as a part of judicial practice in general) has obtained a completely new significance. As fot the legal science, formal membership in the EU has led to the fact that there are not any interstate borders within the EU, which means that the scientific works of German, Italian, Austrian and other scientists from the EU equally compete with those of Croatian scientists, and the only criterion should be the power of arguments. Otherwise, by the nature of things, only science gives the rightanswers to a series of questiones asked concerning the relationship of one general regulation (COA) and one special (MC), which is esentially characterized by a number of international agreements that have a power which is above statute regardless of how they are implemented in Maritime Code. More precisely, legal texts (truely, by the will of the legislature, and not by the will of science) generally do not contain anything on this issue and everything is left to someone else and that someone else my be only science. In this way, without any legislative interventiom, possible changes in attitudes of science are accepted.

---

[7] Ivo Grabovac, Liability of the carrier in the transport of goods by sea in Maritime Code of the Republic of Croatia and in international conventions, Književni krug, Split, 2010., p. 9.

[8] More: Vilim Gorenc in : Zlatko Ćesić, Vilim Gorenc, Hrvoje Kačer, Hrvoje Momčinović, Drago Pavić, Ante Perkušić, Andrea Pešutić, Zvonimir Slakoper, Ante Vidović, Branko Vukmir, The Comment of the COA, RRIF plus d.o.o., Zagreb, 2005., p. 24-27., Vilim Gorenc in : Vilim Gorenc, Loris Belanić, Hrvoje Momčinović, Ante Perkušić, Andrea Pešutić, Zvonimir Slakoper, Mario Vukelić, Branko Vukmir, General editorial staff Vilim Gorenc, The Comment of the COA, NN, Zagreb, 2014., p. 26-29.

3 DEVELOPMENT OF CIVIL OBLIGATIONS ACT AND MARITIME CODE IN RELATION TO THE LEASE AGREEMENT AND THE PROPERTIES OF THAT CONTRACT

3.1 Properties of lease contract in the COA

According to the conventional and professionally accepted definition, a lease contract [9] is consensual two-sided mandatory contract under which one party (the lessor) agrees to pay (rent) to let the other paty (the lessee) to use a thing along with a certain subcharge, where the lessor has to be either the property owner or such proprietary authorized person who can transfer his/her property to another person (eg. Usufruct) and on the basis of the lease agreement the lessee has a right to benefit from the leased object, and this fact determines lease facilities.[10] Of course it is possible for an authorised person to make a lease agreement (ie the one that neither is the owner nor has proprietary authority to transfer the execution of their rights to another person). Such an agreement will be (if there are no other downsides) legally valid, but will be without the effect erga omnes, ie will remain with the effect only between those who have signed it (with a good contractual liability of one who cannot fulfill its contractual obligation).

The lease agreement is one (in addition to the loan, credit, licence and lease) of the contracts on temorary use and the use of another's property, the nominee and nominate contracts (which means that its name and content have become widely accepted, not necessary, but preferably by law), billing or onerous contract (which means that action results in counteraction), commutative contracts (which means that already at the time of conclusion of the contract the action and counteraction are well-known), informal contracts (which means that form or form of the contract is not prescribed), consensual contracts (ie contract is not real and the rights and obligations arise by agreement rather than tradition as with real contracts), contracts with lasting benefits or obligations , the causal contracts (because its economic purpose or Cause is transparent from the contract itself.[11])

The subject of the lease agreement can be real estate (land, commercial property, buildings), movable property (car, movie), but also a right (eg right to licence, but also the right to usufruct),wherby that can be the future fact or law. It is usual to lease unconsumable items and things that are individually determined and recognizable- if a person should lease an expendable item (which ends up spent) that would be the loan contract, and if a given thing is exchangeable, again it would be a loan contract that may be free of charge, and lease is never free of charge.[12]

---

[9] Lease, lat. Locatio- condutio, engl. Lease, germ. Pacht, franc. Bail a ferme- Legal lexicon, Leksikografski zavod Miroslav Krleža, Zagreb, 2007., p. 1811.
[10] Petar Klarić - Marin Vedriš, Civil Law, NN, Zagreb, 2014, p. 515.
[11] Hrvoje Kačer, Zvonimir Slakoper, Lease/loan contract in : Vilim Gorenc, Hrvoje Kačer, Hrvoje Momčinović, Zvonimir Slakoper, Branko Vukmir, Loris Belanić, Mandatory Law- Special part I- Special contracts, Novi informator, Zagreb 2012, p. 155-156.
[12] Hrvoje Kačer, Lease contract in: Zvonimir Slakoper, Vilim Gorenc, Hrvoje Kačer, Mandatory Law- Particular types of contracts, Zagreb, 2010, p. 87.

Like any other contract, lease agreement as well produces rights and obligations of the paties. The lessor has the obligation to submit the item in a correct state[13](ie state which is agreed), to maintain it in good condition (except for minor repairs that requires regular use of things), be liable for material defects[14](all that hamper its agreed or regular use) and legal deficiencies (if a third party has a right which excludes or limits the leaser's right to use). The lessee shall use the item as a good businessman (or a good host, or as stipulate in the contract or by the purpose of the item), idemnify the use contrary to the contract or the purpose of the item, pay the rent[15] (within the deadlines specified by contract, law or custom in te place of transfering the item, keep the item and return it undamaged after the termination of the contract).[16]

It is important to emphasize that according to the COA sublease is permitted unless otherwise agreed (art. 537.), even when after the completion of the agreed period continues the usage of the item , and the lessor does not oppose, it is considered that the contract was tacitly renewed as a contract of indefinite duration, under the same (other) contracts as the previous one, and that the death of a lessee or lessor does not mean the termination of the contract , unless otherwise agreed.

3.2 Maritime Code

Maritime property right, as well as Maritime Law in general, historically developed parallel to the development of freight traffic and shipping activities in the function of the traffic.First, it was only common law (*lex mercatoria*), and later on from these practices specific marine institutes were formed, first throuh statutory rights of autonomous medieval cities, and then through codifications. Property relations in connection to the sea are a universal phenomenon and have an international character.

It was acceptable that the Maritime Code does not deal with contractual part.It is a question of priniple approach of the legislator who can decide on either of the two extreme approaches (according to the first it entirely relies on the general law dealing with the conracts, according to another the total problem is arranged by special law, as well for any of a number of possible compromises or moderate solutions by which the specific law relies on the general law in a greater or lesser extent, ie which in a greater or lesser extent, has its own specific solutions , that more or less, deviate from the general ones.

In the new independent state the integral legal text which combines marine and legal matter (includin maritime contracts) did not happen until 1994. During these three years of independence the regulations of a number of special laws were in force[17], which were by

[13] The item is in the correct state if it is ina condition agreed by the contract, and in the case of lack of contract , in such a condition it can serve the purpose of signing the contract-art. 521, par.2 of COA.
[14] The lessor is responsible to the lessee for all the shortcomings of the rented item that bother its contractual or regular use, regardless of whether he knew about them or not, and for deficiencies properties or characteristics provided by contract or by implication. The shortcomings that are of minor importance are not taken into account.-Art. 525. Parag. 1 and 2 of COA. However, article immediately following provides that the lessor is not liable for defects that in the time of conclusion of the contract were known or could not remain unknown to the lessee.
[15] According to art. 535. of COA, the lesser may cancel the lease contract if the lessee does not pay the rent withing 15 days after the lesser urged the payment, but the contract shall remain vaild if the lessee pays the lease before he is notified about the termination of the contract.
[16] Petar Klarić- Marin Vedriš, Civil Law, NN, Zagreb, 2014, p. 516-518.
[17] Which were by otherwise transitional and final provisions made ineffective and there precisely listed.

otherwise transitional and final provisions of the Maritime Code 94 (Art. 1053) made ineffective and there precisely listed.

Maritime Code 94 is considered to be the *corpus iuris maritmi* because the entire marine and legal relations have been established in a special code[18], in this case Maritime Code precisely. It is interesting that in Article 671 Maritime Code stipulates that :„The contract of affreightment, according to this **Law,**…cretaing a certain contradiction and confusion, given that it bears the name of MARITIME CODE, and the word code in legal theory is indesputably taken as a formal emphasis of the law that has the meaning of overlaw or something that is nevertheless more significant than (the ordinary) law.

Maritime Code 94 dedicated to the lease contract Art.675-686, all together 16 articles.Not only that Maritime Code maintaines the same number of articles (different numberin, so now we are talking about articles 658-673), but its content remains exactly the same, and the only change in the law is that the legislator in Art. 658 (formerly 671) avoids earlier lapse and now states: „The contract of affreightment , according to this **Code**…"

3.3 Affreightment contract properties in the Maritime Code

Maritime Code is a special law in relation to COA. Just as it is true as a general assessment, it also applies to the caseof a lease contract of COA and contract of affreightment from te MC. One one the oldest principles of law needs to be applied here, lex specialis derogat legi generali19 (special law repeals the general) and according to which priority is given to Maritime Code. However, it is so when in these two laws there are mutually conflicting regulations.

Maritime Code in art. 659 stipulates the written form for the contract of affreightment, and under the threat of nullity (true, legal formulation is „has no legal effect" and although it is quite clear, still it would be better to explicitly stipulate nullity).[20] This is a case where a special code (Maritime Code) imposes stricter and more demanding form from the general law (COA).

With liability for material defeciencies situation is different- Maritime Code is more lenient for the lessor because it allows him to prove that he could not detect defecencies due diligence, while COA does not allow it.

In relation to the payment of the rent COA provides the payment within the time limits specified by contractor by law (does not impose the so-called peremptory norm solution), while Maritime Code precisely with peremptory norm in the art. 665 imposes the obligation to pay a month in advance. So Maritime Code (for the lessee) is far more demanding than COA.

In relation to the return of the lease COA does not contain specific regulations in case of violation of this obligation , while Maritime Code provides (again by peremptory norm) for

[18] Ivo Grabovac, The transport of things in inland navigation in Croatia- de lege lata and de lege ferenda, Književni krug , Split, 2007, p. 7.

[19] Special law repeals the general law. –Dragomir Stojčević-Ante Romac, Dicta et regulae iuris, Latin legal rules, dictums and definitions with translation and explanations, 4th supplemented edition, Suvremena administracija, Beograd, 1984, p.262, dictum no. 149.

[20] Maybe the explanation is in the fact that MC was brought before the COA.

that case the obligation of paying compesation in the amount of double rent as a special case of the contractual penalty prescribed by law. [21] So Maritime Code (for the lessee) is far more demanding than COA.

According to COA sublease is allowed if the contract does not state otherwisem while the Maritime Codestipulates theexact opposite- sublease is allowed only in the case of the lessor's consent and in written form (form is a logical consequence of the fact that the contract of affreightment is a formal contract). So Maritime Code (for the lesse) is far more demanding than COA.

In relation to the question of limitation with regard to the lease contract Maritime Code stipulates several important differences in relation to the COA. According to the COAit is forbidden to change the limitation period (not so short as not so long) while in the art. 673.parahraph 3 of MC it is allowed, as a result of claims, in written form bespojke the limitation period that is longer than the one-year deadline stipulated for the contract of affreightment in art.671. The one-year deadline is significantly shorter than the three-year period for the lease under art. 229 of COA and of the general limitation period of five years from art. 225 of COA, as well as from three-year deadline for claims under the contract of trade of goods and services referred to in art. 228 of COA.

We have listed the legal regulations in which Maritme Code digressed from the decisions of COA anf things are very clear there, Maritime Code has the advantage. It is significant , however, to note whether a special law (MC in this case) governs the whole legal institution (that is, not only what COA has, eg. With the lease contract, but what belongs to the so-called general part, eg. Irrevelance, actio Pauliana, lack of will…) which is the exeption that in the case of Maritime Code and the contract of affreigthment didi not happen or specially edited only what requires specifity of the matter (in this case, marine and legal component) and the rest was left to COA as a general law. With such a situation the only thing left is to determine whether there is in the nature of maritime contract something that 'by the nature of things' requires a special approach to a certain problem or how to apply the phrase ' shall be applied in a ppropriate manner' to the application of the regulations of COA to a certain maritime contract (art. 14.of the COA). Without excluding the existance of the specific features, it should be emphasized that these are the exceptions that should be in each case thoroughly proven. Specifically, that requires a logical premise- when legislator has already decided on a special law (Maritime Code), a lease contract should be arranged, even though a lease contract as designated contract is regulated by COA, then it is logical to conclude Maritime Code has included all regulations for which it has been decided to take precedence over those of COA. A contrario, for everything else (appropriately) the regulations of COA are valid.

4 CONCLUSION

In this paper has been researched the legal problem of solving potential collision or antinomy between two laws – Civil Obligations Act and Maritime Code, in the section dealing with the lease contract or contract (COA) of affreightment (MC).

[21] Otherwise, a contractual penalty is, according to COA, excluded when it comes to money penalty.

Conclusions are drawn based on the criterion of specialty (which is considered to be the most important criterion) according to which Maritime Code has an absolute advantage. However, it was pointed out that this applies only to the part that regulates Maritime Code, and in relation to that part which does not cover, in the application is a contract of affreightment and COA as well. The above means that generally both laws will be applied- COA in the so-called general part and special part, if this matter is not covered by the standards of Maritime Code.

REFERENCES

[1] Bukljaš, I. & Vezner, B. (1979). *The Comment of the Civil Obligations Act*, book 3., Zagreb.

[2] Ćesić, Z.,Gorenc, V., Kačer, H., Momčinović, H., Pavić, D., Perkušić, A., Pešutić, A., Slakoper, Z., Vidović, A. & Vukmir B. (2005). *The Comment of the COA*, RRIF plus d.o.o., Zagreb.

[3] Gorenc, V., Belanić, L., Momčinović, H., Perkušić, A., Pešutić, A., Slakoper, Z., Vukelić, M. & Vukmir, B., General editorial staff Gorenc V. (2014). *The Comment of the COA*, NN, Zagreb.

[4] Gorenc, V., Kačer, H., Momčinović, H., Slakoper, Z., Vukmir, B. & Belanić, L. (2012). *Mandatory Law- Special part I- Special contracts*, Novi informator, Zagreb.

[5] Grabovac, I. (2010). *Liability of the carrier in the transport of goods* by *sea* in Maritime *Code* of the *Republic* of *Croatia and in international conventions*, Književni krug, Split.

[6] Grabovac I. (2007). The transport of things in inland navigation in Croatia - de lege lata and de lege ferenda, Književni krug, Split.

[7] Kačer, H., *Lease contract* in: Slakoper, Z., Gorenc, V. & Kačer, H. (2010). *Mandatory Law-Particular types of contracts*, Zagreb.

[8] Klarić, P. & Vedriš, M. (2014). *Civil Law*, NN, Zagreb.

[9] Stojčević, D. & Romac, A. (1984). Dicta et regulae iuris, Latin legal rules, dictums and definitions with translation and explanations, 4th supplemented edition, Suvremena administracija, Beograd.

[10] Vuković, M. (1961). The rules of Civil Codes with additional regulations, judicial practice, footnotes and information from the literature, Školska knjiga, Zagreb.

[11] *Legal lexicon* (2007). Leksikografski zavod Miroslav Krleža, Zagreb.

COMPARISON BETWEEN CONVENTIONAL LNG AND LNG-SRV TANKERS

Dalibor Ivanišević, MEng.
Luka Grbić, MEng.
University of Zadar
Maritime Department
Mihovila Pavlinovića 1, Zadar, Croatia
divanisevic@unizd.hr; lugrbic@unizd.hr

ABSTRACT

Up to the middle of the last decade LNG tankers were built only when the gas exploitation project as well as the market to sell it existed. Ships were operating on the basis of the long term Sales and Purchase Agreement, and predetermined terminals for LNG loading and unloading. As a result of increasing LNG demands, a disproportion between LNG production, available ship transport capacities, and LNG unloading and regasification terminals, has occurred. Such a situation has been recognized as the opportunity to construct and utilise ships with necessary LNG regasification equipment on board enabling ships to unload gas directly to the "grid". The paper compares conventional LNG and LNG – SRV tankers. Furthermore the advantages and disadvantages of SRV (Shuttle and Regas) – LNG tankers have been pointed out in the context of increasing importance of natural gas as the global energy source and its transport as well.

Key words: LNG tankers, SRV-LNG tankers, regasification, gas strategy, LNG production.

1 INTRODUCTION

Tankers carrying liquefied natural gas (hereinafter LNG) are ships that have existed in the shipping industry for the last 50 years. Until 2004, LNG sea transport had been functioning as a conservative industry, i.e. that ships had been built only when there was an existing gas exploitation project or a defined market. Ships were operating on the basis of the long term SPA (sales and purchase agreement) and predetermined terminals for LNG loading and unloading.

Taking into consideration materials used to build cargo tanks, propulsion of LNG tankers and high safety standards of extremely demanding administration, the operating life expectancy of an LNG tanker is approximately 40 years.

As a result of the increased demands for LNG as a source of energy, a disproportion occurred, during the last decade, between LNG production, available ship transport capacities on one side and LNG unloading and regasification terminals, and further distribution on the other side. So, LNG-SRV[1] tankers have proved themselves as economically and technically acceptable solutions. LNG-SRV tankers are used for transportation, storage and LNG regasification as well as for unloading of regasificated natural gas directly to the grid.

[1] Shuttle and Regasification Vessel

2 LNG PRODUCTION AND TRANSPORT

Liquefied natural gas is a fossil fuel which is a gas mixture consisting primarily of 85-98% of methane (CH_4). Natural gas is non-toxic, colourless, odourless and non-corrosive in contact with other materials. Since it consists mainly of methane, natural gas is actually a greenhouse gas because it increases the level of carbon dioxide in the atmosphere. Natural gas could be considered environmentally friendly fossil fuel, because it has the lowest sulphur and nitric oxide emissions whereas solid residues hardly exist. In its gaseous state and mixed with air (in proportion from 5.5 to 15%) it becomes flammable and combustible. Natural gas has been an unwanted by- product of active oil fields for a long time so it used to be burned off at oil fields as "useless component".

Due to its wide usage and existing reserves, natural gas has, nowadays, become the third source of energy in the world. Some scenarios indicate that demand for gas will rise from 2539 Mtoe[2] in 2009 to 3928 Mtoe in 2035 (Chart 1).

It is mostly used as an industrial source of energy and as a household fuel. However, because of its advantages, it is starting to be used as a fuel oil for the road vehicles and ships as well. In 2010, IMO (International Maritime Organisation) adopted the revised MARPOL Annex VI and reduced fuel oil sulphur content for ships to 3.5% globally and to 1.00% in ECA zones (Emission Controlled Areas), with further reduction to 0.1% effective from 2015. It is expected that fuel oil sulphur content for ships will be reduced to 0.5% and applied globally in 2020 [1].

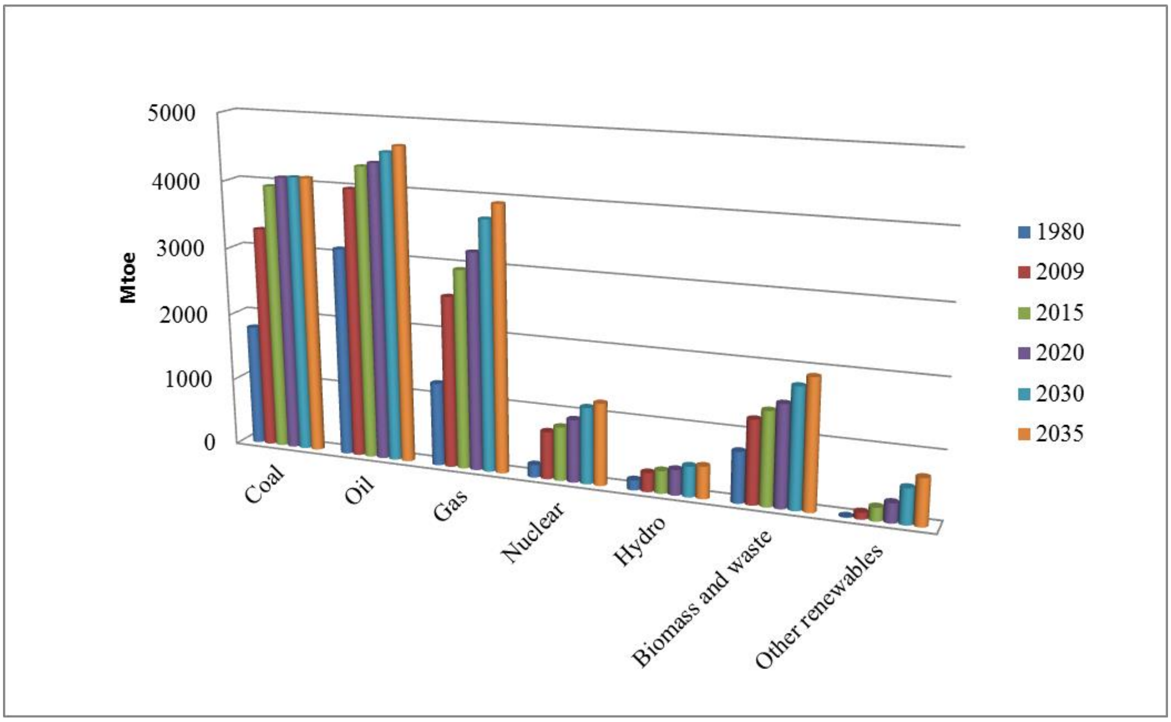


Figure 1: Projection of the consumption of power sources till 2035 (Mtoe)

Source: Authors according to [2]

[2] Million Tonnes of Oil Equivalent

Because of all the above-mentioned reasons, the ship-owners' interest in LNG as a fuel oil is understandable.

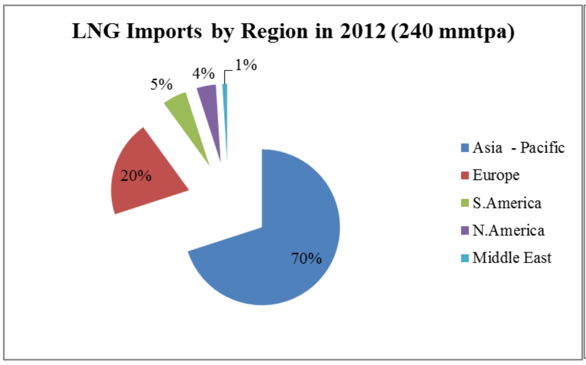
Table 1 shows 20 countries with the largest natural gas reserves[3].

Table 1: Countries with the largest natural gas reserves (Tcf)

No	Country	Reserves	No	Country	Reserves	No	Country	Reserves	No	Country	Reserves
1	Iran	1187	6	Saudi Arabia	291	11	Australia	133	16	Egypt	72
2	Russian Federation	1163	7	United Arab Emirates	215	12	Iraq	127	17	Canada	70
3	Qatar	885	8	Venezuela	196	13	China	109	18	Kuwait	63
4	Turkmenistan	618	9	Nigeria	182	14	Indonesia	103	19	Libya	55
5	US	300	10	Algeria 1	159	15	Norway	74	20	India	47
Top 20 Countries											6049
Rest of World											565
Total											*6614*

Source: [3]

Almost 9% of the total amount of natural gas is, nowadays, transported by sea in LNG state [4] – liquefied state with temperatures varying from -160 to -162 ºC and volume 600 times smaller than when in gaseous state. Therefore, transport of large amounts of natural gas by specially built LNG ships proved to be economically acceptable. Parallel economical parameters have shown that LNG ship transport is far more profitable than pipeline transport at distances larger than 4,500 km [5]. As a result of "geographical incompatibility" between the areas where natural gas is exploited and those with the highest consumption, it is expected that 30% of the world's natural gas production will be transported internationally by 2020 [5]. Chart 2 shows the list of regions which are the biggest importers and exporters of LNG. The biggest importers are not situated close to the exploitation fields, so LNG transport by sea has become a logical choice.



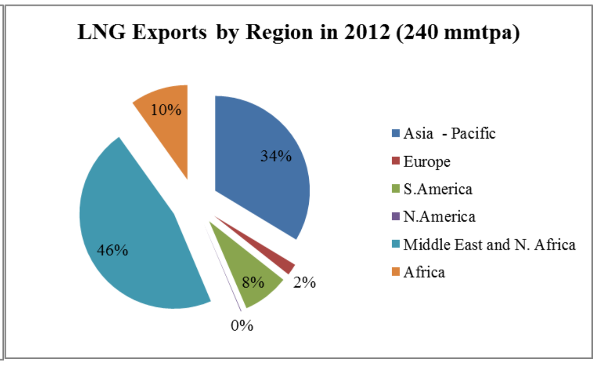


Figure 2: LNG Imports and Exports by Region in 2012 (240 mmtpa[4])

Source: [6]

[3] Measured in trillions of cubic feet (Tcf)
[4] 240 million tonnes per annum

3 LNG SHIP TRANSPORT

LNG sea transport began in 1959 when a redesigned ship Methane Pioneer carried the first LNG cargo from Lake Charles port in Louisiana to Great Britain. In 1964 the two newly constructed commercial LNG tankers, Methane Princess and Methane Progress, were put into service between Algeria and Great Britain. They had 27,000 m^3 cargo capacities and were equipped with Conch independent aluminium cargo tanks[5].

In 1997, the LNG fleet comprised 100 ships. Since then, there has been a gradual growth in number and in capacity (Table 2 and 3.).

Table 2: LNG fleet

Year	Total number	Delivered ships	Order book
2010	360	25	20
2011	359	16	59
2012	378	2	78
2013	393	45	113[6]
2014	402	-	121

Source: Authors according to [9, 10, 11, 12, 13]

Table 3: LNG fleet capacity

Year	Capacity	
	Operational shipping capacity	Total shipping capacity[7]
2010	5110 na 6 m na 3	2610 na 6 m na 3
2011	51910	53510
2012	53510	54010
2013	55410	56310

Source: Authors according [10, 11, 12, 13]

It is to be expected that LNG fleet will surpass 500 ships in the period from 2016-2017. This figure includes both, conventional and non-conventional ships [4]. More than 75% of the existing LNG fleet is younger than 15 years (Table 4).

Table 4: LNG fleet by age

Year	15 years	20 years
2010	77,8%	83,3%
2011	84,1%	89,7%
2012	76,5%	84,9%
2013	77,1%	85,5%

Source: Authors according to [7, 8, 9, 10]

When talking about LNG tankers, it is important to emphasize their safety aspect. That is, no matter the physical or chemical characteristics of LNG when transported by sea, no greater incident has, so far, been recorded on LNG ships.

---

[5] CONCH (Constock Liquid Methane Corp and Chicago Stockyards) are type A independent aluminium tanks which were used when the first LNG ships were built
[6] 6 FSRUs/RVs – in 2014
[7] Without laid-ups

3.1 Conventional LNG ship transport

The term "Conventional LNG Tanker" is used for LNG tankers up to 180,000 m^3 cargo capacity, self-supporting spherical Moss-Rosenberg tanks and prismatic membrane tanks.

Moss-Rosenberg self-supporting spherical tanks are made of aluminium alloys and are designed without secondary barrier since it was found out that possible tank damages would be detected and controlled before they could develop in such extent that can endanger structural integrity of the tank. Today, ships having these tanks have the biggest cargo capacity of approximately 177,000 m^3 (Grace Dahlia) [11].

No structural damage or cargo leakage has been recorded in the exploitation of LNG tankers with spherical tanks so far.

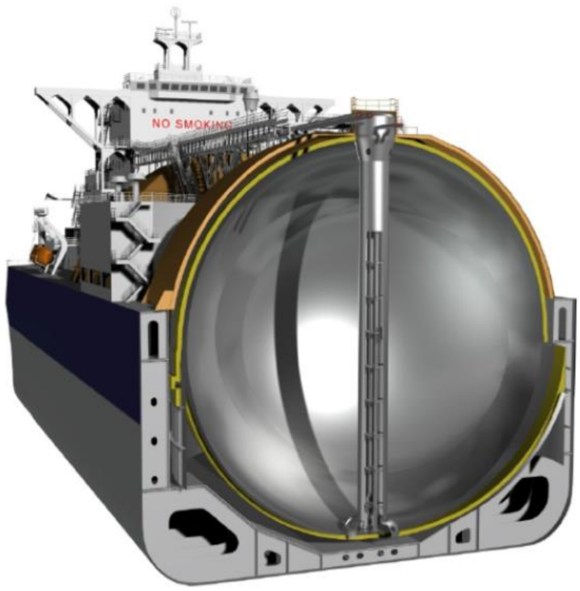


Figure 3: Self-supporting spherical Moss-Rosenberg tank, cross-section view
Source: [12]

Until 2000, LNG tankers with spherical tanks made 54% of the total LNG fleet [13]. However, that has changed with domination of ships with prismatic membrane tanks.

The reasons for this change are mostly economical. The price of tankers with a membrane tank is approximately 10% lower than of those with spherical ones. Furthermore, because of a different design and applied technology, tankers with prismatic membrane tanks need less time for tank cool-down operation while preparing for cargo loading in ports. A membrane tank ship is lighter and of smaller dimensions (when comparing tank capacities). Due to design and ship construction (half of the cargo is stored above the main deck on tankers with spherical tanks), tankers with prismatic membrane pay lower fees when transiting the Suez Canal.

There are two basic types of membrane-type ships that are built in accordance with the design of French company GT&T (Gaz Transport and Tehnigaz). Primary membrane of Mark III tank is constructed of corrugated stainless steel plates whereas polyurethane foam is used for insulation. Secondary barrier is made of triplex, which basically consists of aluminium foil between two layers of fiber-glass texture.

Primary and secondary membranes of No 96 tank type are made of invar–alloy steel (Invariable)[8] containing 36% nickel and 64% steel. Its major feature is resistance to thermal contractions.

This system uses plywood boxes filled with Perlite[9] as insulation.

Table 5: LNG fleet containment system

Year	Containment system		
	Moss Rosenberg	GazTransport &Technigaz	Others
2010	109	245	6
2011	104	245	10
2012	108	255	15
2013	109	268	16

Source: Authors according [7, 8, 9, 10]

3.2 LNG-SRV tankers

The term "non-conventional" LNG tanker refers to, so called Q-Flex and Q-Max LNG tankers[10] with the cargo capacity of above 200,000 m^3, to SRV (Shuttle and Regas Vessels) and to FSRU (Floating Storage and Regasification Unit) ships as well. These ships have the possibility not only to transport LNG but to store and carry out regasification operation as well.

LNG-SRV ships are made on the platform of conventional LNG tankers with cargo capacity of 145,000 to 170,000 cubic metres. Apart from standard LNG loading/unloading equipment, they are also equipped with regasification equipment. The first LNG-SRV ship was built at South Korean DSMI shipyard for the Exmar Company in 2005. Until 2010 the same company built eight LNG-SRV tankers [14]. The Hoegh LNG built two LNG-SRV ships in 2009 and 2010 for the Neptune Project in Massachusetts Bay [15].

Operational versatility of LNG-SRV carriers is enhanced by the ability to transport, store and regasificate LNG, and unload natural gas under high pressure via connecting turrets and submerged buoys directly to the distributional grid. In order to connect to the submerged buoy, these ships are equipped with DP system (Dynamic Positioning) of high navigational accuracy[11]. Moreover, through a manifold located amid ship, it is possible to unload LNG in a conventional way, or under high pressure as a regasificated natural gas. In order to carry out regasification operation, LNG-SRV ships are also equipped with additional heat exchangers.

---

[8] Invar (also known as Invar 36, NILO 36, Pernifer 36 and Invar Steel) is an alloy resistant to thermal contractions containing 36% nickel and the rest is steel. It is, thus, suitable for industries which need high dimension of construction stability.

[9] Perlite is a volcanic mineral which has been exploited and processed with almost no negative impact on the environment. When it is exposed to fast, controlled heating, it can expand to as much as twenty times its original volume and it gets foamy inner structure. This physical transformation, light weight and consistency make expanded perlite extremely efficient at insulating.

[10] The Q-Flex vessels have a cargo capacity ranging from 210,000 m^3 to 217,000 m^3 while the Q-Max can transport between 263,000 m^3 to 266,000 m^3 of LNG. The vessels were constructed at three ship building yards in South Korea: Hyundai Heavy Industries (HHI) at Ulsan, Samsung Heavy Industries (SHI) on Geoje Island and Daewoo Shipbuilding & Marine Engineering (DSME) on Geoje Island. They were made for Qatargas.

[11] (Dynamic Positioning – DP) computer- controlled system which automatically maintains ship's position and heading.

Taking into consideration the fact that LNG has to be transported at the temperature of approximately -160ºC, heat exchangers are of complex technical design and function on the basis of different mediums used for heating and regasification of LNG. LNG-SRV ship Excelsior, built for Exmar Company at DSMI shipyard in South Korea in 2005, uses sea water as a heating medium (Figure 2).

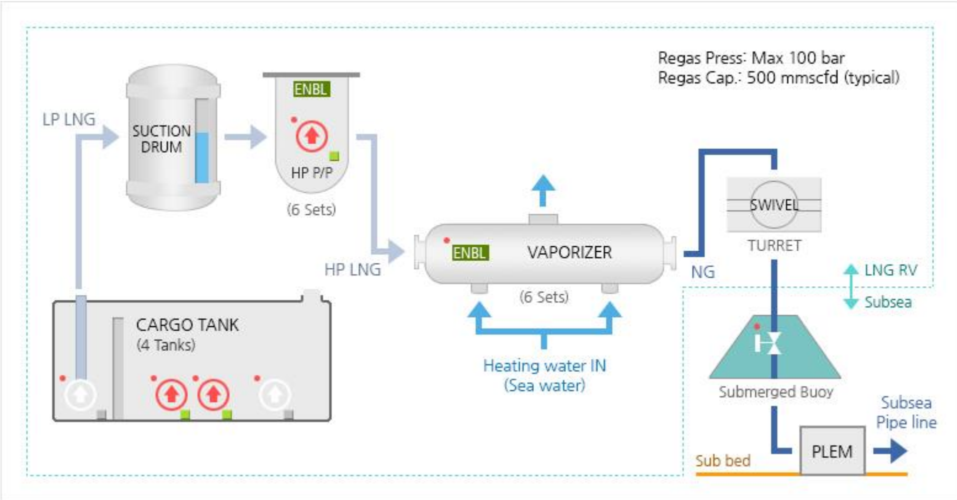


Figure 4: Schematic illustration of regasification equipment on a ship using sea water as a medium for LNG heating
Source: [16]

LNG-SRV ships made for the Neptune Project in Massachusetts Bay, GDF SUEZ Neptune and GDF SUEZ Cape Ann, have been equipped with new regasification equipment and use steam heated glycol as a medium (Figure 3).

The advantages of such design are better temperature and pressure control of LNG. Furthermore, they are in accordance with strict EPA regulations (US Environmental Protection Agency) in order to prevent increase of sea temperature in the area where LNG is unloaded via submerged buoy.

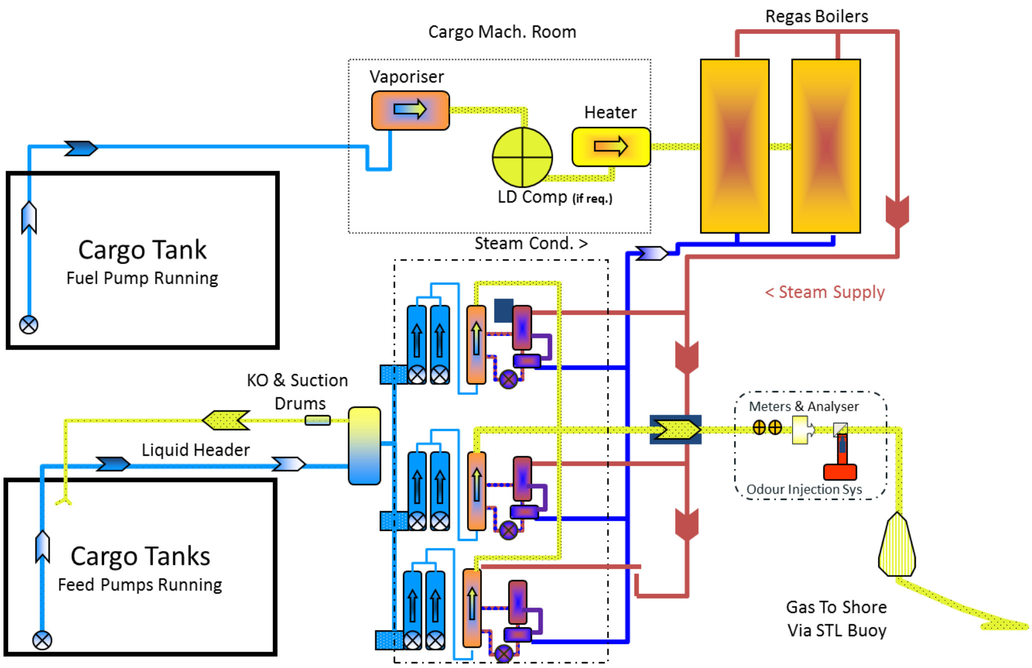


Figure 5: Schematic illustration of regasification equipment on LNG-SRV ship called GDF SUEZ Cape Ann which uses glycol as a medium for LNG heating
Source: [15]

4 ADVANTAGES AND DISADVANTAGES OF LNG-SRV SHIPS

Building an LNG (un)loading terminal has become a capital cyclic investment. According to Barry Rogliano Salles Broking Company, unloading LNG terminals and regasification equipment and distribution of LNG to the grid, make approximately 15-20% of the price in the LNG Value/ Supply Chain [17]. The name LNG Value/ Supply Chain itself describes the process that consists of four independent but closely related segments: exploitation and production of LNG, purification and liquefaction, transport and unloading, storage and regasification at an unloading terminal (Figure 4).

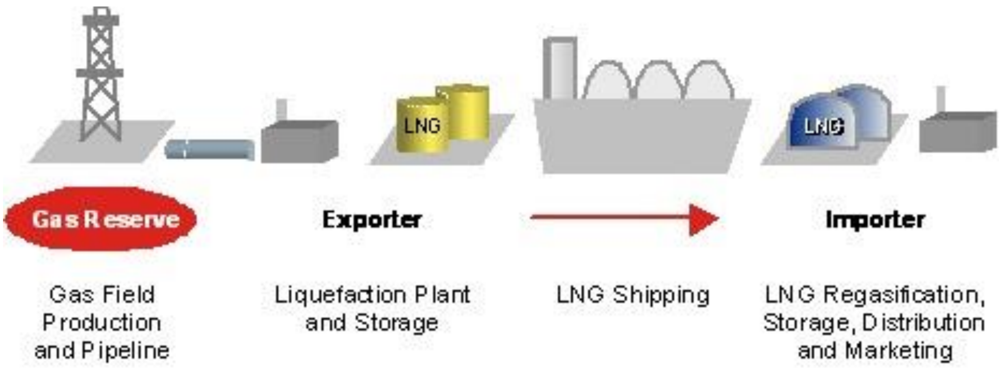


Figure 6: LNG Value Chain
Source: [18]

Alongside with economic factors, it is extremely difficult, for environmental, safety and security reasons, to find suitable locations and obtain permissions to build new LNG unloading terminals. LNG-SRV ships may therefore be an attractive alternative because of their flexibility and because, basically, they are LNG carriers equipped with their own regasification equipment. They can be used to transport and regasificate LNG, and to store and unload natural gas directly to the distributional grid without any need to use the onshore unloading terminal.

Therefore, in the context of LNG – Value/ Supply Chain, it can be concluded that building LNG-SRV shipsinstead of unloading LNG terminals, presents considerable financial benefit for the project. Secondly, bureaucratically speaking, the project is less demanding and requires less documentation.

It takes almost seven years to build an unloading terminal and to obtain all the permits. The price depends on several factors primarily on the position and accessibility of the location, and on the price of local labor as well. On the other hand, it takes less than 30 months to build an LNG-SRV ship. The project itself is almost the same as for an LNG ship whereas ship owner or charterer can use LNG-SRV ship as a traditional LNG tanker or as an off-shore unloading terminal.

As far as the exploitation is concerned, disadvantages of LNG-SRV ships are technical demands and complexity of regasification equipment. The crew has to be additionally trained to work on regasification equipment. Moreover, membrane tanks are subjected to possible damage caused by dynamic movement of liquid inside a partially unloaded tank. This phenomenon is called sloshing and is a result of non-existing compartment barrier inside a tank. Considering the time needed for regasification and LNG unloading via submerged buoys, tanks can stay partially full for days, increasing potential risk of tank damages in case of a bad weather.

5 CONCLUSION

Fast growth of the exploitation of natural gas in the last decade and, consequently, growth of transport of liquefied natural gas (LNG) by sea, has led to the development of new technologies used to build LNG tankers and their equipment. At the same time, IMO has set high construction standards for LNG ships and for their equipment in the so called IGC Code (International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk).

Some ship owners have realised that the disproportion between loading capacities, available capacities of the existing LNG ships and unloading capacities of terminals, gives the possibility to build and exploit LNG-SRV ships. LNG-SRV ships are therefore commercially interesting to all participants of the exploitation-transport cycle of LNG because of their global usage provided by regasification equipment. The usage of these ships, despite the higher price per unit, has justified the need for their construction since they have successfully replaced onshore unloading terminals.

REFERENCES

[1] IMO, Prevention of Air Pollution from Ships, Revised MARPOL Annex VI, London, UK

[2] IEA: World Energy Outlook, 2011, available at: http://www.iea.org/publications/freepublications/publication/weo2011_web.pdf

[3] Canadian Association of Petroleum Producers: An Overview of the World LNG Market and Canada's Potential for Exports of LNG, January 2014, available at: http://www.capp.ca/getdoc.aspx?DocId=237161&DT=NTV

[4] Simpson Spence and Young, Market Commentary, April 2014.

[5] Sylvie Cornot-Gandolphe, Olivier Appert, Ralph Dickel, Marie Francoise Chabrelie, Alexandre Rojey, „The Challenges of Further Cost Reductions for New Supply Options (Pipeline, LNG, GTL), Tokyo, Japan, June 2003.

[6] PFC Energy: Global LNG Supply and Demand Study, May 2013, available at: https://docs.neb-one.gc.ca/ll-eng/llisapi.dll/fetch/2000/90466/94153/552726/963926/977286/963718/A3I5K7_-_Appendix_C_-_Global_LNG_Supply_and_Demand_Study_-_PFC_Energy.pdf?nodeid=963808&vernum=-2

[7] International Group of Liquefied Natural Gas Importers: The LNG Industry in 2010, available at: http://www.giignl.org/system/files/publication/giignl_the_lng_industry_2010.pdf

[8] International Group of Liquefied Natural Gas Importers: The LNG Industry in 2011, available at: http://www.giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_the_lng_industry_2011.pdf

[9] International Group of Liquefied Natural Gas Importers: The LNG Industry in 2012, available at: http://www.giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_the_lng_industry_2012.pdf

[10] International Group of Liquefied Natural Gas Importers: The LNG Industry in 2013, available at: http://www.giignl.org/sites/default/files/PUBLIC_AREA/Publications/giignl_the_lng_industry_fv.pdf

[11] Elengy, „Montoar-de-Bretagne – New Transshipment Operation with the World's Largest Spherical-tank LNG Carrier“, Paris, November 2013.

[12] Aronsson, E.: FLNG Compared to LNG Carriers, Master of Science Thesis, Chalmers University of Tehnology, Sweden

[13] Neftegaz.Ru, „Types of LNG Carriers“, May 2013.

[14] http.exmar.be

[15] http.hoeghlng.com

[16] Daewoo Shipbuilding & Marine Engineering Co., Ltd., „Shipbuilding“

[17] Barry Rogliano Salles, „History, Trends and Prospects for LNG Shipping”, Athens, February 2012.

[18] Center for Energy Economics „Introduction to LNG“

[19] www.edgar-online.com

TRANSPORT INDICATORS WITHIN THE AREAS OF PORTS IN THE ADRIATIC REGION: MOTOR VEHICLE TRAFFIC VOLUMES AND ANALYSIS

Ivan Ivković, D.Sc.
University of Belgrade
Faculty of Transport and Traffic Engineering
Vojvode Stepe 305, Belgrade, Serbia
i.ivkovic@sf.bg.ac.rs

ABSTRACT

Within the work package 4 (Assessment of the Adriatic port system and its integration with hinterland) of the project EA SEA-WAY the researches of road infrastructure and motor vehicles traffic flows within the area of ports in the Adriatic-Ionian region were conducted. This paper presents a part of these studies, which refers to the Croatian ports that are the subject of the project. The analysis of road infrastructure and motor vehicle traffic flows covers six Croatian ports: Rovinj, Pula, Krk, Mali Lošinj, Rab and Dubrovnik. The distribution of traffic flows and analysis of transport volumes are presented for four-year period (2010-2013), taking into account the different categories of motor vehicles (passenger vehicles and freight vehicles) and seasonal inequalities. Seasonal inequalities are expressed using a defined average summer daily traffic (ASDT) for the period from 1 July to 31 August.

Key words: Port, road transport, passenger vehicle, freight vehicles, traffic flow, traffic volume.

1 INTRODUCTION

Transport indicators are simple measures or statistics that demonstrate the state of the occurrence that is the subject of transport analysis (Depolo, 2010). Motor vehicle traffic volumes are among the primary indicators in the transport sector. They are the part of the input data of different transport models by which strategic decisions are made and the goal of these decisions is to create a sustainable transport system. One of the goals of EA SEA-WAY project is development of sustainable passenger transport models for the Adriatic basin and capacity building. Creating these models involves the collection and analysis of transport indicators of each transport modes. Within the road sector for the purposes of models, it is necessary to carry out road traffic flows analysis within the areas of ports in the Adriatic-Ionian region which covers a total of 17 ports from 6 countries, Croatia, Italy, Slovenia, Montenegro, Albania, Greece. In this article is presented a part of the overall research relating to the six Croatian ports: Rovinj, Pula, Krk, Mali Lošinj, Rab and Dubrovnik.

In order to obtain the characteristic values of the traffic volumes realized on a road section or in the whole area which includes part of the road network (e.g. areas of six Croatian ports) it is necessary in the first step to dispose of the characteristic values of *Annual average daily traffic* (AADT). AADT represents the ratio of the sum of the flow of motor vehicles at certain days and the number of days in the year (Kuzović, 1987), Eq. (1):

$$AADT=\frac{\sum_{i=1}^{n} DT_{(i)}}{n} \quad \left(\frac{veh}{day}\right) \tag{1}$$

where: $DT_{(i)}$-motor vehicle flows on certain days (veh/day), n-number of days in the year, n=365

AADT represents one of the main indicators of transport, which is used widely in planning, design, operation, fuel-tax revenue projections and management of roads and facilities (Zhong et al., 2012; Gastaldi et al., 2013).When it comes to certain areas which includes part of the road network, for traffic analysis, traffic volumes are convenient such as transport indicators because they take into account the length of individual road sections of the road network.

However, traffic volumes are the only one segment of the necessary input data for methodological procedure for evaluating the impact of motor vehicles on the environment in the area of Croatian ports so it is therefore necessary to identify and analyze. Figure 1 shows one possible use of the traffic volumes to determine the impact of motor vehicles on the environment in the area of Croatian ports.

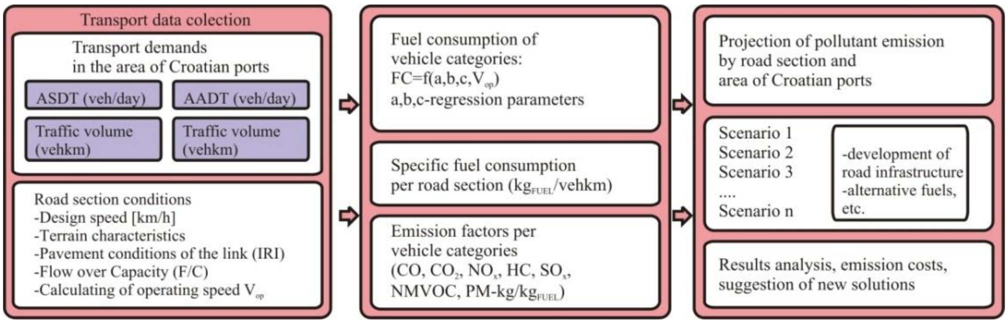


Figure 1: Methodological procedure for evaluating the impact of motor vehicles on the environment in the area of Croatian ports

Source: Own Research

Figure 2 shows distribution of traffic flows in Croatia for the year 2010. This figure depicts two main traffic corridors extending from the capital city Zagreb. The first main corridor (highway A1) provides directions to the west and south west, i.e. through Karlovac to the Croatian coast with the value of the average annual daily traffic (AADT) of approximately 30,000 veh/day (average for the period 2010-2013). The corridor includes the arterial that bypasses Bosiljevo, namely, to Rijeka (highway A6) with AADT value of around 12,000 veh/day and to Zadar, Šibenik and Split (continued highway A1) with AADT value of around 13,000 veh/day. The second main corridor spreads from Zagreb across Nova Gradiška, Slavonski Brod (highway A3) to the Lipovac border crossing with AADT values of around 20,000 veh/day, 13,500 veh/day, 10,500 veh/day, 6,000 veh/day, respectively. If the geographical positions of the Croatian ports (Rovinj, Pula, Krk, Rab, Mali Lošinj, Dubrovnik) are taken into consideration, it is evident that branches of the first main corridor are of particular importance for the analysis of traffic flows in their respective regions, i.e. roads from junction Bosiljevo to Rijeka and from junction Bosiljevo to Split and Dubrovnik.

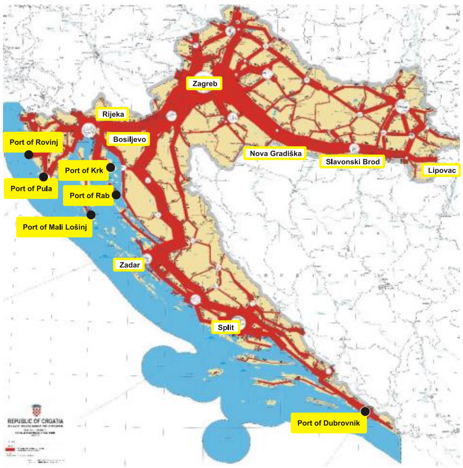


Figure 2: Road traffic distribution in Croatia (AADT/2010)

Source: Hrvatske Ceste, 2011

Figure 3 and Figure 4 show detailed distribution of traffic flows on the Istrian peninsula, the islands of Cres, Krk and Rab, and within the region of the city of Dubrovnik in 2010.

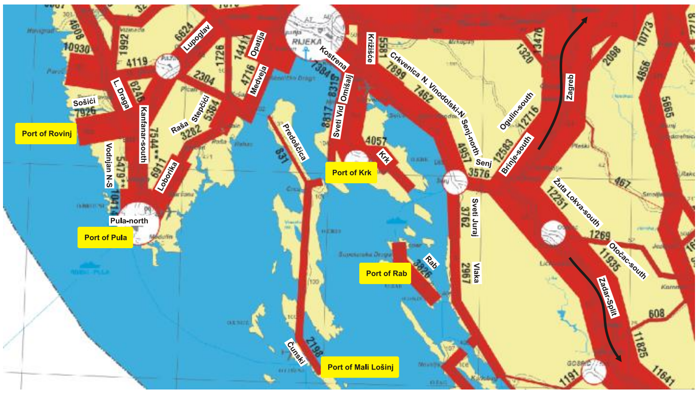


Figure 3: Road traffic distribution within the areas of ports Rovinj, Pula, Krk, Rab and Mali Lošinj (AADT/2010)

Source: Hrvatske Ceste, 2011

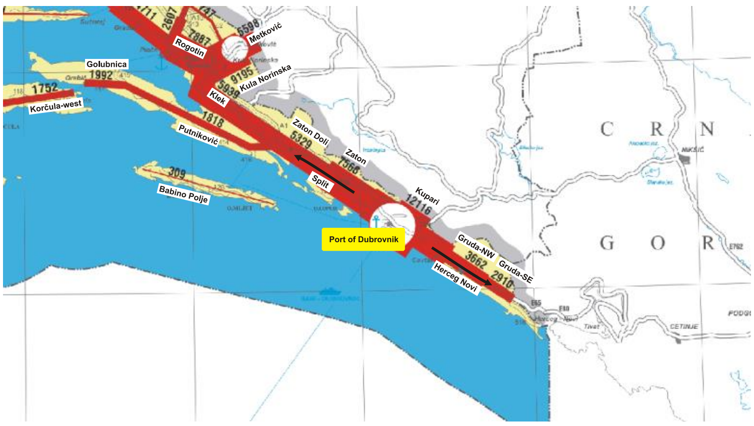


Figure 4: Road traffic distribution within the area of port of Dubrovnik (AADT/2010)

Source: Hrvatske Ceste, 2011

2 DATA AND METHODS

In order to determine the traffic volumes for area of Croatian ports it is necessary to identify the road sections in the characteristic regions, know the road section length and have the data on AADT.

The traffic volumes at the level of area of Croatian ports are based and calculated on the Eq. (2) (Topenčarević, 1987):

$$TV_{(j)} = \sum (AADT \cdot L)_{(j)} \quad (vehkm) \tag{2}$$

where: -$TV_{(j)}$ traffic volumes for (j)th area of Croatian ports; L-road section length (km)

Data on AADT and road sections length, obtained on the basis of traffic counting conducted by the company “Hrvatske ceste” (Croatian roads). The methodology of traffic counting involves someone counting methods:

- Periodical automatic traffic counting (periodically automatic counting is executed at specified times in the manner planned of schedule of counting)
- Continuous automatic traffic counting (for continuous automatic traffic count are used stationary automatic traffic counters)
- Toll-paid traffic counting (conducted on the basis of use of some modern road building where the charge tolls)

Table 1 contains the values of road traffic flows in the areas that are shown on Figures 3 and 4. The level of detail involves the following data:

- The year in which the actual traffic flow is realized (2010, 2011, 2012 and 2013)
- Categories of motor vehicles - passenger car, bus and truck (available for the years 2012 and 2013)
- Seasonal inequalities

Seasonal inequalities are expressed using a defined average summer daily traffic (ASDT). ASDT represents the average daily number of vehicles that pass through the road section in the summer period, from 1 July to 31 August.

Table 1: Detailed view of the actual traffic flows within the areas of ports Rovinj, Pula, Krk, Rab, Mali Lošinj and Dubrovnik [veh/day]

Rovinj-Pula area		2010		2011		2012								2013							
	km	AADT	ASDT	AADT	ASDT	AADT	Pass. V.	Bus	Fre. V.	ASDT	Pass. V.	Bus	Fre. V.	AADT	Pass. V.	Bus	Fre. V.	ASDT	Pass. V.	Bus	Fre. V.
Sušići	7.4	7,926	12,639	7,930	12,692	7,902	6,668	73	1,161	12,816	10,824	124	1,868	7,575	6,319	79	1,177	13,113	10,880	144	2,089
Limska Draga	7.4	6,246	12,094	6,898	12,009	5,520	4,677	82	761	12,472	10,583	140	1,749	5,974	5,218	89	667	13,423	11,467	142	1,814
Kanfara-south	14.5	7,544	12,088	6,513	12,220	6,097	5,207	101	789	12,080	10,503	147	1,430	6,402	5,653	102	647	12,879	11,202	144	1,533
Vodnjan N-S	6.2	5,479	9,196	4,746	9,656	4,683	4,016	74	593	9,669	8,425	112	1,132	4,949	4,366	78	505	10,239	8,893	115	1,231
Pula-north	4	10,414	13,022	10,696	13,527	10,659	8,522	137	2,000	13,300	10,534	153	2,613	10,514	8,890	80	1,544	13,262	11,488	84	1,690
Loborika	2.1	6,911	8,621	6,973	8,729	6,979	6,132	41	806	8,883	7,860	48	975	6,724	5,871	28	825	8,423	7,554	26	843
Raša	8.4	3,282	5,063	3,290	5,097	3,298	2,805	28	465	5,161	4,412	41	708	3,186	2,696	23	467	4,736	4,192	26	518
Stepčići	5.5	5,364	7,818	5,889	7,882	5,682	4,848	59	775	8,019	7,014	53	952	5,592	4,787	56	749	7,949	7,012	50	887
Medveja	7.7	4,716	8,139	4,671	7,846	4,672	4,244	55	373	7,992	7,336	68	588	4,427	4,012	61	354	7,789	7,161	70	558
Opatija	2.6	14,411	18,378	15,259	21,065	15,250	14,299	67	884	20,763	19,601	85	1,077	8,817	8,198	13	606	10,595	9,852	10	733
Lupoglav-south	12.8	6,624	10,114	6,803	10,187	6,297	5,039	104	1,154	9,603	7,926	124	1,553	6,363	5,082	111	1,170	9,675	8,020	121	1,534
Krk area		2010		2011		2012								2013							
		AADT	ASDT	AADT	ASDT	AADT	Pass. V.	Bus	Fre. V.	ASDT	Pass. V.	Bus	Fre. V.	AADT	Pass. V.	Bus	Fre. V.	ASDT	Pass. V.	Bus	Fre. V.
Krk	2.3	4,057	8,892	4,166	8,958	4,275	3,719	51	505	9,009	8,116	60	833	4,329	3,729	51	549	9,271	8,307	68	896
Sveti Vid	3.1	8,817	18,913	8,799	19,070	8,756	7,318	81	1,357	19,146	16,052	174	2,920	9,197	7,512	92	1,593	19,793	16,416	186	3,191
Omišalj	2.3	8,315	15,374	8,586	15,466	8,622	7,264	92	1,266	15,573	13,459	126	1,988	8,738	7,282	90	1,366	16,099	13,764	129	2,206
Kostrena	2.2	7,384	10,183	5,952	7,402	4,794	4,264	92	438	6,915	6,265	87	563	4,220	3,724	91	405	6,143	5,540	77	526
Križišće	3.7	5,581	11,506	5,801	11,606	5,267	4,580	44	643	10,961	9,823	128	1,010	4,663	4,085	37	541	8,254	7,436	96	722
Crkvenica	3.1	7,789	14,493	7,789	14,132	7,620	6,368	59	1,193	13,968	11,941	99	1,928	7,637	6,423	60	1,154	14,768	12,650	105	2,013
N. Vinodolski-N	5.6	7,462	14,663	7,431	14,685	7,153	5,893	84	1,176	14,750	12,173	157	2,420	7,596	6,294	76	1,226	13,911	11,618	142	2,151

Mali Lošinj area		**2010**		**2011**		**2012**								**2013**							
	km	**AADT**	**ASDT**	**AADT**	**ASDT**	**AADT**	**Pass. V.**	**Bus**	**Fre. V.**	**ASDT**	**Pass. V.**	**Bus**	**Fre. V.**	**AADT**	**Pass. V.**	**Bus**	**Fre. V.**	**ASDT**	**Pass. V.**	**Bus**	**Fre. V.**
Predošćica	10.1	831	2,669	779	2,524	749	627	7	115	2375	2,008	21	346	685	578	6	101	2,057	1,750	17	290
Čunski	6.3	2,198	4,578	2,216	4,596	2,217	1,889	21	307	4,509	3,992	24	493	2,172	1,859	20	293	4,525	4,019	24	482
Rab area		**2010**		**2011**		**2012**								**2013**							
		AADT	**ASDT**	**AADT**	**ASDT**	**AADT**	**Pass. V.**	**Bus**	**Fre. V.**	**ASDT**	**Pass. V.**	**Bus**	**Fre. V.**	**AADT**	**Pass. V.**	**Bus**	**Fre. V.**	**ASDT**	**Pass. V.**	**Bus**	**Fre. V.**
Senj-north	13.3	4,957	11,436	4,885	11,133	4,758	4,127	52	579	11,037	9,775	98	1,164	3,938	3,146	65	727	8,473	7,164	82	1,227
Senj	11	3,576	7,680	3,597	7,619	3,574	2,708	46	820	7,827	6,212	57	1,558	3,417	2,838	42	537	7,555	6,593	64	898
Sveti Juraj	8.1	3,762	8,769	3,764	8,794	3,666	3,061	40	565	8,728	7,296	94	1,338	3,732	2,988	44	700	8,618	7,016	106	1,496
Vlaka	19	2,967	7,478	3,077	7,525	2,993	2,444	36	513	7,242	6,231	62	949	2,914	2,350	37	527	7,179	6,169	65	945
Rab	5.3	3,826	9,011	3,699	8,631	3,616	3,177	18	421	8,376	7,391	38	947	3,580	3,328	42	210	8,150	6,683	89	1,378
Žuta Lokva-south	11.6	12,251	30,873	12,841	32,809	12,162	10,363	191	1,608	31,133	27,916	293	2,924	12,414	10,996	196	1,222	32,404	29,037	302	3,065
Brinje-south	11.1	12,583	32,508	13,244	34,542	12,595	10,818	189	1,588	32,845	29,550	307	2,988	12,839	11,418	195	1,226	34,046	30,597	314	3,135
Ogulin-south	28.3	12,716	32,635	13,378	34,654	12,684	10,900	190	1,594	32,962	29,646	310	3,006	12,958	11,533	198	1,227	34,159	30,701	317	3,141
Otočac-south	32.1	11,935	30,408	12,529	32,341	11,898	10,135	187	1,576	30,731	27,560	288	2,883	12,145	10,743	191	1,211	3,9,45	28,622	295	3,028
Dubrovnik area		**2010**		**2011**		**2012**								**2013**							
		AADT	**ASDT**	**AADT**	**ASDT**	**AADT**	**Pass. V.**	**Bus**	**Fre. V.**	**ASDT**	**Pass. V.**	**Bus**	**Fre. V.**	**AADT**	**Pass. V.**	**Bus**	**Fre. V.**	**ASDT**	**Pass. V.**	**Bus**	**Fre. V.**
Kupari	0.6	12,116	17,144	12,106	17,688	12,129	10,635	257	1,237	17,873	15,714	397	1,762	12,286	10,737	275	1,274	17,778	15,563	393	1,822
Zaton	9.1	7,568	13,416	7,824	14,102	7,737	5,749	100	1,888	13,834	9,854	131	3,849	7,788	6,582	136	1,070	13,831	11,951	194	1,686
Zaton Doli	6.1	5,329	10,050	4,804	9,769	4,630	3,732	135	763	9,698	8,301	210	1,187	4,556	3,686	138	732	9,338	8,050	205	1,083
Putnikovic	6	1,818	3,931	1,787	3,892	1,712	1,383	31	298	3,694	3,124	56	514	1,548	1,276	25	247	3,248	2,781	41	426
Golubnica	6.7	1,992	3,930	1,902	3,697	1,856	1,538	17	301	3,599	2,983	36	580	1,822	1,510	17	295	3,411	2,827	34	550
Babino Polje	15.5	309	670	311	652	338	285	1	52	627	552	0	75	327	279	0	48	660	581	1	78
Gruda-SE	1.6	2,910	5,693	3,088	6,369	2,730	1,721	26	983	5,432	3,254	44	2,134	3,626	3,213	74	339	6,124	5,533	87	504
Klek	8.8	5,939	11,132	5,374	10,775	5,191	4,185	75	931	10,585	8,504	115	1,966	5,063	4,081	73	909	10,414	8,367	152	1,895
Korčula-west	0.8	1,752	3,490	2,007	3,351	1,937	1,671	10	256	3,239	2,831	14	394	1,822	1,510	17	295	3,411	2,827	34	550
Kula Norinska	2.2	9,195	12,617	9,249	13,513	9,336	7,793	106	1,437	13,898	11,833	158	1,907	9,192	7,674	104	14,14	13,498	11,491	154	1,853
Metković	1	5,598	7,756	5,635	7,531	4,963	4,538	82	343	6,852	6,317	133	402	4,794	4,492	70	232	6,578	6,266	94	218
Rogotin	3.1	7,887	14,169	8,103	14,952	7,840	6,459	140	1,241	14,566	12,581	191	1,794	8,562	6,784	64	1,714	13,127	10,740	70	2,317

Source: Hrvatske Ceste, 2010; Hrvatske Ceste, 2011; Hrvatske Ceste, 2012; Hrvatske Ceste, 2013

3 DATA ANALISYS AND DISCUSSION

Table 2 shows the values of the realized average daily traffic volume expressed in vehicle kilometers within the areas of ports Pula and Rovinj. Data were obtained from Table 1.

Table 2: Realized average daily traffic volume in the four-year period within the areas of ports Pula and Rovinj [vehkm]

Year	**2010**		**2011**		**2012**		**2013**	
Season	full-year	summer period	full-year	summer period	full-year	summer period	full-year	summer period
Vehkm	520,039.5	810,948.0	513,762.2	824,026.1	489,236.0	819,990.8	475,928.7	812,194.2
Percentage value compared to 2010	-	-	-1.21	1.61	-5.92	1.12	-8.48	0.15

Based on Table 2 it can be seen that the largest value of a daily traffic volume within the areas of ports Pula and Rovinj is realized in the summer period of 2011 with 824.02 thousand vehkm, which is 1.61% higher compared to the same period in 2010. The smallest positive change in terms of an increase in traffic volume in relation to the year 2010 was recorded in the summer period of 2012 and is 0.15%. 2012 and 2013 were characterized by a drop in realized vehkm for 5.92% and 8.48%, respectively, if the whole year is being observed, which suggests that traffic volume in this area out of summer season is having smaller value than the equivalent value in 2010. By observing all four years, traffic has greater intensity during summer period than in the other months for approximately 85%.

Table 3 shows the values of the average daily traffic volume for the road sections "Sušići" (port of Rovinj), "Pula-north" and "Loborika " (port of Pula).

Table 3: Realized average daily traffic volume on the road sections "Sušići" (port of Rovinj), "Pula-north", "Loborika" (port of Pula) [vehkm]

Road section	Year	2010		2011		2012		2013	
	Season	full-year	summer period	full-year	summer period	full-year	summer period	full-year	summer period
Sušići	vehkm	58,652.4	93,528.6	58,682.0	93,920.8	58,474.8	94,838.4	56,055.0	97,036.2
	Percentage value compared to 2010	-	-	0.05	0.42	-0.30	1.40	-4.43	3.75
Pula-north	vehkm	41,656.0	52,088.0	42,784.0	54,108.0	42,636.0	53,200.0	42,056.0	53,048.0
	Percentage value compared to 2010	-	-	2.71	3.88	2.35	2.13	0.96	1.84
Loborika	vehkm	14,513.1	18,104.1	14,643.3	18,330.9	14,655.9	18,654.3	14,120.4	17,688.3
	Percentage value compared to 2010	-	-	0.90	1.25	0.98	3.04	-2.71	-2.30

It is interesting to note that the traffic volume that was realized in 2011 and 2012 at the road section "Sušići" for all vehicle categories is almost identical to the one that was realized in 2010. The value of percentage change is less than 1.5% for both, summer and full-year period. In 2013 the realized value of vehkm for the whole year decreased for 4.43% compared to 2010, while in the summer period it can be seen an increase by 3.75%.

The road section "Pula-north" is characterised by an increase in the realized traffic volume for all three years (2011, 2012 and 2013) compared to 2010. The largest percentage increase was noted in 2011 and for the summer period is 3.88%, while for the full year is 2.71%. During the next two-year period the traffic volume is reduced compared to the year 2011 but still has a higher value than in 2010.

The road section "Loborika" is specified by the lowest change of the realized traffic volume compared to 2010. The highest positive change (3.04%) was observed in the summer period of 2012, while in 2013 was noted a small decline of traffic volume: -2.71% and -2.30%.

Table 4 shows the values of realized average daily traffic volume measured in vehicle kilometres in the areas of ports Pula and Rovinj according to vehicle categories (passenger and freight) in years (2012 and 2013) for which data were available.

Table 4: The realized values of average daily traffic volume in the areas of ports Pula and Rovinj according to vehicle categories in years 2012 and 2013 [vehkm]

Year	2012			2012			2013			2013		
Season	Year			Summer			Year			Summer		
Road Section	Pass. V.	Fre. V.	%Pass. V.	Pass. V.	Fre. V.	%Pass. V.	Pass. V.	Fre. V.	%Pass. V.	Pass. V.	Fre. V.	%Pass. V.
Sušići	49,883.4	8,591.4	85.3	81,015.2	13,823.2	85.4	47,345.2	8,709.8	84.5	81,577.6	15,458.6	84.1
Limska Draga	35,216.6	5,631.4	86.2	79,350.2	12,942.6	86.0	39,271.8	4,935.8	88.8	85,906.6	13,423.6	86.5
Kanfara-south	76,966.0	11,440.5	87.1	154,425.0	20,735.0	88.2	83,447.5	9,381.5	89.9	164,517.0	22,228.5	88.1
Vodnjan N-S	25,358.0	3,676.6	87.3	52,929.4	7,018.4	88.3	27,552.8	3,131.0	89.8	55,849.6	7,632.2	88.0
Pula-north	34,636.0	8,000.0	81.2	42,748.0	10,452.0	80.4	35,880.0	6,176.0	85.3	46,288.0	6,760.0	87.3
Loborika	12,963.3	1,692.6	88.5	16,606.8	2,047.5	89.0	12,387.9	1,732.5	87.7	15,918.0	1,770.3	90.0
Raša	23,797.2	3,906.0	85.9	37,405.2	5,947.2	86.3	22,839.6	3,922.8	85.3	35,431.2	4,351.2	89.1
Stepčići	26,988.5	4,262.5	86.4	38,868.5	5,236.0	88.1	26,636.5	4,119.5	86.6	38,841.0	4,878.5	88.8
Medveja	33,102.3	2,872.1	92.0	57,010.8	4,527.6	92.6	31,362.1	2,725.8	92.0	55,678.7	4,296.6	92.8
Opatija	37,351.6	2,298.4	94.2	51,183.6	2,800.2	94.8	21,348.6	1,575.6	93.1	25,641.2	1,905.8	93.1
Lupoglav-south	65,830.4	14,771.2	81.7	103,040.0	19,878.4	83.8	66,470.4	14,976.0	81.6	104,204.8	19,635.2	84.1
total	422,093.3	67,142.7	average	714,582.7	105,408.1	average	414,542.4	61,386.3	average	709,853.7	102,340.5	average

Year	2012			2012			2013			2013		
Season	Year			Summer			Year			Summer		
Road Section	Pass. V.	Fre. V.	%Pass. V.	Pass. V.	Fre. V.	%Pass. V.	Pass. V.	Fre. V.	%Pass. V.	Pass. V.	Fre. V.	%Pass. V.
% 2013/2012	-	-	86.9	-	-	87.5	-1.79	-8.57	87.3	-0.66	-2.91	88.3

By observing the entire area of ports Rovinj and Pula, the share of traffic volume that comes from passenger vehicles (passenger cars and buses) has the average value greater than 86% for all road sections, regardless of whether the traffic volume is realized in the summer period or throughout the whole year. It can be seen that the average value of the share of passenger cars is approximately equal (constant - close to a value of 87%) during the summer period and throughout the whole year and regardless of the year (2012 or 2013). The share of passenger vehicles in traffic flow on the road section “Sušići” (port of Rovinj) is around 85% during 2012 and 2013. A similar distribution of the share of passenger vehicles in the traffic flow is also observed on the road section “Loborika” (port of Pula) but with a higher value (approximately 89%). The road section “Pula-north” (port of Pula) is specified by the share of passenger vehicles in the traffic flow which is less for the year 2012 (approximately 81%) than for the year 2013 (approximately 88%).

Table 5 shows the values of realized average daily traffic volume measured in vehicle kilometers in the areas of ports Krk, Mali Lošinj and Rab.

In the area of port of Krk the realized total traffic volume during the summer period was twice higher than the overall traffic volume realized during the other months of the year (2010-2.38; 2011-2.34; 2012-2.45; 2013-2.31).

The traffic volume in 2011 had a lower rate compared to 2010, but with a small percentage by observing both time frames. In 2012 it was observed the decline in traffic volume by 5.1% compared to the full year, but an increase of total traffic in the summer period for almost 3%. In 2013 it can be noted an increase in traffic volume throughout the year (4.6%), while a higher increase can be seen during the summer season (6.2%) throughout the whole four-year period.

Table 5: The realized average daily traffic volume for the four-year period in the areas of ports Krk, Mali Lošinj and Rab [vehkm]

Year	2010		2011		2012		2013	
Season	Full-year	Summer period	Full-year	Summer period	Full-year	Summer period	Full-year	Summer period
Krk area, vehkm	158,615.9	306,458.0	156,924.1	300,564.0	150,520.2	297,560.7	151,314.2	287,446.1
Percentage value compared to 2010	-	-	-1.07	-1.92	- 5.10	2.90	4.60	6.20
Mali Lošinj area, vehkm	22,240.5	55,798.3	21,828.7	54,447.2	21,532.0	52,394.2	20,602.1	49,283.2
Percentage value compared to 2010	-	-	-1.85	-2.42	-3.19	-6.10	-7.37	-11.68
Rab area, vehkm	107,123.0	260,869.2	108,556.1	259,950.7	105,726.4	252,687.6	104,569.2	249,401.8
Percentage value compared to 2010	-	-	1.34	-0.35	-1.30	-3.14	-2.38	-4.40

The situation in the area of port of Mali Lošinj is different regarding the realization of traffic volume in relation to the area of port of Krk. The traffic had been in continuous decline starting from 2011 until the end of 2013. Rates of traffic decrease related to the average values during the whole year were increasing from 1.85% (2011) to more than 7% (2013). Changes in the decline of traffic volume were even more expressed in the summer months

(2011-3.19%; 2012-7.37%; 2013-11.68%) compared to 2010. Despite of higher rates of decrease of traffic volume during the summer season, in this period was realized an increased value of average traffic (3.3-3.5 times higher) compared to its average value during the whole year.

Rab island is specific by its values of the realized traffic volumes (average value throughout the whole year and average value during the summer period) that have the same trend over the four year period as realized traffic volume in the area of port of Mali Lošinj but with minor oscillations and smaller rates of traffic decline which can be seen from Table 5. Additionally, as in the two previous cases, traffic has greater intensity during the summer months as compared to other months (3.5 times higher).

Table 6 shows the values of the average daily traffic volume for the road sections “Krk”, “Sveti Vid” (port of Krk), “Čunski” (port of Mali Lošinj), “Rab” (port of Rab).

Table 6: Realized average daily traffic volume on road sections “Krk”, “Sveti Vid” (port of Krk), “Čunski” (port of Mali Lošinj), “Rab” (port of Rab) [vehkm]

Road Section	Year	2010		2011		2012		2013	
	Season	Full-year	Summer period	Full-year	Summer period	Full-year	Summer period	Full-year	Summer period
Krk	vehkm	9,331.1	20,451.6	9,581.8	20,603.4	9,832.5	20,720.7	9,956.7	21,323.3
	Percentage value compared to 2010			2.69	0.74	5.37	1.32	6.70	4.26
Sveti Vid	vehkm	27,332.7	58,630.3	27,276.9	59,117.0	27,143.6	59,352.6	28,510.7	61,358.3
	Percentage value compared to 2010	-	-	-0.20	0.83	-0.69	1.23	4.31	4.65
Čunski	vehkm	13,847.4	28,841.4	13,960.8	28,954.8	13,967.1	28,406.7	13,683.6	28,507.5
	Percentage value compared to 2010	-	-	0.82	0.39	0.86	-1.51	-1.18	-1.16
Rab	vehkm	20,277.8	47,758.3	19,604.7	45,744.3	19,164.8	44,392.8	18,974.0	43,195.0
	Percentage value compared to 2010	-	-	-3.32	-4.22	-5.49	-7.05	-6.43	-9.55

On the road section “Krk” in the area of port of Krk the realized traffic volume for all the three years after 2010 increases in terms of AADT. In the summer period it is also evident a traffic increase, but with lower rates ranging from 0.74% (2011) to 4.26% (2013). For years 2011 and 2012, on the road section “Sveti Vid” were recorded lower values of traffic volume by observing the whole year, but in a very small percentage (0.2% and 0.69%, respectively). During the summer months it can be seen a continuous traffic growth over the three years period from 2011 to 2013.

The road section “Čunski” has higher traffic volume in 2011 and 2012 in a small percentage (less than 1%), but it should be mentioned that during the summer in 2012 the traffic had less intensity than the equivalent value in 2010. Rates of traffic decrease throughout the year and during the summer period were present in 2013.

For the road section “Rab” as in the case of the whole region of the port of Rab it is characteristic continuous traffic reduction. Rates of decrease in relation to the whole area were higher which can be seen from the previous two tables.

Table 7 shows the values of realized traffic volume measured in vehicle kilometers within the areas of ports Krk, Rab and Mali Lošinj according to vehicle categories (passenger and freight) in years (2012 and 2013) for which data are available.

Table 7: Realized values of average daily traffic volume within the areas of ports Krk, Rab and Mali Lošinj according to vehicle categories for the years 2012 and 2013 [vehkm]

	Year	2012			2012			2013			2013		
	Season	Year			Summer			Year			Summer		
	Road Section	Pass. V.	Fre. V.	%Pass. V.	Pass. V.	Fre. V.	%Pass. V.	Pass. V.	Fre. V.	%Pass. V.	Pass. V.	Fre. V.	%Pass. V.
Port of Krk	Krk	8,671.0	1,161.5	88.2	18,804.8	1,915.9	90.8	8,694.0	1,262.7	87.3	19,262.5	2,060.8	90.3
	Sveti Vid	22,936.9	4,206.7	84.5	50,300.6	9,052.0	84.7	23,572.4	4,938.3	82.7	51,466.2	9,892.1	83.9
	Omišalj	16,918.8	2,911.8	85.3	31,245.5	4,572.4	87.2	16,955.6	3,141.8	84.4	31,953.9	5,073.8	86.3
	Kostrena	9,583.2	963.6	90.9	13,974.4	1,238.6	91.9	8,393.0	891.0	90.4	12,357.4	1,157.2	91.4
	Križišće	17,108.8	2,379.1	87.8	36,818.7	3,737.0	90.8	15,251.4	2,001.7	88.4	27,868.4	2,671.4	91.3
	Crkvenica	19,923.7	3,698.3	84.3	37,324.0	5,976.8	86.2	20,097.3	3,577.4	84.9	39,540.5	6,240.3	86.4
	N. Vinodol.-N	33,471.2	6,585.6	83.6	69,048.0	13,552.0	83.6	35,672.0	6,865.6	83.9	65,856.0	12,045.6	84.5
	total	128,613.6	21,906.6	average	257,516.0	40,044.7	average	128,635.7	22,678.5	average	248,304.9	39,141.2	average
	% 2013/2012	-	-	86.4	-	-	87.9	0.02	3.52	86.0	-3.58	-2.26	87.7
Port of M . Lošinj	Predošćica	6,403.40	1,161.50	84.65	20,492.90	3,494.60	85.43	5,898.40	1,020.10	85.26	17,846.70	2,929.00	85.90
	Čunski	12,033.00	1,934.10	86.15	25,300.80	3,105.90	89.07	11,837.70	1,845.90	86.51	25,470.90	3,036.60	89.35
	total	18,436.40	3,095.60	average	45,793.70	6,600.50	average	17,736.10	2,866.00	average	43,317.60	5,965.60	average
	% 2013/2012	-	-	85.4	-	-	87.2	-3.80	-7.42	85.9	-5.41	-9.62	87.6
Port of Rab	Sveti Juraj	25,118.1	4,576.5	84.6	59,859.0	10,837.8	84.7	24,559.2	5,670.0	81.2	57,688.2	12,117.6	82.6
	Vlaka	47,120.0	9,747.0	82.9	119,567.0	18,031.0	86.9	45,353.0	10,013.0	81.9	118,446.0	17,955.0	86.8
	Rab	16,933.5	2,231.3	88.4	39,373.7	5,019.1	88.7	17,861.0	1,113.0	94.1	35,891.6	7,303.4	83.1
	total	89,171.6	16,554.8	average	218,799.7	33,887.9	average	87,773.2	16,796.0	average	212,025.8	37,376.0	average
	% 2013/2012	-	-	85.3	-	-	86.8	-1.57	1.46	85.8	-3.10	10.29	84.2

Average values of the share of passenger cars in the realization of the traffic volume are similar to those on the Istrian peninsula. In the area of port of Krk, average values are in the range of 86% to 88% for the two-year period. If the values related to the summer and full-year period are compared, the differences are very small. In the area of port of Mali Lošinj the shares of passenger traffic were slightly lower than in the case of port of Krk (min 85.4% for the year 2012; max 87.6% in 2013). Also, the shares of passenger traffic in the area of port of Rab were slightly lower compared to the equivalent values of the port of Mali Lošinj (min 84.2% in 2012 - summer period; max 86.8% in 2012 - summer period).

Table 8 shows the values of the realized average daily traffic volume measured in vehicle kilometers in the area of port of Dubrovnik.

Table 8: Realized average daily traffic volume in the four-year period in the area of port of Dubrovnik [vehkm]

Year	2010		2011		2012		2013	
Season	Full-year	Summer period	Full-year	Summer period	Full-year	Summer period	Full-year	Summer period
vehkm	246,286.7	443,278.7	240,992.0	448,061.8	235,277.9	438,779.4	235,970.1	427,200.1
Percentage value compared to 2010	-	-	-2.15	1.08	-4.47	-1.02	-4.19	-3.63

According to data from Table 8, it is evident that the highest traffic volume in the area of port of Dubrovnik was realized during 2010. On an annual basis, the value of the traffic value is continuously decreasing from 2010 to 2012 (rate of decline ranges from 2.15% to 4.19%). The realized traffic volume in 2013 is very close to the value of 2012. During the summer period, it is also noticeable decrease of traffic that was realized in 2012 and 2013, while in 2011 the traffic had the same intensity as in 2010. If the traffic during the summer period and in months beyond the summer period are being compared for all four years, it can be seen that the traffic flow is 4 times higher during the summer period.

Table 9 shows the values of the average daily traffic volume on the road sections “Krk”, “Sveti Vid” (port of Krk), “Čunski” (port of Mali Lošinj), “Rab” (port of Rab).

Table 9: Realized average daily traffic volume on road sections of port of Dubrovnik [vehkm]

Road Section	Year	2010		2011		2012		2013	
	Season	**Full-year**	**Summer period**	**Full-year**	**Summer period**	**Full-year**	**Summer period**	**Full-year**	**Summer period**
Kupari	vehkm	7,269.6	10,286.4	7,263.6	10,612.8	7,277.4	10,723.8	7,371.6	10,666.8
	Percentage value compared to 2010	-	-	-0.08	3.17	0.11	4.25	1.40	3.70
Zaton	vehkm	68,868.8	122,085.6	71,198.4	128,328.2	70,406.7	125,889.4	70,870.8	125,862.1
	Percentage value compared to 2010	-	-	3.38	5.11	2.23	3.12	2.91	3.09
Gruda-SE	vehkm	4,656.0	9,108.8	4,940.8	10,190.4	4,368.0	8,691.2	5,801.6	9,798.4
	Percentage value compared to 2010	-	-	6.12	11.87	-6.19	-4.58	24.60	7.57

Based on Table 9 it is evident that in the case of road section “Kupari” traffic volume has approximately the same values for all four years (the maximum change was 1.4% for 2013). During the summer months, an increase in traffic can be noticed ranging from approximately 3% (2011) to 4% (2012) compared to 2010. In summer period, traffic flows have values that are 1.5 times (2010) to 1.6 times (2012) higher.

The road section “Zaton” is characterized by the largest increase in traffic volume by 5.11% (2011-summer period) compared to the equivalent value in 2010. Since 2011, traffic has slightly decreased. Rates of decrease have values of 2.23% and 2.91% in 2012 and 2013, respectively. For the road section “Gruda-SE” it is evident that are present higher percentages of change in traffic volume for the last three years of the four-year period compared to 2010. The highest values of the traffic volume were realized in 2013 (percentages of growth were 24.60% and 7.57% for the whole year and summer period, respectively). For the year 2012, it is noticeable traffic decrease of approximately 6%.

Table 10 shows the values of the realized average daily traffic volume measured in vehicle kilometers in the areas of ports Krk, Rab and Mali Lošinj according to vehicle categories (passenger and freight) in years (2012 and 2013) for which data were available.

Table 10: Realized values of average daily traffic volume within the area of of port of Dubrovnik according to vehicle categories for the years 2012 and 2013 [vehkm]

Year	**2012**			**2012**			**2013**			**2013**		
Season	**Year**			**Summer**			**Year**			**Summer**		
Road Section	**Pass. V.**	**Fre. V.**		**Pass. V.**	**Fre. V.**		**Pass. V.**	**Fre. V.**		**Pass. V.**	**Fre. V.**	
Kupari	6,535.2	742.2	89.8	9,666.6	1,057.2	90.1	6,607.2	764.4	89.6	9,573.6	1,093.2	89.8
Zaton	53,225.9	17,180.8	75.6	90,863.5	35,025.9	72.2	61,133.8	9,737.0	86.3	110,519.5	15,342.6	87.8
Zaton Doli	23,588.7	4,654.3	83.5	51,917.1	7,240.7	87.8	23,326.4	4,465.2	83.9	50,355.5	6,606.3	88.4
Putnikovic	8,484.0	1,788.0	82.6	19,080.0	3,084.0	86.1	7,806.0	1,482.0	84.0	16,932.0	2,556.0	86.9
Golubnica	10,418.5	2,016.7	83.8	20,227.3	3,886.0	83.9	10,230.9	1,976.5	83.8	19,168.7	3,685.0	83.9
Babino Polje	4,433.0	806.0	84.6	8,556.0	1,162.5	88.0	4,324.5	744.0	85.3	9,021.0	1,209.0	88.2
Gruda-SE	2,795.2	1,572.8	64.0	5,276.8	3,414.4	60.7	5,259.2	542.4	90.7	8,992.0	806.4	91.8
Klek	37,488.0	8,192.8	82.1	75,847.2	17,300.8	81.4	36,555.2	7,999.2	82.0	74,967.2	16,676.0	81.8
Korčula-west	1,344.8	204.8	86.8	2,276.0	315.2	87.8	1,221.6	236.0	83.8	2,288.8	440.0	83.9
Kula Norinska	17,377.8	3,161.4	84.6	26,380.2	4,195.4	86.3	17,111.6	3,110.8	84.6	25,619.0	4,076.6	86.3

Year	2012			2012			2013			2013		
Season	Year			Summer			Year			Summer		
Road Section	Pass. V.	Fre. V.		Pass. V.	Fre. V.		Pass. V.	Fre. V.		Pass. V.	Fre. V.	
Metković	4,620.0	343.0	93.1	6,450.0	402.0	94.1	4,562.0	232.0	95.2	6,360.0	218.0	96.7
Rogotin	20,456.9	3,847.1	84.2	39,593.2	5,561.4	87.7	21,228.8	5,313.4	80.0	33,511.0	7,182.7	82.3
total	190,768.0	44,509.9	average	356,133.9	82,645.5	average	199,367.2	36,602.9	average	367,308.3	59,891.8	average
% 2013/2012	-	-	82.9	-	-	83.8	4.51	-17.76	85.8	3.14	-27.53	87.3

Based on Table 10 it can be observed that the average values of the share of passenger cars in realizing the overall traffic volume are slightly lower in 2012 than in 2013 (about 83% in 2012 and about 86% in 2013). This factual situation is present for both, the full-year time frame as well as for the summer period.

4 FORECASTS ON TRAFFIC VOLUMES

Generally, the total realized traffic volume on the road network for the certain area depends on a number of factors which can be divided into several groups: geographical and location parameters, socio-economic and sociopolitical characteristics, deployment activities, the characteristics of the transport network, the parameters of the movement of passengers and cargo. Most of the mentioned factors in the prediction of traffic or transport volume on the road network are based on Transtools transport model. Therefore, the results of this software package were used for forecasting of transport volumes for years 2020 and 2030.

Data of transport volumes until 2012 and forecasted transport volumes for 2020 and 2030 based on the results of the Transtools model (TenConnect, 2008) are given in Table 11, and are shown in Figure 5. Results are presented for the entire territory of Republic of Croatia.

Table 11: Forecasted transport volumes for Republic of Croatia (1000 x million PKM/TKM)

	2005	2006	2007	2008	2009	2010	2011	2012	2020	2030	Change 20/12 (%)	Change 30/12 (%)
Pass car PKM	24.00	25.00	26.00	27.00	26.80	25.70	25.24	26.15	34.60	43.90	32.33	67.90
Bus PKM	3.4	3.5	3.8	4.1	3.4	3.2	3.1	3.2	3.8	4.4	17.70	35.90
Freight TKM	9.33	10.18	10.50	11.04	9.43	8.78	8.93	8.65	14.60	18.40	68.81	112.74

Source: Statistical pocketbook 2013 transport in figures EU, Statistical pocketbook 2012 transport in figures EU, Statistical pocketbook 2011 transport in figures EU, International Transport Forum, Eurostat, Transtools Model

The declining trend in actual transport volume of passenger vehicles (passenger cars and buses in 2011), and trucks (2012) stagnation (buses 2012) or a slight growth (passenger cars for the year 2012 and trucks in 2011) in the case of Croatia are in line with the trend of actual traffic volume on road sections in the port area observed within the study. Therefore the changes at the state level can be characterized as relevant for assessing the growth or decline of traffic in the future (short-term or medium-term) in the Adriatic region. Major discrepancies can be evident during the summer months of 2011 and 2012, which was expected given the fact that the data in Table 11 refer to the full-year period of observation. From Table 11 it can be seen that in the short term (up to 2020) according to the results of the model, expected growth in passenger kilometers is 32.33% for passenger cars and 17.70% for buses compared to 2012. In relation to trucks, it is expected for 2020 tonne kilometers growth of 68.81% compared to 2012. In 2030, the expected growth in transport volume based on model approximation is 67.90% (passenger cars), 35.90% (buses) and 112.74% (trucks).

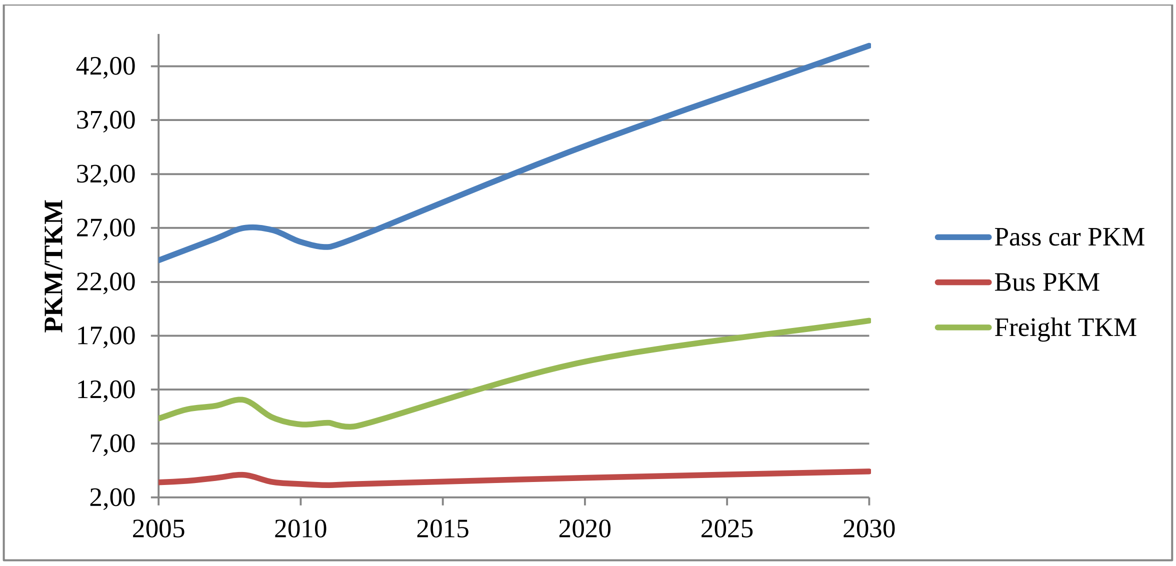


Figure 5: Forecasted transport volumes for Republic of Croatia (1000 x million PKM/TKM)

Source: Statistical pocketbook 2013 transport in figures EU, Statistical pocketbook 2012 transport in figures EU, Statistical pocketbook 2011 transport in figures EU, International Transport Forum, Eurostat, Transtools Model

5 CONCLUSION

Based on the performed detailed analysis, in most cases, we can perceive the continuous reduction of the generated traffic volumes in recent years in the areas of Croatian ports. The higher decreasing rates of traffic volumes (passenger and freight) are typical for a wider overall area of port of Pula and Rovinj, wider area of port of Mali Lošinj and Dubrovnik, narrow area of port of Rab (especially, “Rab” section). The least decreasing rates are typical for port of Krk, while in 2013 growth rates of traffic volumes are evident. Also in the narrow area of port of Dubrovnik (sections: “Kupari” and “Zaton”) an increase of traffic volumes from 2011 to 2013 are realized. During the summer months, decreasing rates of traffic volumes have less value than the rates of all year with exception of areas of port of Rab and Mali Lošinj. Larger deviations (traffic flow reduction compared to 2012) of the freight traffic volumes are typical for the areas of the port of Dubrovnik and Mali Lošinj especially in the summer months. In the future (2020 and 2030), we can expect an increase primarily vehkm by passenger cars. The largest increase rate (in %) of vehkm is characteristic for trucks but is quantitatively less than vehkm by passenger cars. The smallest change in the future in terms of the transport volumes is characteristic for the buses.

ACKNOWLEDGMENT

This paper is based on the Europe Adriatic SEA-WAY project, co-financed by the European Union in the framework of the IPA Adriatic Cross-Border Cooperation Programme 2013-2016.

REFERENCES

[1] Depolo, V. (2010). Indicators in the traffic engineering. *Techniques of traffic regulation TES 2010.* (CD-rom). Belgrade-Subotica, Serbia: University of Belgrade-Faculty of transport and traffic engineering.

[2] Kuzović, Lj. (1987). *The theory of traffic flow*. Belgrade: Građevinska knjiga.

[3] Zhong, M., Bagheri, E., & Christie, J. (2012). Improving Group Assignment and AADT Estimation Accuracy of Short-term Traffic Counts using Historical Seasonal Patterns & Bayesian Statistics. *Procedia - Social and Behavioral Sciences 43*(2012), 607-617.

[4] Gastaldi, M., Rossi, R., Gecchele, G., & Della Lucia, L. (2013). Annual Average Daily Traffic estimation from Seasonal Traffic Counts. *Procedia - Social and Behavioral Sciences 87*(2013), 279-291.

[5] Topenčarević, Lj. (1987). *Organization and technology of road transport*. Belgrade: Građevinska knjiga.

[6] TenConnect. (2008). TREN B1/159-2007: Traffic flow: Scenario, traffic forecast and analysis of traffic on the TEN-T, taking into consideration the external dimension of the Union. Tetraplan A/S, Copenhagen, Denmark.

THERMODYNAMIC ANALYSIS OF ONBOARD COMPRESSED AIR SUPPLIED SYSTEM

Zdeslav Jurić, D.Sc.
Nikola Račić, D.Sc.
Đorđe Dobrota, M.Eng.
University of Split
Faculty of Maritime Studies
Zrinsko-Frankopanska 38, Split, Croatia
zdeslav@pfst.hr

ABSTRACT

This paper discusses an onboard compressed air supplied system. The system is described by differential equations of its components by which the model is developed. The simulation of the system has been made for different operating conditions (different initial conditions of the air and stepped regulation of air flow through compressor). Furthermore, simulation of the system under heat exchanger failure is also considered. The results of the simulation show the changes in pressure and temperature over time and the energy consumption for different operating conditions. In addition, the simulation results show that the energy consumption is the lowest in case of normal operation of the system with air flow regulation through compressor.

Key words: Onboard compressed air supplied system, simulation model, energy consumption.

1 INTRODUCTION

Increasing requirements for the preservation of the environment and reducing emissions from ships, forced the International Maritime Organization (IMO) to introduce a series of measures to regulate this issue. In addition to the restrictions that apply to ships operating in certain protected areas (Emission Control Area – ECA), one of the important IMO measures regarding the environmental protection against emissions from ships is the MEPC's decision on the inclusion of the Chapter 4 into Annex VI of MARPOL 73/78. This refers to the rules for determining and controlling the energy efficiency of ships, i.e. Energy Efficiency Design Index (EEDI) and operational measures – Ship Energy Efficiency Management Plan (SEEMP) apply to all ships on international voyages of more than 400 GRT, starting from 01 January 2013.

Some measures for increasing energy efficiency which are simply to implement were neglected. This can be explained by insignificantly small part of carbon dioxide emission in total maritime transport gas emission related to other type of transport (from 2.1 % to 2.7 % related to [1] and [2], respectively).

Proper and responsible ship energy system management can considerably reduce gas emission, and thus increase energy efficiency on annual basis. An example of energy efficiency measures, which can taken, will be presented through the analysis of the compressed air system.

2 COMPRESSED AIR SYSTEM

An example of a supplied air system on a ship with two-stroke slow-speed diesel engine as propulsion is shown in Figure 1. The system is made according to the rules of classification society for vessels fitted with fixed pitch propeller (FPP).

The compressed air system is served by two main two-stage air compressors and one emergency two-stage air compressor. Air compressors are fitted with intercoolers (heat exchanger between two stages of compression) and heat exchanger at the outlet of the second stage of air compression.

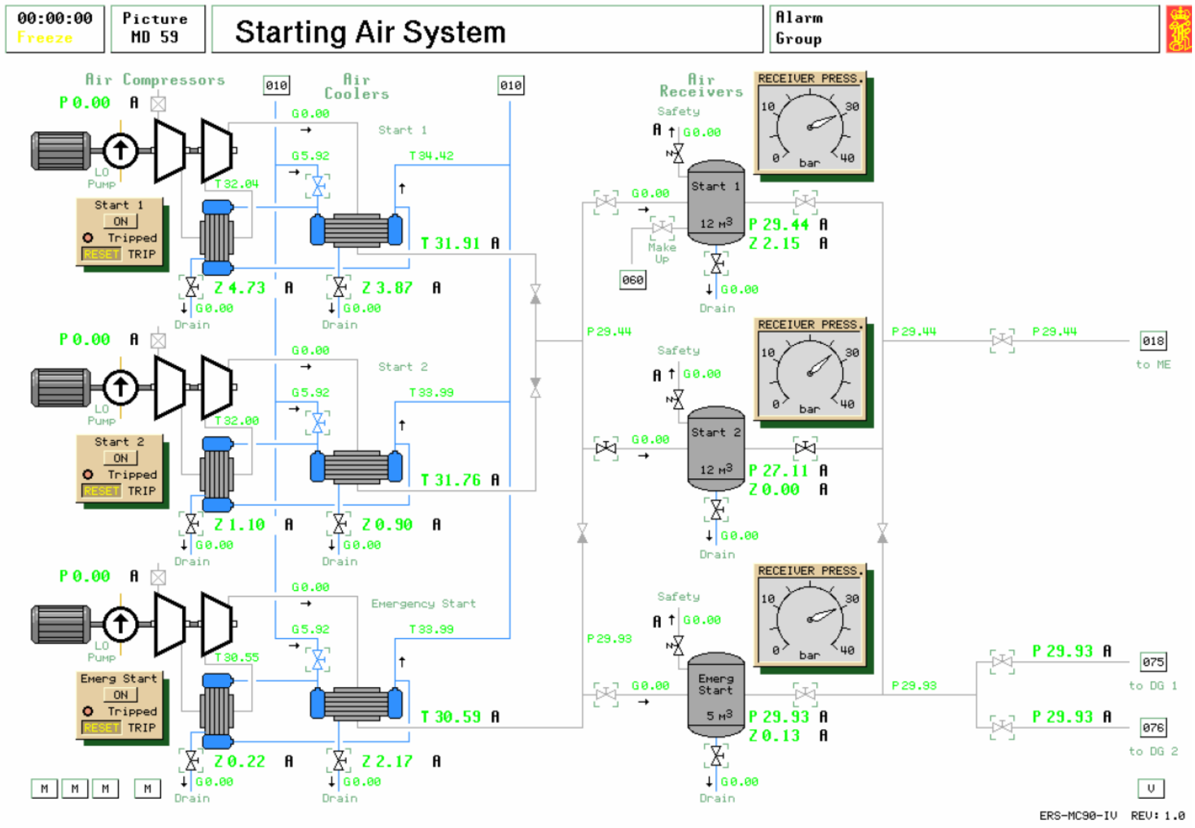


Figure 1: Compressed air system

Compressors take air from engine room and compressed it in air reservoir. The reservoirs are dimensioned to provide at least twelve consecutive starts of the reversible engine [4]. Pressure in air reservoir is usually $30 \cdot 10^5$ Pa. The operation of the air compressors can be automated, which means that, when pressure in air reservoir reaches or drops under desired value, they switch off or switch on automatically. Under normal operating condition, both compressors work automatically, and one is selected as the main compressor. All three air reservoirs are charged at operating pressure. Emergency air compressor, if necessary, can be started manually.

Based on differential equations, a model in MATLAB-Simulink has been derived. The analysis of changing parameters and their impact on energy consumption can be made through the simulation of operation of the air compressed system.

2.1 Air compressor model

Two-stage air compressors with intercoolers are used in order to compress air from engine room to working pressure ($30 \cdot 10^5$ Pa). The compression of air in the compressor will be taken as reversibly adiabatic.

Air compression power can be calculated by air volume flow through compressor $\dot{V}$, pressure ratio of air in the air reservoir p_{out}, and compressor intake pressure p_{in} (from the environment – engine room) [5]:

$$P = \rho_{in} \cdot \dot{V} \cdot c_p \cdot dT = p_{in} \cdot \dot{V} \cdot \frac{\varkappa}{\varkappa - 1} \cdot \left[\left(\frac{p_{out}}{p_{in}} \right)^{\frac{\varkappa}{\varkappa-1}} - 1 \right] \tag{1}$$

where: c_p – specific heat capacity at constant pressure and κ – specific heat capacity ratio.

Marks in index "*in*" and "*out*" are related to the states at the inlet and the outlet of the compressor. If the compression is polytropic, heat exchange is present during air compression, and polytropic index n can be used instead of κ. The value of n can be between 1 for isothermal compression and κ for reversible adiabatic compression.

Air pressure is greater at the outlet of the compressor than in the air reservoir, due to air pressure drop caused by air flow resistance in the system. In this paper, air pressure drop will not be taken into the consideration (air will be considered as non-viscous fluid).

To determine power required for driving the compressor, it is necessary to take into account the losses that occur: mechanical and electric engine losses with related coefficients, η_{mech} and η_{el}:

$$P_{el} = \frac{P}{\eta_{mech} \cdot \eta_{el}}. \tag{2}$$

2.2 Heat exchanger

Air temperature at the heat exchanger inlet is determined by the compressor's outlet temperature, which depends on the air reservoir pressure. Assuming that the compression is reversible adiabatic, according to the First law of thermodynamics for flow processes, there is an equation [6]:

$$dh = v \cdot dp, \tag{3}$$

where: dh – differential change of enthalpy, $\mathrm{d}h = c_p \cdot \mathrm{d}T$, and specific volume $v = \frac{R \cdot T}{p}$, whence follows:

$$c_p \cdot dT = \frac{R \cdot T}{p} \cdot dp \quad and \tag{4}$$

$$\frac{R \cdot \varkappa}{\varkappa - 1} \cdot dT = \frac{R \cdot T}{p} \cdot dp. \tag{5}$$

Temperature changing during time is expressed by equation:

$$\frac{dT}{dt} = \frac{(\varkappa - 1) \cdot T}{\varkappa \cdot p} \cdot \frac{dp}{dt}. \tag{6}$$

In case of polytropic compression, this change of temperature during time will be expressed by equation:

$$\frac{dT}{dt} = \frac{(n-1)\cdot T}{n\cdot p}\cdot\frac{dp}{dt}. \tag{7}$$

By using expression for the energy conservation, water temperature change during time in the heat exchanger can be determined by equation [7]:

$$m_{w,HE}\cdot c_w\cdot\frac{dT_w}{dt} = \dot{m}_{w,in}\cdot c_w\cdot T_{w,in} - \dot{m}_{w,out}\cdot c_w\cdot T_{w,out} - \dot{Q}_{HE} \tag{8}$$

where: $\dot{Q}_{HE}$ – heat transferred from cooling fresh water and compressed air, T – temperature, $m_{w,HE}$ – mass of fresh water in the heat exchanger, $\dot{m}$ – mass flow. Marks in index "*w*", "*in*" and "*out*" refer to water, inlet and outlet values respectively.

Change of compressed air temperature in the heat exchanger is expressed by equation:

$$m_{air,HE}\cdot c_{p,air}\cdot\frac{dT_{air}}{dt} = \dot{m}_{air,in}\cdot c_{p,air}\cdot T_{air,in} - \dot{m}_{air,out}\cdot c_{p,air}\cdot T_{air,out} + \dot{Q}_{HE} - \dot{Q}_{conv} - \dot{Q}_{rad} \tag{9}$$

where: $m_{w,HE}$ – mass of air in the heat exchanger, $\dot{Q}_{conv}$ – heat transferred from the compressed air to the environment by convection, $\dot{Q}_{rad}$ – heat transferred from the compressed air to environment by radiation. These heats can be neglected with respect to the heat which is exchanged between compressed air and cooling water, $\dot{Q}_{HE}$, [7]. The temperature of fluid in the heat exchanger and the heat exchanger outlet temperature of each fluid are nearly equal ($T_w \cong T_{w,out}$ and $T_{air} \cong T_{air,out}$). Based on these assumptions, equations 13 and 14 can be expressed as:

$$\frac{dT_w}{dt} = \frac{\dot{m}_w\cdot(T_w - T_{w,in})}{m_{w,HE}} + \frac{\dot{Q}_{HE}}{m_{w,HE}\cdot c_w} \quad and \tag{10}$$

$$\frac{dT_{air}}{dt} = \frac{\dot{m}_{air}\cdot(T_{air} - T_{air,in})}{m_{air,HE}} - \frac{\dot{Q}_{HE}}{m_{air,HE}\cdot c_{p,air}}. \tag{11}$$

Heat transferred from compressed air to cooling water is expressed by equation:

$$\dot{Q}_{HE} = k\cdot A_{HE}\cdot\Delta T_{mean,log} \tag{12}$$

where: k – coefficient of heat transfer, A_{HE} – area of the heat exchanger between compressed air and cooling water, $\Delta t_{mean,log}$ – mean logarithmic temperature between compressed air and cooling water for the counter flow heat exchanger:

$$\Delta T_{mean,log} = \frac{(T_{air,in} - T_w) - (T_{air} - T_{w,in})}{ln\frac{(T_{air,in} - T_w)}{(T_{air} - T_{w,in})}}. \tag{13}$$

As the amount of the exchanged heats in the heat exchanger is equal by absolute values, the combination of equations 8, 9 and 12 gives:

$$\dot{Q}_{HE} = k\cdot A_{HE}\cdot\Delta T_{mean,log} = -\dot{m}_{air}\cdot c_{p,air}\cdot(T_{air} - T_{air,in}) = \dot{m}_w\cdot c_w\cdot(T_w - T_{w,in}). \tag{14}$$

2.3 Air reservoir

Pressure change in the air reservoir can be determined by differentiating equation for ideal gasses:

$$p \cdot V = m \cdot R \cdot T \ / \frac{d}{dt} \tag{15}$$

to achieve:

$$p \cdot \frac{dV}{dt} + V \cdot \frac{dp}{dt} = m \cdot R \cdot \frac{dT}{dt} + m \cdot \frac{dR}{dt} \cdot T + \frac{dm}{dt} \cdot R \cdot T. \tag{16}$$

If it is assumed that the air reservoir wall is ideally rigid, the air reservoir pressure change over time is

$$\frac{dp}{dt} = \frac{R}{V} \cdot \left(m \cdot \frac{dT}{dt} + \frac{dm}{dt} \cdot T\right) \tag{17}$$

Changes in the air reservoir temperature can be obtained by the Law of conservation of energy for non-stationary systems [9]:

$$\dot{Q} = \int_{t_I}^{t_{II}} \left[\dot{m} \cdot \left(h + \frac{\dot{c}^2}{2} + g \cdot z\right)\right]_{out} \cdot dt - \int_{t_I}^{t_{II}} \left[\dot{m} \cdot \left(h + \frac{\dot{c}^2}{2} + g \cdot z\right)\right]_{in} \cdot dt +$$

$$\left[\dot{m} \cdot \left(u + \frac{c^2}{2} + g \cdot z\right)\right]_{II} - \left[\dot{m} \cdot \left(u + \frac{c^2}{2} + g \cdot z\right)\right]_{I} + W \tag{18}$$

where: $\dot{Q}$ – exchanged heat between the reservoir air and environment through the reservoir wall, $\frac{c^2}{2}$ – specific kinetic energy, $g \cdot z$ – specific potential energy, and W – work obtained by compressed air. As it has been mentioned before, if the reservoir walls are ideally rigid, the value $W = p \cdot \frac{\mathrm{d}V}{\mathrm{d}t} = 0$. Kinetic and potential energy of compressed air in the reservoir can be neglected, so the expression can be written as:

$$\frac{d(m \cdot u)}{dt} = \dot{Q} + \sum(\dot{m} \cdot h)_{in} - \sum(\dot{m} \cdot h)_{out} \tag{19}$$

Since the compressed air is considered as ideal gas whose specific internal energy and enthalpy are functions of temperature, where $u = c_v \cdot T$, c_v – specific heat capacity at constant volume, it follows:

$$\frac{m \cdot c_v \cdot dT}{dt} + \frac{m \cdot dc_v \cdot T}{dt} + \frac{dm \cdot c_v \cdot T}{dt} = \dot{Q} + \sum m_{in} \cdot c_p \cdot T_{in} - \sum m_{out} \cdot c_p \cdot T_{out} \tag{20}$$

Assuming that the change of specific heat capacity in used temperature ranges are neglected, and the temperature at the outlet of the air reservoir is nearly equal to the temperature of air in the reservoir, $T \cong T_{out}$, equation 20 becomes:

$$\frac{dT}{dt} = \frac{1}{m \cdot c_v} \cdot \left(\dot{Q} + \sum m_{in} \cdot c_p \cdot T_{in} - \sum m_{out} \cdot c_p \cdot T - \sum m_{in} \cdot c_v \cdot T + \sum m_{out} \cdot c_v \cdot T\right) \tag{21}$$

By combination of equations 17 and 21, change of air pressure reservoir becomes:

$$\frac{dp}{dt} = \frac{R}{V} \cdot \left[\frac{1}{c_v} \cdot \left(\dot{Q} + \sum m_{in} \cdot c_p \cdot T_{in} - \sum m_{out} \cdot c_p \cdot T\right)\right]. \tag{22}$$

Heat exchange between the air reservoir and environment through the reservoir wall, $\dot{Q}$, determined by thermal transmission coefficient k, area of air reservoir wall A and temperature potential (difference of reservoir air temperature T and environmental air temperature T_{env}), is expressed by equation:

$$\dot{Q} = k \cdot A \cdot (T_{env} - T). \tag{23}$$

At the same time, heat transferred by convention from air in the reservoir to the reservoir wall is proportional to convective heat coefficient α, area of air reservoir wall A and temperature difference between wall materials and air reservoir temperature:

$$\dot{Q}_{mat} = \alpha \cdot A \cdot (T_{mat} - T). \tag{24}$$

By combination of the two last equations, reservoir wall temperature change can be expressed by:

$$\frac{dT_{mat}}{dt} = \frac{\alpha \cdot A}{m_{mat} \cdot c_{mat}} \cdot (T - T_{mat}). \tag{25}$$

3 SIMULATION RESULTS

Based on the sets of differential equations, the model of a ship's compressed air system in MATLAB-Simulink has been made (Figure 2). The mathematical model is used to examine the influence of air temperature increasing at the inlet of air compressor, using compressors with changeable speed, and the influence of fouling in pipes on energy consumption for air compressing.

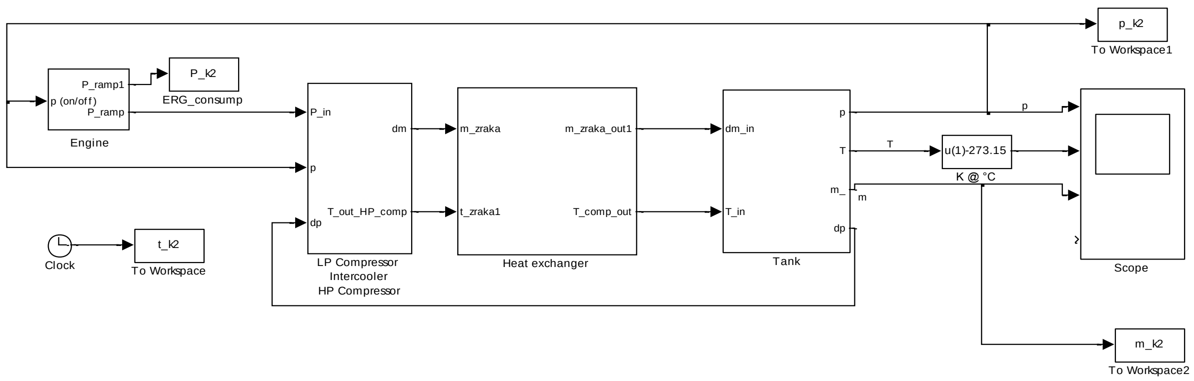


Figure 2: MATLAB-Simulink model of compressed air system

Figure 3 shows the diagram of energy consumption and mass of compressed air in the reservoir. This type of diagram is used to avoid misinterpreted simulation results (as it is obvious that the air pressure in the reservoir reaches the upper value faster at irregular work than at regular work, e.g. heat exchanger scaling, failure of cooling water pumps in the system fresh cooling water ...), because these results will show lower energy consumption.

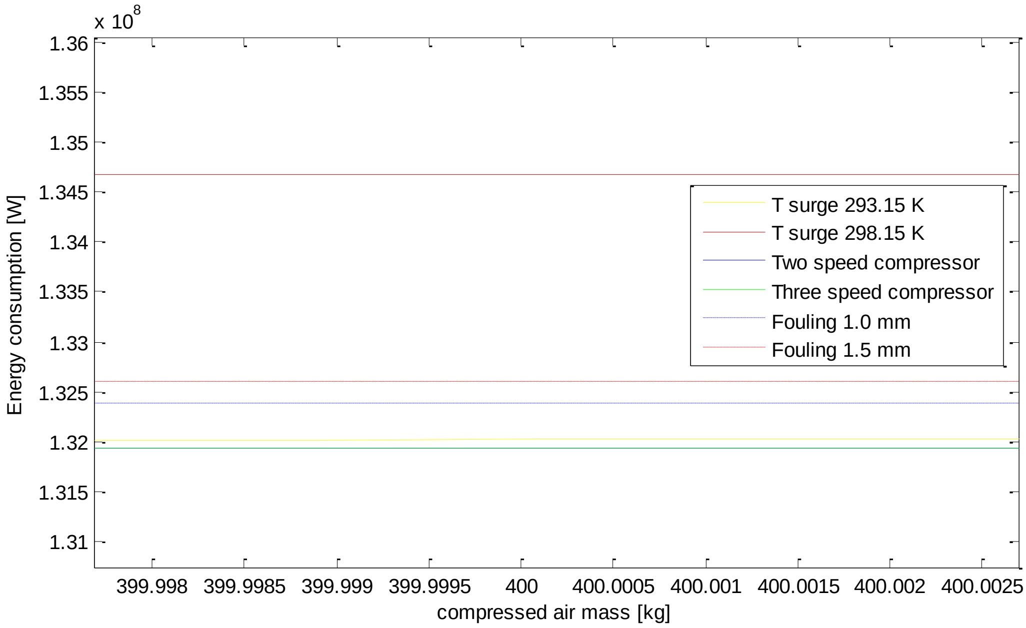


Figure 3: Compressed air mass – energy consumption diagram

The air inlet temperature of 293.15 K will be taken as the referent value, for the purpose of comparing energy consumption. Energy consumption will be examined in the event of air temperature increasing at the compressor inlet, use of compressors with variable speed, and scaling at pipes on water side.

For the air temperature increasing at the compressor inlet by 5 K (from 293.15 K to 298.15 K), simulation results show an increase in energy consumption by 0.98 %. Air, which is used in the compressed air system, is taken from the engine room where temperature is usually higher up to 15 K than the outside air temperature. This is caused by a greater specific volume at the compressor intake, which results in the reduction of air mass surged in the compressor. The use of air from the outside of the engine room may result in reducing energy consumption in the long term.

In case of using two-stage speed compressors, with pressure 10% less than nominal, the compressor speed is reduced to 50 % of the nominal speed. In this way energy consumption is reduced by 0.24%. In case of using three-stage speed compressor (70% of the nominal speed is applied if the reservoir pressure is greater than $2.95 \cdot 10^5$ over the time period of 3 minutes) there is no significant decrease in energy consumption with respect to the two-stage speed compressor. Combining the nominal speed reduction and switching the timing of the reduced speed, energy saving can be considerable and the use of three-stage speed compression gains in importance.

The simulation results reveal an increase in energy consumption caused by fouling on pipes on the water side. An energy loss due to 1 mm thick fouling on pipes is 0.27%, while the thickness of 1.5 mm causes energy loss of 0.43%. By means of regular chemical treating of the cooling fresh water and heat exchanger cleaning and maintenance, these energy losses can be prevented.

It is important to mention that the simulation model did not take into consideration the losses of air flow resistance through the system, nor the consumption of energy required for circulation of fresh cooling water through the heat exchanger. Hence, the presented losses and reduction of energy consumption in the compressed air system are higher, especially in case of scaling where the resistance of flow is significantly higher as is, accordingly, the energy consumption for the circulation of fresh cooling water through the system.

4 CONCLUSION

More demanding and stricter regulations on maritime environment protection and reducing gas emissions from ships encourage the analysis and implementation of measures for energy efficiency improvement. Various measures, to be considered and taken during the process extending from ship design to ship exploitation, including the ones referring to the modifications of the systems, can provide ship energy efficiency improvement. According to the results of the performed simulation, during the period of ship's exploitation, even minor measures that may look insignificant, can contribute to significant energy saving.

REFERENCES

[1] MAN Diesel & Turbo. (2004). Exhaust Gas Emission Control Today and Tomorrow, Application on MAN B&W Two-stroke Marine Diesel Engines. Retrieved December 5, 2014, from http://www.mandieselturbo.com/files/news/filesof9187/5510-0060-01ppr_low.pdf

[2] Andreasen, A. & Nyggard, K. B. (2010). Water-in-fuel emulsion as marine engine fuel for reduced NOx and particulate emissions. Retrieved December 5, 2014, from Danish Ministry of the Environment , Environmental Protection Agency

[3] Govnerment Web site: http://www2.mst.dk/udgiv/publications/2011/08/978-87-92779-30-4.pdf

[4] DNV Rules for Classification of Ship. (2010). Machinery and Systems Main Class, Part 4 Chapter 6, Piping System. Norway: Det Norske Veritas.

[5] Kleiser, G. & Rauth, V. (2013). Dynamic Modelling of Compressed Air Energy Storage for Small-Scale Industry Applications. International Journal of Energy Engineering, 3(3), 127-137.

[6] Cengel, Y. A. & Boles, M. A. (2014). Thermodynamics: An Engineering Approach. Boston: Mcgraw-Hill Higher Education.

[7] Cengel Y. A. (2002). Heat Transfer: A Practical Approach. Boston: Mcgraw-Hill.

[8] Chen, Y.-H., Wong, K-L. & Pin Kuo, I-P. (2009). The Heat Transfer Characteristics of an Insulated Circular Duct Considering and Neglecting the Influence of Heat Radiation. Proceedings of International MultiConference of Engineers and Computer Scientists. Hong Kong, China: International MultiConference of Engineers and Computer Scientists.

[9] Ekroth, I. & Granryd, E. (1994). Tillmpad termodynamiik, Sweden: Royal Institute of Technology.

[10] Sjostedt, C.-J. (2004). Modelling of displacement compressors using MATLAB/Simulink software, NordDesign 2004 - Product Design in Changing Environment (pp. 192-200). Tampere, Finland: NordDesign.

[11] Maxwell, G. & Rivera, P. (2003). Dynamic Simulation of Compressed Air Systems. Summer Study on Energy Efficiency in Industry (pp. 146-156). Rye Brook, New York: American Council for an Energy-Efficient Economy.

LOGISTICS, LOGISTICAL, LOGISTIC: DIACHRONIC AND SYNCHRONIC CORPUS ANALYSIS

Violeta Jurkovič, D.Sc.
University of Ljubljana
Faculty of Maritime Studies and Transport
Pot pomoršlakov 4, SI 6320 Portorož, Slovenia
violeta.jurkovic@fpp.uni-lj.si

ABSTRACT

Corpus linguistics relies on the use of corpora or collection of texts in the digital format that can be used for a variety of linguistic analyses, in particular in the field of lexicography. Today all modern dictionaries are based on carefully planned and analysed language corpora. Because of the need for digitalization of written texts or transcription of spoken texts as well as complex and expensive computer applications used for data analysis, in the past language corpora used to be limited to the exclusive domain of dictionary writers and large publishing houses. With the availability of ready-made digitalized texts and accessible (freeware) corpus analysis tools, language corpora are now widely used by translators and foreign language practitioners whose main purpose may be to observe how selected lexical items behave in context rather than to produce comprehensive dictionaries.

The analysis that will be presented in this paper stems from the frequent doubts of Slovenian students of English for traffic technology and logistics with reference to which word form to use in the role of pre-modifier in nominal phrases, whether 'logistics', 'logistical', or 'logistic'. The specialized language corpora used for this study consist of three volumes (1994, 2004, and 2013) of the International Journal of Physical Distribution & Logistics Management. Two types of analysis have been carried out. Firstly, a diachronic perspective will reveal the changes in the use in the examined words through time, from 1994 to 2013. Secondly, a synchronic analysis will indicate the most frequent collocates of each analysed word. To summarize, the results presented in this paper will provide the answer to the question which among 'logistics', 'logistical', or 'logistic' should be used when pre-modifying a nominal phrase in English texts in the field of logistics.

Key words: Language corpora, corpus analysis, diachronic analysis, synchronic analysis, logistics.

1 INTRODUCTION

In the Slovene language, pre-modifiers of nouns are typically expressed through adjectives. On the other hand, using nouns to pre-modify other nouns is highly uncommon. The *Nova beseda*[1] corpus, for instance, lists 1690 occurrences of the adjective *logističen* in its various case and definite as well as indefinite forms (e.g., *logistični servis*, *logističnega terminala*) when pre-modifying nominal phrases. On the contrary, in English the use of nouns as pre-modifiers of other nouns in compounds is part of the nominal nature of this language.

Cross-linguistic influence or (positive or negative) transfer from the mother tongue undoubtedly is an important factor in foreign language learning and acquisition when making assumptions about the language system of the language that is being learnt. Based on the

[1] http://bos.zrc-sazu.si/

erroneous assumption that adjectives would typically be used to pre-modify nouns, Slovene learners of English for Specific Academic Purposes (ESAP) have produced the following sentences:

- The terminal in Verona supports the production of three main operator categories: production activities, forwarding agents and *logistic* operators.
- In order to alleviate the pressure on the environment, it will be necessary for further *logistical* plans to include green solutions.
- Environmental impacts are much higher in big cities with intense *logistic* activities.
- Redesigning the *logistical* system can play an important role, but can be expensive.

Should these ESAP learners be directed to use a dictionary to ascertain whether they have used a correct form, they would find that both adjectival forms, 'logistic' and 'logistical', are indeed listed in dictionaries. Among the definitions of these terms learners would also find that they can mean "of or relating to logistics"[2], and that typical collocations in which 'logistic' or 'logistical' are used include "logistic problems"[3] or "logistical support/problems"[4].

In order to be able to provide empirically based feedback to frequent student inaccuracies in the use of 'logistic', 'logistical', 'logistics' in the adjectival pre-modifying function in nominal phrases, this paper has two aims. First, it will take a diachronic perspective and examine the evolution of these word forms through two decades (from 1994 to 2013) in a selected peer-reviewed journal relevant for the field: the International Journal of Physical Distribution and Logistics Management. Then, from a synchronic perspective, it will indicate the most frequent collocates that are used with each analysed word. In brief, the results of this study will provide the answer to the question which word form, 'logistics', 'logistical', or 'logistic', should be used in the pre-modifying function in nominal phrases in English texts in the field of logistics.

2 THEORETICAL FRAMEWORK

The development of computer software has enabled language teachers to engage in corpus linguistics and acquire relevant information for the teaching of vocabulary and other language elements. Corpus linguistics and analysis have certainly reached beyond the domain of lexicography that was the first discipline to have recognized the benefits of computer language analysis, and is today widely used for pedagogical purposes (e.g. Godnič Vičič, 2008; Dostal, 2015). Mukherjee (2006) speaks of three possible pedagogic uses of language corpora: informed materials design, use of language corpora in the classroom, and learner corpora analysis. A fourth potential use is corpus analysis as a tool for providing empirically based feedback to frequent student mistakes or inaccuracies deriving from negative cross-linguistic transfer.

In contemporary linguistics, a language corpus represents a collection of authentic texts (Krek and Arhar, 2010), which is homogeneously encoded and computer readable (Aston, 1996). Several referential wordlists based on general English corpora are available on the internet

[2] http://www.collinsdictionary.com/
[3] http://www.oxforddictionaries.com/
[4] http://dictionary.cambridge.org/

(e.g., the British National Corpus (BNC) or the Brown corpus wordlist). However, general language corpora and wordlists do not indicate the specialized vocabulary inherent to a specific study discipline and hence specialized corpora have to be constructed. Specialized corpora refer to collections of texts that are designed in order to represent a sample of a sub-language that we wish to examine (Gavioli, 2005) and comprise representative texts of this particular domain (Fuertes-Olivera, 2008).

Research into language variation and use can adopt a synchronic or diachronic perspective. A diachronic corpus will be based on texts from the same field but belonging to different periods (Lüdeling and Kytö, 2008). Diachronic corpus analysis will thus illustrate variation or change in language use through time. A synchronic corpus, on the other hand, will focus on language use at a particular (historical or contemporary) moment of time. It will commonly be used to identify and interpret the extra- or intra-linguistic factors that affect the choice among a variety of options in a given field (Lüdeling and Kytö, 2008).

Almost 25 years ago, Sinclair (1991) proposed that two interpretative principles should be used in interpreting and constructing language meaning. The open-choice principle sees grammatical and morpho-syntactical correctness as the guiding principle in the formation of sentences from strings of otherwise unrelated words. On the other hand, the idiom principle is based on the notion that sentences are made of pre-constructed language chunks that may consist of several related words and should thus be considered as lexical units. According to this principle, the choice of words is not arbitrary but depends on the context and co-text.

A large proportion of text, in fact, consists of fixed or semi-fixed language chunks that will frequently occur within a corpus and whose meaning is associated with the unit as a whole rather than with the meaning of each of its constituent parts (McEnery and Hardie, 2012). In relation to these, analyses of language corpora will not indicate what is possible in a language but rather, based on authentic examples of language use, what is typical and frequently occurring (Krek and Arhar, 2010). In this paper, the term collocation will be used to denote "co-occurrence patterns observed in corpus data" (McEnery and Hardie, 2012, 123).

Statistical corpus analysis can provide different information about the sub-language under examination. The first is keyness. A word will be considered as key if its relative frequency in the specialized corpus will be significantly higher than the relative frequency in the reference corpus. Therefore, keyness is based on repetition. We may assume that in a specialized corpus of logistics, for instance, logistics-related words will be key compared to a reference general English corpus. The second piece of information about a particular term or keyword is its co-occurrence with lexical items that can most commonly be found in positions left or right to the examined term and that significantly contribute to its meaning.

3 METHODOLOGY

A specialized corpus that contains 162 academic articles from three volumes (1994, 2004, 2013) of the International Journal of Physical Distribution and Logistics Management has been compiled. More specifically, three specialized sub-corpora, each representing one volume, contain all academic articles that were published in this academic journal in 1994, in 2004, and 2013 respectively. The scope of the journal is to link theory and practice in order to enhance the development of more competitive physical distribution and logistics management systems, which indicates that the selected journal can be considered as being lexically representative of the field of transport logistics. Essential corpus data is presented in Table 1.

Table 1: Corpus data (International Journal of Physical Distribution & Logistics Management)

	1994	2004	2013
Number of articles	56	66	40
Number of tokens	181,981	226,328	243,041
Number of types	8,964	10,316	11,042

As data presented in Table 1 show, the specialized corpus consists of three sub-corpora. The 1994 volume contains 56 academic articles, the 2004 volume contains 66 academic articles, and the 2013 volume contains 40 academic articles. Each sub-corpus includes more than 100,000 tokens or running words, which is a limit set for specialized corpora by Kaewphannagam et al. (2002). The number of types refers to the number of different words in each sub-corpus. All texts were available in electronic format and corpus construction took approximately three hours.

Oxford WordSmithTools 4.0 was the main application used to build the wordlist and extract the keywords from each sub-corpus. To do so, the application compared the words in each sub-corpus with the referential BNC, which represents a wide-cross section of current British English. Any word that was found to appear in the specialized corpus significantly more often (at the level of p=0.000) than in the referential corpus, was considered "key". Secondly, the same application was used to identify the most frequent collocates with 'logistic', 'logistical', and 'logistics' in each sub-corpus.

4 RESULTS

The analysis presented in the Results section will chronologically follow these questions:

- Which are the keywords in each of the sub-corpora compared to the BNC?
- Does a comparison among the results of the analysis of the 1994, 2004, and 2013 sub-corpora indicate any variation in the use of 'logistic', 'logistical', and 'logistics' through time?
- What are the most frequent collocates with 'logistic', 'logistical', and 'logistics' in each volume?

Firstly, each specialized sub-corpus was compared against the BNC that was used as the reference corpus (RC). The results indicate that 'logistics' is the keyword with the highest keyness (8,135.27 at p=0.000) in the 1994 sub-corpus. The frequency of occurrence in the specialized sub-corpus is 721 (share of 0.40 % of all tokens in the sub-corpus) compared to only 199 in the significantly larger reference corpus (Table 2). Among the keywords we can find 'logistical' with 79 occurrences (share of 0.04 % and keyness of 758.12 at p=0.000) against 94 occurrences in the reference corpus, and 'logisticians' with nine occurrences (against one in the reference corpus) at keyness of 107.00 at p=0.000.

Table 2: 1994 keywords

N	Key word	Freq.	%	RC. Freq.	RC. %	Keyness	P
1	LOGISTICS	721	0.40	199		8,135.27	0.000
2	CUSTOMER	714	0.39	4,348		4,903.75	0.000
3	SUPPLIER	508	0.28	1,306		4,261.17	0.000
4	SERVICE	776	0.43	30,252	0.03	2,642.60	0.000
5	DISTRIBUTION	444	0.24	6,27		2,353.34	0.000
6	PRODUCT	495	0.27	11,039	0.01	2,198.57	0.000
7	INVENTORY	244	0.13	526		2,117.60	0.000
8	SUPPLIERS	302	0.17	1,797		2,086.25	0.000
9	PURCHASING	266	0.15	1,21		1,966.80	0.000
10	SUPPLY	404	0.22	9,563		1,749.08	0.000
11	CHAIN	281	0.15	3,666		1,530.99	0.000
12	PACKAGING	196	0.11	959		1,423.48	0.000
13	FIRMS	316	0.17	7,48		1,367.95	0.000
14	OMITTED	198	0.11	1,438		1,295.18	0.000
15	TRANSPORT	310	0.17	8,472		1,258.72	0.000
33	LOGISTICAL	79	0.04	94		758.12	0.000
360	LOGISTICIANS	9		1		107.00	0.000
	LOGISTIC	0	0	148			

Table 3 shows the keywords extracted from the 2004 specialized sub-corpus after a comparison against the BNC reference corpus. The term ‘logistics’ is ranked second, after ‘supply’. It displays 846 occurrences in the specialized sub-corpus (share of 0.37 % of all tokens and keyness of 9,287.20 at p=0.000) against 199 occurrences in the BNC reference corpus. Among the keywords extracted from the 2004 specialized sub-corpus we can find ‘logistic’ with 22 occurrences (keyness of 137.55 at p=0.000) compared to 148 occurrences in the BNC, and ‘logistical’ with 19 occurrences (keyness of 129.41 at p=0.000) compared to 94 occurrences in the BNC. The term ‘logisticians’ is not used in the 2004 specialized sub-corpus.

Table 3: 2004 keywords

N	Key word	Freq.	%	RC. Freq.	RC. %	Keyness	P
1	SUPPLY	1,586	0.70	9,563		10,244.27	0.000
2	LOGISTICS	846	0.37	199		9,287.20	0.000
3	CHAIN	1,202	0.53	3,666		9,216.46	0.000
4	SUPPLIER	562	0.25	1,306		4,565.17	0.000
5	MANAGEMENT	884	0.39	21,61	0.02	3,409.62	0.000
6	RISK	732	0.32	11,759	0.01	3,394.68	0.000
7	VALUE	795	0.35	17,758	0.02	3,198.91	0.000
8	SUPPLIERS	443	0.20	1,797		3,174.99	0.000
9	CUSTOMER	466	0.21	4,348		2,632.89	0.000
10	BUSINESS	808	0.36	35,127	0.04	2,269.73	0.000

N	Key word	Freq.	%	RC. Freq.	RC. %	Keyness	P
11	CHAINS	288	0.13	1,269		2,021.60	0.000
12	VULNERABILITY	244	0.11	528		2,010.28	0.000
13	ET	397	0.18	5,331		1,973.48	0.000
14	AL	400	0.18	5,668		1,948.22	0.000
15	RESEARCH	644	0.28	26,704	0.03	1,863.00	0.000
390	LOGISTIC	22		148		137.55	0.000
411	LOGISTICAL	19		94		129.41	0.000
	LOGISTICIANS	0	0	1			

The final keywords list, presented in Table 4, has been extracted from the 2013 specialized sub-corpus. The term 'logistics' has the sixth highest keyness value (6,486.05 at p=0.000), and 619 occurrences (a share of 0.24 %) against 199 occurrences in the BNC. Among the keywords we can also find 'logistical' with 29 occurrences (share of 0.01 % and keyness of 212.41 at p=0.000), and 'logistic' with 28 occurrences (share of 0.01 % and keyness of 180.86 at p=0.000). The term 'logisticians' is not used in the 2013 specialized sub-corpus.

Table 4: 2013 keywords

N	Key word	Freq.	%	RC. Freq.	RC. %	Keyness	P
1	AL	1,231	0.48	5,668		8,262.30	0.000
2	ET	1,193	0.47	5,331		8,070.81	0.000
3	SUPPLY	1,176	0.46	9,563		6,675.93	0.000
4	CHAIN	937	0.37	3,666		6,558.65	0.000
5	LOGISTICS	619	0.24	199		6,486.05	0.000
6	OMITTED	523	0.21	1,438		3,978.78	0.000
7	RESEARCH	950	0.37	26,704	0.03	3,211.16	0.000
8	ARTICLE	553	0.22	6,607		2,743.55	0.000
9	PERFORMANC E	672	0.26	12,961	0.01	2,736.21	0.000
10	FIGURE	691	0.27	17,214	0.02	2,487.64	0.000
11	IMAGE	527	0.21	7,356		2,462.02	0.000
12	SCI	236	0.09	80		2,461.03	0.000
13	INVENTORY	295	0.12	526		2,453.24	0.000
14	MANAGEMENT	725	0.28	21,61	0.02	2,372.76	0.000
15	OUTSOURCING	206	0.08	26		2,297.28	0.000
301	LOGISTICAL	29	0.01	94		212.41	
368	LOGISTIC	28	0.01	148		180.86	0.000
	LOGISTICIANS	0	0	1			

The data presented in Tables 2-4 show the keywords and their statistical properties at a given moment of time (in 1994, 2004, and 2013 respectively). Picture 1, on the other hand, indicates a trend or variation in the keyness of each examined word form from 1994 through 2013. Firstly, as we can see the keyness of 'logistics' fluctuated: it rose from 8,135 in 1994 to 9,287 in 2004 but then fell again to 6,486 in 2013. The keyness of 'logistical' was highest in 1994 (758), then dropped to 129 in 2004, and rose again to 212 in 2013. The keyness of 'logistic' seems to be recording a gradual increasing trend, from no occurrences in 1994, to keyness of 137 in 2004, and 180 in 2013.

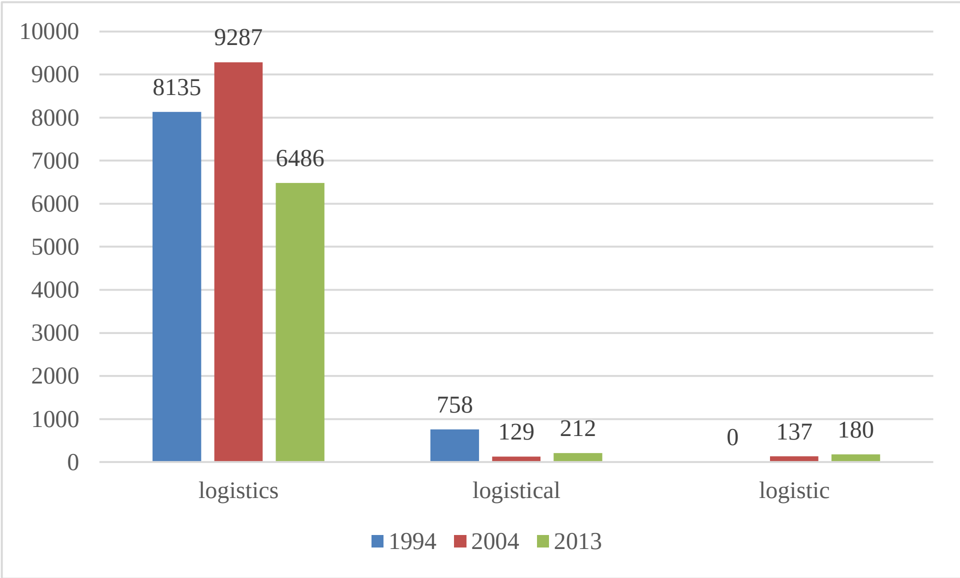


Figure 1: Keyness of 'logistics', 'logistical', and 'logistic' in the 1994, 2004, and 2013 specialized sub-corpora

Picture 2 shows similar trends for shares held by 'logistics', 'logistical', and 'logistic' in each specialized sub-corpus. The share held by 'logistics' gradually decreased from 0.40 % in 1994 to 0.37 % in 2004, and finally to 0.24 % in 2013. In 2004, the share of 'logistical' dropped to 0 % from the initial 0.04 % and rose to 0.01 % in 2013. The share held by 'logistic', on the other hand, displays a slightly increasing trend, representing 0.01 % of all tokens in the 2013 specialized sub-corpus.

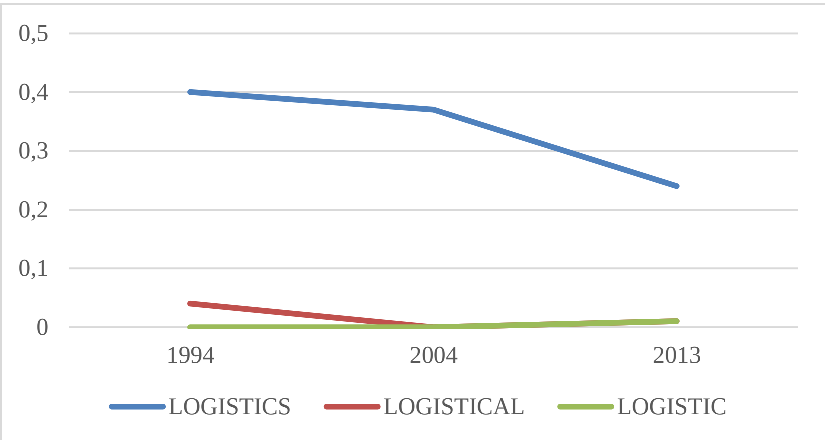


Figure 2: Shares of 'logistics', 'logistical', and 'logistic' in the 1994, 2004, and 2013 specialized sub-corpora

In the final step of the analysis we will examine the most frequent R1 collocates of 'logistics', 'logistical', and 'logistic' through time.

Table 5: R1 collocates with "logistics" (grey colour indicates pre-modifying function)

1994		2004		2013	
Word	**R1**	**Word**	**R1**	**Word**	**R1**
IS	36	AND	67	AND	44
MANAGEMENT	32	MANAGEMENT	52	ALLIANCE	26
OPERATIONS	31	RESEARCH	51	ACTIVITIES	21
SERVICE	29	CAPABILITIES	38	SERVICES	21
SYSTEM	29	DISCIPLINE	35	RESEARCH	18
PERFORMANCE	26	IN	25	SCHOLARS	17
IN	24	IS	20	SUPPORT	15
AND	23	FLOWS	19	ALLIANCES	14
STRATEGY	18	ACTIVITIES	17	SERVICE	14
ACTIVITIES	17	FUNCTIONS	16	IS	13
FUNCTIONS	15	FUNCTION	14	PROCESSES	12
CONCEPT	14	AS	12		
SYSTEMS	14	FLOW	12		
COSTS	13	SERVICES	11		
PRACTICE	13				
AS	12				
RESEARCH	12				
HAS	11				
WAS	11				

Table 5 shows R1 collocates with 'logistics' with frequency of occurrence higher than ten. In addition to nouns, 'logistics' frequently precedes auxiliary verbs (is, has, was), prepositions (in), and conjunctions (and, as). 'Logistics' is often used as a pre-modifier of nouns. In 1994 and 2004 the most frequent lexical R1 collocate was 'management' (*logistics management*) while in 2013 it was 'alliance' (*logistics alliance*). Collocates that occur frequently in more than one specialized sub-corpus include 'management', 'service/s', 'activity/-ies', 'function/s', and 'research'. From the contemporary perspective, in 2013 there are some collocates that were not as frequently used in the past. These are 'alliance/s', 'scholars', 'support', and 'processes'.

Table 6 shows the most frequent R1 collocates with 'logistical'. We can see that in 1994 the list of collocates is longer and consists exclusively of lexical words, more specifically nouns. The most frequent R1 collocate in 1994 was 'segmentation'. In 2004 there were only two collocates with 'logistical' with a single occurrence, the conjunction 'and' and the noun 'packaging'. In 2013 the list shortened further to a single collocate with five R1 occurrences, which is 'support'.

Table 6: R1 collocates with "logistical"

		1994		2004		2013
Word		**R1**	**Word**	**R1**	**Word**	**R1**
SEGMENTATION		14	AND	1	SUPPORT	5
CHANNELS		5	PACKAGING	1		
COSTS		5				
EXCELLENCE		5				
FUNCTIONS		5				

Finally, the data presented in Table 7 show that in 1994 and 2004 the term 'logistic' used to appear together with 'flow' (*logistic flow*). In 2004 a second collocate was 'regression' (*logistics regression*) with 12 occurrences. In 2013, on the other hand, two other collocates appeared: the lexical R1 collocate 'support' (*logistic support*) with eight occurrences, and the conjunction 'and' with three occurrences.

Table 7: R1 collocates with "logistic"

1994		2004		2013	
Word	**R1**	**Word**	**R1**	**Word**	**R1**
FLOW	4	REGRESSION	12	SUPPORT	8
		FLOW	5	AND	3

5 DISCUSSION AND CONCLUSION

The objective of this paper was to provide an empirically based answer to the question whether 'logistics', 'logistical', or 'logistic' should be used as a pre-modifier of nominal phrases in English texts in the field of logistics. The presented data clearly indicate the prevalent use of the noun 'logistics' where in the Slovene language an adjective would typically be used. However, some other interesting findings can be reported on.

Firstly, the very high frequency of occurrence of 'logistics' compared to those of 'logistic' and 'logistical' can be attributed to its use as pre-modifier in nominal phrases but also, or above all, to its use as a single-word unit or in multi-word units where its acts as the core, for instance 'reverse logistics', 'military logistics', and 'forward logistics'. The English nouns, therefore, have a versatility that English adjectives do not and that, importantly for Slovene learners of English, Slovene nouns do not. Interestingly, however, it seems that 'support' can easily link with all three word forms (*logistics support, logistical support, logistic support*).

Secondly, the data reveal that the share held by the term 'logistics' in the specialized sub-corpora gradually decreased and so did the ranking of 'logistics' in the keywords lists (first in 1994, second in 2004, and sixth in 2013). Possibly more important than the ranking itself (because of the inclusion of terms such as 'et', 'al', etc. in the keywords lists) is the fact that in 1994 the term 'supply' was ranked tenth (share of 0.22 % of all tokens and keyness of 1,749 at p=0.000) and 'chain' eleventh (share of 0.15 and keyness of 1,530 at p=0.000). Already in 2004 'supply' became the word with highest keyness (10,244 at p=0.000, and a share of 0.70 %), followed by 'logistics', and 'chain' in the third place with keyness of 9,216 at p=0.000, and share of 0.53 %. In 2013 both terms ('supply' is ranked third with keyness of 6,675 at p=0.000, and a share of 0.46 %; 'chain' is ranked fourth with keyness of 6,558 at p=0.000, and a share of 0.37 %) preceded 'logistics' ranked fifth. These results might indicate a shift of research focus from logistics management ('management' cannot be found among the most frequent R1 collocates of 'logistics' in 2013) towards supply chains and supply chain management.

Finally, the results indicate that, in addition to trends in the development and use of lexical items, corpus analysis may illustrate research and operational trends in a particular discipline, in this case logistics. Among the R1 collocates identified in the 1994 and 2004 specialized sub-corpora we cannot find the term 'alliance' and its plural form 'alliances', which only appear in the 2013 collocates list, with 26 and 14 occurrences respectively. Given that an alliance can be defined as "a union or association formed for mutual benefit, especially between countries or organizations"[5], these results may be interpreted as an indication of a need for establishing alliances in the logistics sector that had not been present a decade or two decades ago. This assumption, however, would have to be corroborated through a qualitative insight into the texts that the corpus is made of.

REFERENCES

[1] Aston, G. (1996). What Corpora for ESP? Paper presented at a conference on ESP at the University of Pavia, November 1996. Retrieved 23 February 2010 from: http://home2.sslmit.unibo.it/~guy/pavesi.htm.

[2] Dostal, M. (2015). Gradnja govornega učnega korpusa simulacij poslovnih sestankov za raziskavo o vlogi učitelja pri razvijanju tujejezikovne sporazumevalne zmožnosti za poslovne sestanke v angleškem jeziku. In V. Jurkovič & S. Čepon (Eds.), Raziskovanje tujih jezikov stroke v Sloveniji (in press). Ljubljana: Slovenian Association of LSP Teachers.

[3] Fuertes-Olivera, P.A. (2008). Pedagogical application of specialized corpora in ESP teaching: the case of the UVaSTECorpus. Scripta manent, 3(2), 68-81.

[4] Gavioli, L. (2005). Exploring corpora for ESP learning. Amsterdam/Philadelphia: John Benjamins Publishing Company.

[5] Godnič Vičič, Š. (2008). Potentials and challenges of ESP learner corpora: The case of modal auxiliaries in Slovene ESP learners' written interlanguage. In Brkan et al. (Eds), Inter alia 1 (pp. 15-30). Ljubljana: Slovenian Association of LSP Teachers.

[6] Kaewphannagam, C., Broughton, M.M., & Soranasataporn, S. (2002). Corpus-based analysis: Guidelines for getting practical language input in materials development. Retrieved 11 Feburary 2005 from www.sc.mahidol.ac.th/sclg/ sllt/sllt2002/ArtileSLLT(Maurice).pdf.

[7] Krek, S. & Arhar, Š. (2010). Slovenski besedilni korpusi: kako v razred? Sodobna pedagogika, 1, 224-241.

[8] Lüdeling, A. & Kytö; M. (2008). Corpus linguistics: An international handbook. Berlin/New York: Walter de Gruyter.

[9] McEnery, T. & Hardie, A. (2012). Corpus linguistics. Cambridge: CUP.

[10] Mukherjee, J. (2006) Corpus linguistic and language pedagogy: The state of the art – and beyond. In J. Mukherjee (Ed.), Corpus Technology and Language Pedagogy: New Resources, New Tools, New Methods (pp. 5-24). Frankfurt am Main: Peter Lang.

[11] Sinclair, J. (1991). Corpus, concordance, collocation. Oxford: OUP.

[5] http://www.oxforddictionaries.com/

MARITME SINGLE WINDOW AS A SOLUTION OF E-NAVIGATION

Nexhat Kapidani, M.Sc.
Ministry of Transport and Maritime Affairs
Maritime Safety Department
Maršala Tita br 14, 85000 Bar, Montenegro
kapidani@t-com.me

ABSTRACT

E-Navigation is a concept and vision led by International Maritime Organization (IMO) created to harmonize navigation systems and ashore services in maritime sector in order to satisfy end-user needs [8]. IMO has defined E-Navigation concept and it is anticipated to have substantial results associated to ship based, shore based and communication systems [8]. According to the IMO Strategy, one of the benefits of E-Navigation is expected to be higher efficiency and reduced costs in maritime transport. These benefits will be enabled by automated and standardized reporting formalities, leading to reduced administrative burden that could be achieved by implementing Maritime Single Window (MSW). MSW is defined as an electronic system that allows stakeholders involved in maritime transport to provide and receive standardized information and documents in a single entry point to satisfy all necessary reporting requirements. This paper presents an overview of the E-navigation and MSW developments and their interconnection. The expected developments in both fields will be briefly presented.

Key words: E-Navigation, Maritime Single Window, maritime safety, e-maritime, maritime cloud.

1 BACKGROUND

Since 2005, several IMO member countries (Japan, the Marshall Islands, Netherlands, Norway, Singapore, UK and USA) have submitted a paper [1] to the Maritime Safety Committee (MSC) on the development on an E-Navigation strategy. Submitted paper proposed adding E-Navigation as a new topic to the work programme of the Safety of navigation (NAV) and Radio communications and Search and Rescue (COMSAR), both sub committees of IMO. The main purpose of that paper was to initiate development of strategic vision for the utilization of existing and new navigational tools, in particular electronic tools, in a holistic and systematic manner. Even if the scope of the proposal was broad, it was anticipated that IMO will "develop a broad strategic vision for incorporating the use of new technologies in a structured way and ensuring that their use is compliant with the various electronic navigational and communication technologies and services that are already available" [18]. Submitted paper also noted a possibility of E-Navigation strategy to support IMO Facilitation Committee (FAL) for development of a solution for simplification and facilitation of ship reporting formalities [1].

On 2009, IMO MSC on its 85th session came out with Strategy for the development and implementation of E-Navigation and defined it as "the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment." [2].

After considerable work carried out not only by IMO, but also by numerous organizations like International Association of Lighthouse Authorities (IALA), International Hydrographic Organization (IHO), IMO came out with preliminary list of nine main categories and practical E-Navigation solutions [3]. When members of Correspondence Group (CG) on E-Navigation to NAV were tasked to prioritize and propose a list of five out of the nine predefined categories of E-Navigation solutions, they prioritized solutions that focus on efficient transfer of marine information/data between all appropriate users (ship-ship, ship-shore, shore-ship and shore-shore) [6]. Namely, solutions S2 (Means for standardized and automated reporting) and S4 (Integration and presentation of available information in graphical displays received via communication equipment) were most voted solutions among members of CG. This result was expected having in mind that there are a lot of online reporting systems globally and the systems are not harmonized, often duplicated, and based on different formats and platforms. Driven from these reasons IMO has indicated application of MSW as a priority among planed outputs, on its proposals for the high-level action plan of the organization and priorities for the 2016-2017 biennium for the FAL [4]. Within the European Union (EU), need for MSW implementation is defined in Reporting Formalities Directive (RFD) that was adopted on 2010. The important element of RFD is that each Member State must introduce a MSW, so that ships arriving at EU ports can submit standard messages once, to a single point and that information will be disseminated as required to all authorities that need access to it. Furthermore, from 1 June 2015 the directive prohibits acceptance of reporting formalities in paper form so everything from that date will have to be submitted electronically [5].

2 CURENT SITUATION RELATED TO E-NAVIGATION

In last year's we have seen huge developments in Information and Communication Technology (ICT) that had great positive impact within maritime navigation and communication systems. Nowadays, technical support systems for mariners are developing rapidly and therefore there is a need to coordinate systems and harmonise standards in maritime sector. Currently vessels are equipped with various systems like Global Satellite Navigation Systems (GNSS) and Electronic Chart Displays and Information Systems (ECDIS). These on board systems need further improvement in order to be able to integrate with various systems that are installed on other vessels or ashore [6]. Also there are a lot of other electronic navigational and communication technologies and services available. Mariners and supporting staff on shore are now familiar, to a greater or lesser extent, with other systems like: Automatic Identification System (AIS), Integrated Bridge Systems and Integrated Navigation Systems (IBS/INS), Automatic Radar Plotting Aids (ARPA), Long Range Identification and Tracking (LRIT), Vessel Traffic Service (VTS), Global Maritime Distress and Safety System (GMDSS) and other ICT systems used in maritime sector. Also latest advancement in ICT related to data processing, storing and visualisation should be used also in maritime industry. E-Navigation offers a vision for the integration of existing and new navigational tools in a holistic and systematic manner.

2.1 IMO's E-Navigation concept

IMO has developed E-Navigation Strategy Implementation Plan (SIP) that sets up a list of tasks and specific timelines for the implementation of prioritized E-navigation solutions during the period 2015-2019, facilitating a coordination of efforts by relevant Sub-Committees, related international organisations, Member States, relevant regional bodies and the maritime industry [6].

After it was introduced to Navigation Communication Search and Rescue (NCSR) sub-committee, SIP was presented to MSC for approval at end of 2014. Following are five E-Navigation solutions that SIP gives importance:

- solution S1 related to bridge system design,
- solution S2 dedicated to standardized and automated reporting,
- solution S3 is focused to improve consistency and integrity of bridge system equipment and navigation information,
- solution S4 aims to integrate and present different layers of available information in graphical displays received from communications equipment and
- solution S9 objective is to improve communication of VTS Service Portfolio [6].

Solutions S2, S4 and S9 focus on efficient transfer of marine information and data between all appropriate users (ship-ship, ship-shore, shore-ship and shore-shore) [6].

As part of each one of the above prioritized E-Navigation solutions, several sub-solutions were identified. In this paper we will present sub solutions for solution S2, means for standardized and automated reporting, that are important for MSW implementation. They are illustrated in table 1 alongside with their descriptions, task actions and task identifiers.

Table 1: Required regulatory framework and technical requirements for implementation (tasks) for solution 2: Means for standardised and automated reporting [6]

Sub-Solution	Description	Task Action	Task Identifier (see Table 2)
S2.1	Single-entry of reportable information in single-window solution	Develop test beds demonstrating the use of single window for reporting along with S2.4.	**T8** **T15**
S2.2	Automated collection of internal ship data for reporting	Much data is already collected in the navigation equipment – investigate the use of this data for reporting of ship navigational information.	**T9**
S2.3	Automated or semi-automated digital distribution/communication of required reportable information, including both "static" documentation and “dynamic” information	Review the original AIS long range port facility as well as the new long range frequencies made available at WRC 2012 described in the latest revision of ITU-R M.1371-5, the revised IEC 61993-2, or the developments within VDES (VHF Data Exchange System) and see if the information could be used for no cost or low cost automated or semi-automated reporting. The long range port was not used during the development of LRIT due to the cost to ship-owners of sending this information.	**T9** **T15**
S2.4	All national reporting requirements to apply standardized digital reporting formats based on recognized internationally harmonized standards such as IMO FAL Forms or SN.1/Circ.289	Liaise with all Administrations and agree on standardised formats for ship reporting so as to enable “single window” worldwide. In this respect national and regional harmonisation is the first step.	**T8**

Task identifiers from table 1, that are related to sub solutions of S2, are presented in table 2, alongside with their tasks, expected deliverables, transition arrangements and implementation schedule.

Table 2: Tasks, expected deliverables, transition arrangements and implementation schedule [6]

Task No	Task	Expected Deliverable	Transition Arrangements	Prioritised Implementation Schedule
T8	Member States to agree on standardised format guideline for ship reporting so as to enable "single window" worldwide (SOLAS regulation V/28, resolution A.851(20) and SN.1/Circ.289)	Updated Guidelines on single window reporting.	National/Regional Arrangements	2019
T9	Investigate the best way to automate the collection of internal ship data for reporting including static and dynamic information.	Technical Report on the automated collection of internal ship data for reporting.	None	2016
T15	Identify and draft guidelines on seamless integration of all currently available communications infrastructure and how they can be used (e.g. range, bandwidth etc.) and what systems are being developed (e.g., maritime cloud) and could be used for E-Navigation. The task should look at short range systems such as VHF, 4G and 5G as well as HF and satellite systems taking into account the 6 areas defined for the MSPs	Guidelines on seamless integration of all currently available communications infrastructure and how they can be used and what future systems are being developed along with the revised GMDSS.	Use existing on board communications infrastructure	2019

SIP clearly recognised the need for identifying shore-based functions and services. There are many different types of services in maritime sector. In order to harmonise and standardise these service, in SIP are introduced the Maritime Service Portfolios (MSPs). MSPs have been identified as the means of providing electronic information in a harmonised way. In SIP are proposed 16 MSPs where are identified various services like: VTS Information Service (IS), Navigational Assistance Service (NAS), Traffic Organisation Service (TOS), Local port Service (LPS), Maritime Safety Information Service (MSI), pilotage, tug, vessel shore reporting, Tele medical Assistance Service (TMAS), Maritime Assistance Service (MAS), nautical chart service, nautical publications service, ice navigation service, meteorological information service, real time hydrographic and environmental information service and last but not least Search and Rescue Service (SAR) [6].

For vessel shore reporting (MSP8) as service providers are identified National Competent Authority (NCA), Ship-owner, Operator and Master. Furthermore the aim of MSP8 is to "safeguard traffic at sea, ensure personnel safety and security, ensure environmental protection and increase the efficiency of maritime operations" [6]. Single Window is recognised as one of the most important solutions to reduce the mariner's workload (amount of time spent on preparing and submitting reports to shore-based authorities). To achieve this, reports should be automatically generated as much as possible from on board systems. Some other important possibilities for vessel shore reporting system may include [6]:

- single-entry of reportable information in single-window solution,
- automated collection of internal ship data for reporting,
- all national reporting requirements to apply standardized digital reporting formats based on IMO FAL forms and
- automated or semi-digital distribution/communication of required reportable information.

2.2 IALA's role in the E-Navigation concept

IMO as leading agency of the E-Navigation concept has expressed an interest in the contribution other outside organizations like IALA, IHO and others to the work on E-Navigation. At the request of IMO, IALA is supporting IMO in the development and implementation of E-Navigation by offering architecture proposals for coordinated review by IMO [8]. For that purpose IALA Council have established an E-Navigation Committee (e-NAV) as they had considered that a subject of E-Navigation was relevant to the aims of IALA and it needed further study, clarification or discussion. Furthermore e-NAV is created with purpose of developing recommendations and guidelines on shore-based E-Navigation systems and services. The e-NAV is mainly dealing with technical aspects of E-Navigation relating to aids to navigation (AtoN). Main objective of e-NAV is to develop IALA documents like guidelines and recommendations related to AIS, DGNSS and AtoN systems. It is evident the E-Navigation concept is complex so the technical solution will not be simple. Several steps are required to arrive at a suitable technical solution. The first steps were taken in IALA recommendation [9], while other consecutive IALA Recommendations on E-Navigation are based upon this one.

The e-NAV closely cooperates with other international organizations and manufacturers, distributors who are industrial members of IALA, in order to contribute to E-Navigation concept and supports IMO by providing technical expertise. E-NAV committee is consisted of following working groups:

- Operations group dealing with ashore activities,
- Position, Navigation, and Timing (PNT) group is focused on shore side sensors and radio navigation,
- AIS and Communications group is covering technical aspects of AIS and communications spectrum and closely cooperates with International Telecommunication Union (ITU) and International Electrotechnical Commission (IEC),
- Technical Architecture group is focused in creating shore side perspective of E-Navigation architecture and
- Data Modelling and Interfaces group is cooperating with IHO in order to prepare product specifications for IHO S-100 GI Registry [10].

Another important role of IALA is in its efforts to provide a guideline in reporting of results of E-Navigation testbeds. IALA has issued a document that offers guidance on the reporting of results of E-Navigation testbeds [11]. This document includes initial considerations that have to be reflected when planning a testbed and a reporting template for results in order to ensure that results are valuable to the E-Navigation development community. A testbed itself is a platform for trialling development projects and in principle involve rigorous, transparent and replicable testing of scientific theories, computational tools and new technologies.

Various administrations and organisations have conducted testbeds related to E-Navigation. Some of them are ongoing. List of E-Navigation testbeds could be found in [11] and [12].

2.3 Overarching E-Navigation architecture

IMO has defined an overarching architecture for E-Navigation as given in the following Figure 1.

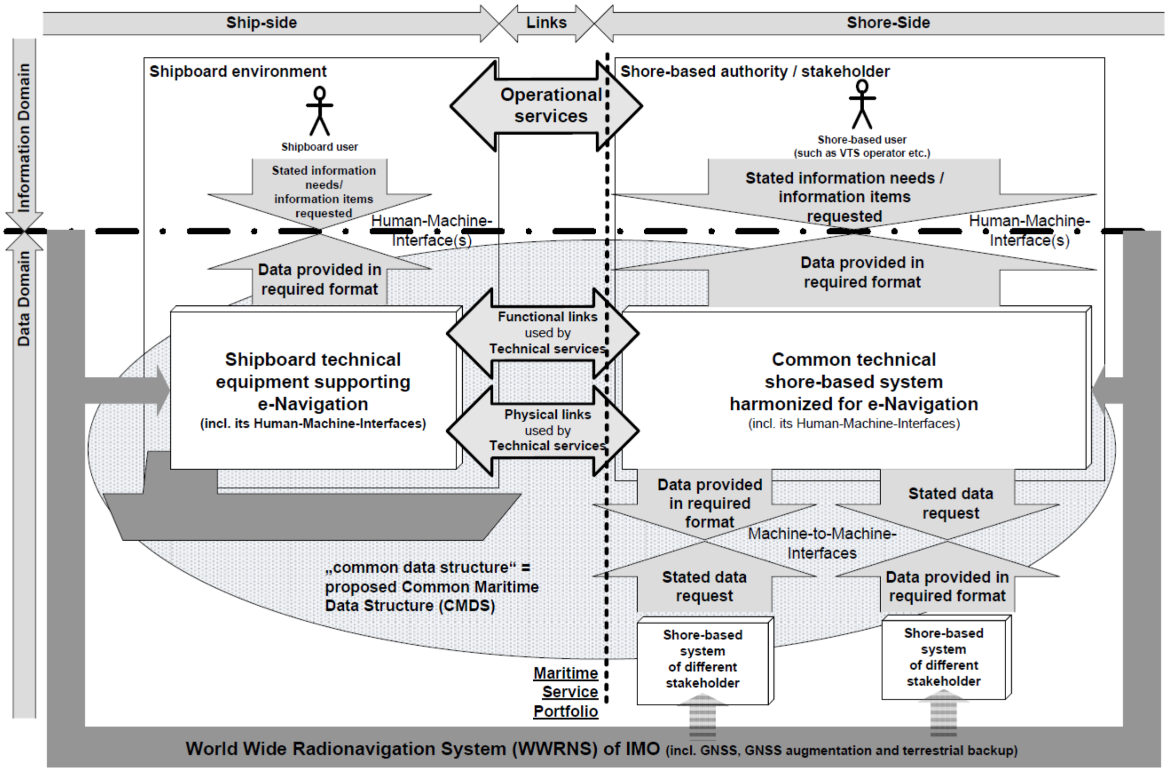


Figure 1: Overarching E-Navigation architecture [13]

On figure 1 it is easy to notice in horizontal level three most important parts of E-Navigation: ship side and shore side structures are connected with communication links in between. In vertical level are illustrated information and data domain with human and machine interfaces in between.

The figure also presents one important feature that is also important for MSW implementation. The shaded ellipsoid in the background represents Common Maritime Data Structure (CMDS) that extends through whole horizontal level. CMDS should be most important factor that will have impact on harmonization among different shipboard and ashore technical systems [13]. It is worth mentioning that IHO S-100 data model will play a key role in achieving above mentioned harmonization [6].

3 PREPEARING FOR MSW IMPLEMENTATION

Single Window concept has been introduced as a major platform for collaboration and information exchange among different government agencies involved in international trade. In 2005 the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) summarized the Single Window concept in its Recommendation 33 [14] as a “facility that allows parties involved in trade and transport to lodge standardized information and documents with a single entry point to fulfil all import, export, and transit-related regulatory requirements. If information is electronic, then individual data elements should only be submitted once".

As regard for MSW, IMO addresses this issue, which is related to facilitation of international maritime traffic, through FAL Committee. Work of FAL Committee, among other topics, is focused on simplification of formalities, documentary requirements and procedures on the arrival and departure of ships and harmonization of documents required by the public authorities. Main result of work of this Comities are standardized IMO FAL Forms. Having in mind that most of literature available on the single window concept is mostly concerned with trade and cargo related issues, IMO has published guidelines for setting up a single window system in maritime transport [15]. These guidelines attempt to provide more specific guidance on maritime transport clearance, including the clearance of the ship. Guidelines are built upon general single window concepts and characteristics which have been expanded to integrate the requirements of maritime transport.

According to IMO, MSW would be focused on facilitating the clearance of ships, passengers and crew members, and on connecting the cargo-related information with the single window on cargo clearance already in place, using the information provided in the IMO FAL Forms [4].

3.1 EU initiative – Reporting Formalities Directive

Unlike international level where MSW is still a concept that is broadly discussed, in EU level there is clear road map and predefined dates for MSW implementation. RFD imposes to EU member states to implement MSW, linking it with SafeSeaNet[1], e-Customs and other electronic systems, where all information will be reported once and made available to various competent authorities and the member states. There are three types of reporting formalities referred to RFD [5]:

1. Reporting formalities resulting from legal acts of the EU that includes information which shall be provided like:
   - Notification for ships arriving in and departing from ports of the EU,
   - Border checks on persons,
   - Notification of dangerous or polluting goods carried on board,
   - Notification of waste and residues,
   - Notification of security information,
   - Entry summary declaration.
2. FAL forms and formalities resulting from international legal instruments
   - FAL form 1: General Declaration
   - FAL form 2: Cargo Declaration
   - FAL form 3: Ship's Stores Declaration
   - FAL form 4: Crew's Effects Declaration
   - FAL form 5: Crew List
   - FAL form 6: Passenger List

[1] SafeSeaNet is a EU platform for vessel traffic monitoring and information exchange between member states maritime authorities established in order to enhance maritime safety, port and maritime security, marine environment protection and the efficiency of maritime traffic and maritime transport.

- FAL form 7: Dangerous Goods
- Maritime Declaration of Health

3. Any other relevant national legislation

RFD also require from each member states to ensure that the reporting formalities at their ports are requested in a harmonised and coordinated manner. According to RFD, MSW must be interoperable, compatible and accessible to the SafeSeaNet system and, where applicable, with other paperless systems for customs and trade.

4 FUTURE TRENDS

A common feature of E-Navigation and MSW is to provide seamless transfer of information across all available communication systems needed for their implementation. One of proposed solution to achieve 'Common technical shore based system harmonized for E-Navigation' (figure 1.) is Maritime Cloud. Maritime Cloud is defined as: "A communication framework enabling efficient, secure, reliable and seamless electronic information exchange between all authorized maritime stakeholders across available communication systems" [16]. Relevant IMO bodies also noted that the Maritime Cloud could complement MSW concept. It is important to note that Maritime Cloud is not a 'storage cloud' containing all information about every ship or cargo, nor is it referring to 'cloud computing' [19]. 'Maritime Cloud' is envisaged as an enabler of seamless information exchange between various systems and across different communication links in the maritime sector, that will enable realization of communication infrastructure necessary for E-Navigation and MSW [19].

On EU level is present E-Maritime initiative that aims to foster the use of advanced information technologies for working and doing business in the maritime transport sector. E-Maritime envisages facilitating the movement of goods over sea, by using of ICT technology to accelerate processes and services in maritime sector [17]. MSW that should be implemented at EU level could be considered as a part of E-Maritime initiative. It is noted that E-Maritime and E-Navigation could contribute to the development of each other. One of views of coherence between E-Navigation and E-Maritime (including MSW) is that main aim of E-Navigation is "to enhance the navigation capabilities of a ship without compromising its efficiency", while "e-Maritime aimed to increase its profitability without compromising its safety" [17].

5 CONCLUSION

Nowadays there is an increasing demand by national maritime authorities to ask for more information from vessels calling their ports and transiting waters under their jurisdiction in order to manage possible safety, security and environmental risks. Moreover, ports and coastal states are implementing more rules, requirements and mandatory reporting for vessels arriving in or transiting waters within their jurisdiction. Number of regional and bilateral agreements among coastal states related to maritime safety and environmental protection is also increasing. Most of these agreements seek for additional reporting. All this impose to stakeholders in maritime transport additional burden and workload. With implementation of E-Navigation and MSW administrative burden, on board and on shore, will be reduced, that will improve navigational safety and reduction of risks of accidents at sea.

Both concepts, E-Navigation and MSW, have common key words: harmonization, standardization and facilitation. In front of stakeholders, international bodies and industry there is a great challenge, in coming years, in producing a unified strategies and latter develop specific systems to meet needs for harmonization, standardization and facilitation in maritime transport. If this will be achieved it will have great impact on maritime safety, security and marine environmental protection.

REFERENCES

[1] WORK PROGRAMME, Development of an E-Navigation strategy, Submitted by Japan, Marshall Islands, the Netherlands, Norway, Singapore, the United Kingdom and the United States, IMO MARITIME SAFETY COMMITTEE, MSC 81/23/10, 19 December 2005

[2] REPORT OF THE MARITIME SAFETY COMMITTEE ON ITS EIGHTY-FIFTH SESSION, MSC 85/26/Add.1, 6 January 2009, ANNEX 20: STRATEGY FOR THE DEVELOPMENT AND IMPLEMENTATION OF E-NAVIGATION

[3] E-NAVIGATION Report of the Working Group, IMO SUB-COMMITTEE ON SAFETY OF NAVIGATION, NAV 58/WP.6/Rev.1, 9 July 2012

[4] REPORT OF THE FACILITATION COMMITTEE ON ITS THIRTY-NINTH SESSION, IMO FACILITATION COMMITTEE, FAL 39/16, 2 October 2014

[5] DIRECTIVE 2010/65/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 October 2010 on reporting formalities for ships arriving in and/or departing from ports of the Member States and repealing Directive 2002/6/EC

[6] DEVELOPMENT OF AN E-NAVIGATION STRATEGY IMPLEMENTATION PLAN, Report of the Correspondence Group on e-navigation Submitted by Norway, NCSR 1/9, 28 March 2014

[7] The Norwegian Coastal Administration, E-Navigation, URL: http://www.kystverket.no/en/About-Kystverket/International-work/enavigation/Strategy-Implementation-Plan/, last access on 28th January 2015

[8] IALA, E-Navigation FAQ, URL: http://www.iala-aism.org/about/faqs/enav.html, last access on 27th January 2015

[9] The e-Navigation Architecture -the initial Shore-based Perspective, IALA Recommendation e-NAV-140, December 2009

[10] IALA, IALA Committees, ENAV, URL: http://www.iala-aism.org/committees/enav.html, last access on 27th January 2015

[11] IALA Guideline No. 1107 on The Reporting of Results of e-Navigation Testbeds, Edition 1, December 2013

[12] e-Navigation portal, Test Beds/ Projects URL: http://www.e-navigation.net/index.php?page=test-beds, last access on 27th January 2015

[13] DEVELOPMENT OF AN E-NAVIGATION STRATEGY IMPLEMENTATION PLAN, Report of the Working Group, IMO SUB-COMMITTEE ON SAFETY OF NAVIGATION, NAV 57/WP.6, 8 June 2011

[14] Recommendation and Guidelines on establishing a Single Window, Recommendation No. 33, United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT), 2005.

[15] GUIDELINES FOR SETTING UP A SINGLE WINDOW SYSTEM IN MARITIME TRANSPORT, IMO FAL, FAL.5/Circ.36, 9 November 2011

[16] DEVELOPMENT OF AN E-NAVIGATION STRATEGY IMPLEMENTATION PLAN Overview of the maritime Cloud concept Submitted by Denmark, France and the Republic of Korea, IMO SUB-COMMITTEE ON NAVIGATION, COMMUNICATIONS AND SEARCH AND RESCUE, NCSR 1/INF.21, 25 April 2014

[17] EMAR project Deliverable D5.7.11, e-Maritime + e-Navigation, URL: http://www.emarproject.eu/, last access on 29th January 2015

[18] Polish Approach to e-Navigation Concept, A. Weintrit R. Wawruch C. Specht L. Gucma Z. Pietrzykowski, International Journal on Marine Navigation and Safety of Sea Transportation, Volume 1 Number 3 September 2007

[19] An overview of the 'Maritime Cloud' – proposed information exchange infrastructure for e-navigation, input to the IMO e-navigation CG by DENMARK

THE IMPACT OF SULPHUR DIRECTIVE ON THE EUROPEAN SHIPPING MARKET

Izabela Kotowska, DSc.
Maritime University of Szczecin
H. Poboznego 11, Szczecin, Poland
i.kotowska@am.szczecin.pl

ABSTRACT

Transport is a sector of economy that largely contributes to the growth of global pollution. A vast majority of harmful substances emitted as a result of transport activities comes from the road transport means. However, maritime transport, due to high sulphur level in the maritime fuel oil, is mainly responsible for the emission of sulphur oxides.

Bearing in mind such a large share of maritime transport in sulphur emissions, European Union implemented the Directive 2012/33/EU. The Directive, in force since January 2015, requires a cut in sulphur emissions from vessels, by using low sulphur fuels or installing scrubbers on ships.

The adverse effect of the implementation of the Directive - increased operating costs of shipowners active in the Sulphur Emission Control Area (SECA) - the Baltic Sea, the North Sea and the English Channel, can lead to a reduction in sea traffic. Additionally, the fact that the SECA area does not cover the Mediterranean, the Bay of Biscay and the Norwegian Sea may lead to reorganization of transport chains. The aim of this article is to answer how the implementation of the Sulphur Directive affects the European shipping market.

The research has been based on an analysis of traffic and freight costs of two segments of shipping market: ferry and container. It has shown that the restrictions of sulphur content in maritime fuel oil in SECA tightened from 2015 on should not result in a reduction of traffic or necessitate reorganization of transport chains.

Key words: Sulphur Directive, maritime transport, sustainable transport, sulphur dioxide, Annex VI of MARPOL.

1 INTRODUCTION

Sustainable transport, as one of the objectives of sustainable development, should contribute to social development and economic growth with the least negative impact on the environment. It is hard to overestimate the economic role of transport, but unfortunately transportation also generates negative social and environmental effects, known as externalities. Transport externalities are mainly due to environmental pollution arising from the combustion of fossil fuels by means of transport. The main compound emitted by transport activities is carbon dioxide - a greenhouse gas that causes global warming. It entails a growing number of locally occurring floods, hurricanes, droughts and rising water levels. Apart from carbon dioxide, the burning of fossil fuels results in the formation of other pollutants such as nitrogen oxides, sulfur oxides, particulate matters and non-methane volatile organic compounds. In Europe, transport is responsible for almost half of emissions of nitrogen oxides and about 10-15% of other pollutants and greenhouse gases.

The vast majority of harmful substances emitted as a result of transport activity comes from road transport vehicles, while maritime transport, mainly due to the capacity, is considered the most environmentally friendly transport mode. However, the emissions from the maritime transport sector cannot be considered a negligible source of atmospheric pollutants in European coastal areas (Viana et. al., 2014). Maritime transport is a heavy contributor to SOx emissions due to the nature of fuel used by ship engines; that is, mainly heavy fuel oil (HFO) with a high sulphur content (Dore, 2006, Doudnikoff, Lacoste, 2014). Sulphur oxides are responsible for the formation of acid rain, which results in the acidification of soil. In addition, sulphur oxides have a strong impact on human health and life, resulting in, among others, pulmonary and cardiovascular diseases and cancers (Pawłowska, 2000). The share of maritime transport in SOx emissions is significant. De Meyer et. al. (2008) research proved that in 2003 maritime transport was responsible for about 30% of total emissions in the Belgian part of the North Sea. Hongisto (2014) studies have shown that ship emissions contributed from 10% to 25% of the SO_2 and SO_4 concentrations along Baltic Sea coasts. The growing importance of SO_2 emissions from international shipping contrasts with the strong downward trend in land-based SO_2 emissions. The permissible sulphur content in the road fuel is only 10 ppm (1 thou. times less than in maritime fuel oil IFO 380 1.0% S).

In response to the growing contamination resulting from maritime transport the International Maritime Organisation introduced Annex VI to International Convention for the Prevention of Pollution from Ships (MARPOL). Although it was announced in 1997, it entered into force only in 2005. Annex VI limited the main air pollutants contained in ships exhaust gas, including sulphur oxides (SOx) and nitrous oxides (NOx). The annex set the global limits of sulphur in maritime fuel to 4.5% by weight. It also introduced the special SOx Emission Control Areas (SECA) covering the Baltic Sea, the North Sea and the English Channel only, where the sulphur content was established not to exceed 1.5%. The regulations allowed to use scrubbers instead of low sulphur fuel. This annex was implemented to European legislation by the 2005/33/EC Directive. The Directive specified the terms of introduction of the sulphur content restrictions in SECA as August 2006 at the Baltic Sea and August 2007 at the North Sea and English Canal. Additionally, since 2010 the Directive has required the use 0.1% sulphur fuel oil by ships berthing in EU ports. This restriction brought tangible benefits in short time. The research conducted in Mediterranean ports has shown that the introduction of the directive requiring all ships at berth or anchorage in European harbours to use low sulphur fuels led to decrease of the sulphur dioxide concentrations up to 66% (Schembari et. al. ,2012).

The Annex VI of MARPOL Convention was revised in 2008 (entered into force in 2010). It introduced new limits of the sulphur content in the maritime fuel oil up to 3.50% by weight after 1 January 2012 and 0.50% - after 1 January 2020. Within an SECA, the sulphur content in fuel oil was set: 1% after 1 July 2010, and 0.1% after 1 January 2015 (IMO, 2008). The revised Annex VI was implemented to the EU legislation by the 2012/33/EU Directive. Unfortunately, these strict regulations concern only vessels operating in SECAs, excluding the area of the Mediterranean, the Bay of Biscay and the Norwegian Sea.

The adverse effect of the implementation of the Directive is the increase of the operating costs of shipowners active in the SECA (Bengtsson et al., 2014). The three main options to reduce sulphur emissions: low sulphur distillates, liquefied natural gas (LNG) and, SOx scrubbers highly increase the operating costs of shipping companies (Gilbert, 2014). Low sulphur distillates are about 50% more expensive than heavy fuel oils. Using LNG as a fuel or scrubbers needs heavy investments. For example, the cost of installing a scrubber reaches $5 million. The Interferry shipping association studies have shown that in 2011 of 108 examined

Baltic ferries, up 60 percent were not suitable, either for technical reasons or due to lack of financial viability, to install scrubbers (Shipowners under pressure of ecology, 2012).

There is a concern that increased shipping costs could lead to reduction in maritime traffic and modal shift to road transport, effectively increasing the total adverse environmental impact. However, researchers' opinions on this issue are divided. Notteboom, Delhay and Vanherle (2010) indicate that the use of MGO (0.1%) will have a negative effect on freight rates and the modal split on a large set of origin-destination relations. On some trade routes the short sea option might lose its appeal to customers.

Kehoe et. al. (2010) studies predict that introduction of low sulphur fuel in SECA will cause a modal shift in favor of the road-only route by approximate 10%, while the designation of the Mediterranean as a SECA can cause a modal shift by 5.2% (Panagakos et. al., 2014).

However, not all studies support the modal shift thesis. The research results based on analysis of five land-sea routes between Lithuania and Great Britain indicate that, despite the cost increase as a consequence of the new requirements for maritime fuel, a modal shift from sea-dominated routes to road-dominated routes is unlikely to occur (Holgman et. al., 2014).

2 METHODOLOGY

The studies of the impact of Sulphur Directive on the European shipping market were based on analysis of two segments: container and ferry shipping. Although the European shipping market covers dry and liquids bulk cargo and conventional and unitized general cargo shipping, only ferry and container shipping lines highly compete with land (road and rail) transport and their competitive position is strongly dependent on the maritime transport costs.

The study aimed to show how the introduction of the new requirements of Sulphur Directive affected the activities of shipping companies. The study was conducted for the two segments of short sea shipping market: ferry and container shipping.

Due to the fact that the European container shipping is primarily a final link of intercontinental transport chains, there are no official freight rates. Prices are calculated for the entire marine transport process. In order to determine the impact of changes introduced in 2015, a comparative analysis of the costs of freight from Chinese to main European ports located in Mediterranean, North and Baltic Sea was conducted. The analysis was based on average freight costs in one week of November ’14 and one week in January ’15 published by China Shipping. The research included the analysis of China Shipping Container Index in May ’14 – January ’15 period.

In order to determine how the previous changes of maximum sulphur content in fuel oil have affected the container transport in the European region, the analysis of the dynamics of container handling in ports located in the SECA and non-SECA was conducted. It was based on Eurostat Database.

In order to determine the direct impact of regulations introduced in January 2015 in SECA on the ferry market, a comparative analysis of ferry transport costs was made. The analysis was based on tariffs published in December 2014 and January 2015 by the ferry carriers: Unity Line, TT-Line and Polferries operating the routes Świnoujście-Ystad and Świnoujście–Trelleborg. The analysis of ferry traffic, based on 2005-2013 Shippax statistic, complemented the considerations.

3 RESULTS

An important factor influencing the shape of the entire container land-sea transport chain, is the place of origin and/or destination of the cargo. The European container shipping market consists of two segments:

1. Continental transport, where the place of origin and destination of the cargo are located in Europe; it is usually operated by short sea shipping companies.
2. Intercontinental transport, where the place of origin or destination of the cargo is located outside Europe and the whole transport chain consists of two or more chain links: ocean and feeder shipping (Kotowska, 2014).

Intercontinental transport constitutes the vast majority of European container traffic. The ocean link is operated by global carriers, while feeder link could be operated by a global carrier (who offers feeder services as additional part of the business) or independent feeder carrier. In both cases the global carrier acts as the multimodal operator: it creates the whole transport chain (the route and the price). Differentiation of regulations of sulphur content in maritime fuel oil between the seas of Northern Europe and the Mediterranean can influence competitive positions of container transport chains. Due to higher fuel costs of vessels operating in SECAs there is some concern, namely that the global container operators will redesign transport chains, especially on Asia-Europe loops. The higher volume of cargo will be delivered to the Mediterranean ports and thence - by road or rail transport - to customers in Northern Europe (Fig. 1).

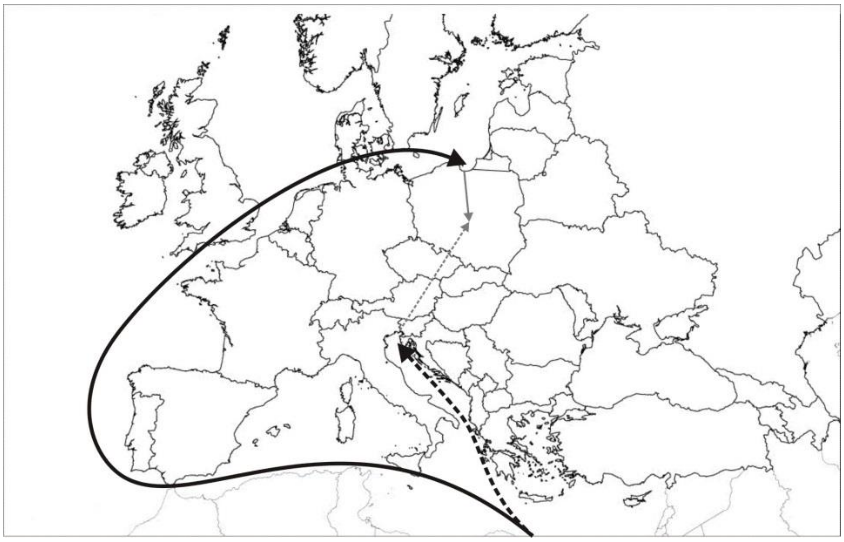


Figure 1: Container land-sea transport chains

Source: author's drawing.

The first changes are already noticeable. In 2015 Maersk is operating 11 loops on Asia-Europe routes, two more than in 2014 (Porter, 2014b). In 2015 the number of Maersk shipping lines calling at European ports located at the Mediterranean Sea increased from three in 2014 to six in 2015, while to the North Europe ports – by one only from five to six.

The analysis of the previous transhipments in European ports does not support this thesis. Figure 2 shows the share of container handling in ports of SECA and non SECA European regions. The share of North Sea and Baltic Sea ports is about 60%, whereas until 2008 there was a slight 2% increase, followed by a 4% decrease. This dynamic should be rather identified with the global crisis, the gradual change from hub-and-spoke network to multilayer network (see Ducruet and Notteboom, 2012) and development of Eastern Europe than with Sulphur Directive. Since 2002 the share of Baltic ports has increased from 4.3% till 6.5% and Black Sea ports from 0.2% to 4.8%.

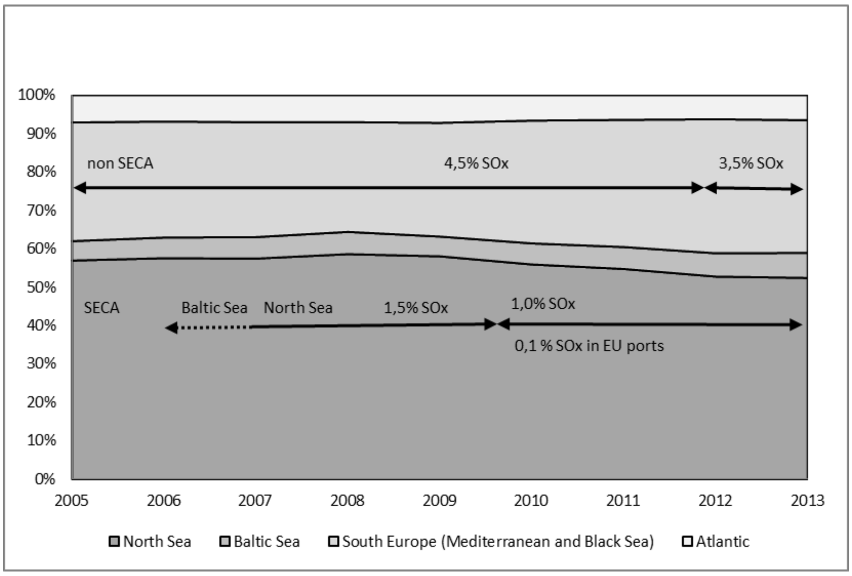
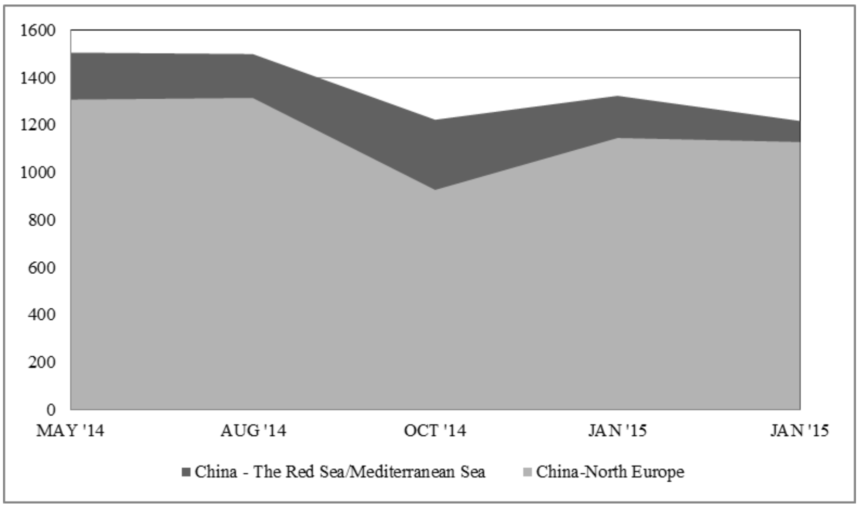


Figure 2: The share of container handling in ports of SECA and non SECA European regions

Source: author's calculations based on Eurostat Database

The average freight cost on the China-Mediterranean route is usually about $200 higher than on China-North Europe route (Fig. 3). It is probably the main reason of such significant share of northern ports in total European ports turnover. However, the expected increase in operating costs resulting from the implementation of the Sulphur Directive highly affected the fluctuations of freight prices. At the end of the 2014, the rate differences reached $400, while in January decreased to $90 only.



Ports considered in the index: China - Guangzhou, Shenzhen, Xiamen, Ningbo, Shanghai, Qingdao, Tianjin, Dalian; North Sea - Antwerp, Bremen, Felixstowe, Hamburg, Le Havre, Rotterdam, Zeebrugge; Mediterranean/Red Sea - Aqaba, Barcelona, Constanza, Fos, Genova.

Figure 3: China forwarders freight index

Source: author's drawing based on ShippingChina (2014).

In November 2014 Shipping Companies calculated that on intercontinental routes the cost to shippers through low sulphur surcharges rose from \$10 to \$120 per TEU, depending on the service in question. The higher surcharges concerned the shippers with cargo on services within the Baltic region. MSC's surcharge for cargo moving on Lion and Silk services from Asia to northern Europe has been set at \$15 per TEU, rising to \$52 for Scandinavian and Baltic destinations (Porter, 2014a).

Figure 4 shows the average freight rates between China and European ports in a selected week in November '14 and January '15. In January the costs of freights on most routes were higher than in November. The highest, almost 50% increase, was on routes from China to Baltic Sea ports (Gdynia, Gdańsk), while to North Sea ports the increase was smaller and reached only 40%, similarly to the increase on China-North Adriatic route. Thereby the difference between freight costs to Baltic ports and North Sea ports increased from \$300 to \$550. In the same period, the cost of freight from China to West Mediterranean ports decreased by about 10%.

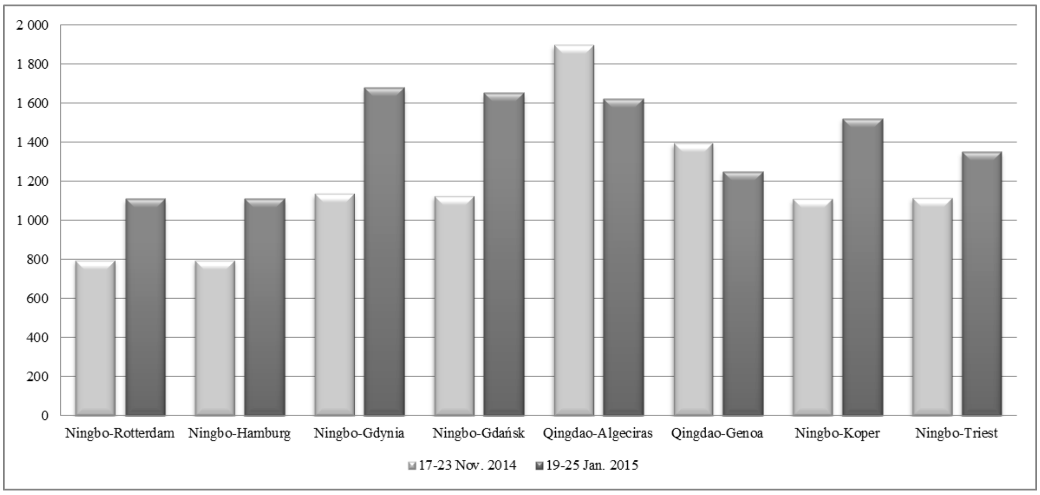


Figure 4: The freight costs on selected Asia-Europe routes in November '14 and January '15

Source: author's research based on ShippingChina (2014).

The increase of freight costs to the ports located in SECA area was noticed despite the large decrease of fuel prices. The price of low sulphur diesel oil in February was at the same level as maritime gas oil (IFO 380) in October '14. Considering the costs of fuel, the freight prices should not increase at all. But the fluctuation of freight cost strongly depends on market demand (in January the prices increased due to the Chinese New Year). At the beginning of February the freight costs dropped again to \$1100 per TEU on China – North Sea routes and \$1400 per TEU on China-Baltic Sea routes. Thereby, the difference in freight costs to Baltic ports and North Sea ports returned to \$300 that was noted in November '14.

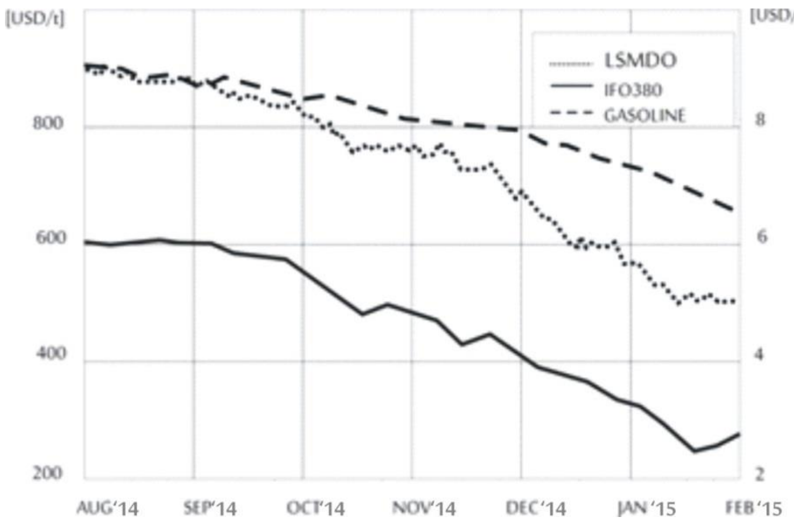
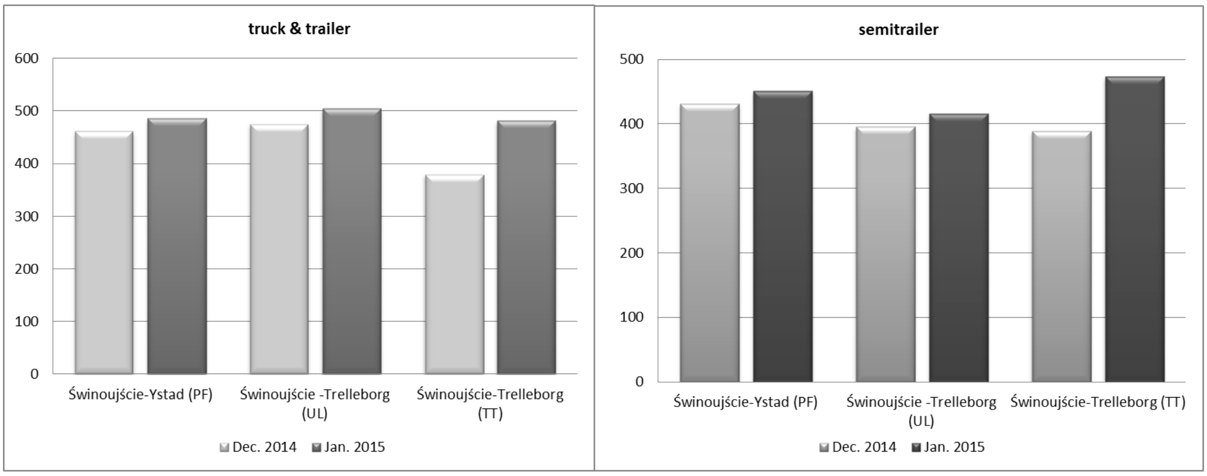


Figure 5: The average prices of: gasoline in Europe for road transport (right scale), low sulphur maritime diesel oil (LSMDO) and heavy fuel oil (IFO380) for maritime transport (left scale) from August 14 to Februar 15

Source: author's drawing based on: Bunkerworld (2015), EIA (2015).

Ferry shipping experiences a different situation . The latest sulphur regulations in SECA forced the ferry companies to change their investment policies. Some operators, like DFDS and Color Line, decided to install scrubbers, others, e.g. Containerships, ordered new LNG-fuelled vessels or, like Stena Line, converted the old one to methanol propulsion (Martin, 2013; Roueche, 2013; Bonney 2014; Stena Line introduces methanol-fuelled ship, 2014). Unfortunately, some carriers (e.g. DFDS and Transfennica), because of concerns that the new regulation would result in a loss of volumes, cut some services (Brett, 2015). But most shipping companies began to use low sulphur fuels. All of the mentioned methods contribute to an increase in the operating costs of ferry companies, which in turn affects freight prices. Most ferry tariffs consist of three components: basic fee, bunker adjustment factor surcharge (BAF) and low sulphur surcharge (LS). Two of three analyzed tariffs of ferry carriers operating on Świnoujście (Poland) to Trelleborg/Ystad (Sweden) route are designed in this way. In both cases the basic fee has not been changed in 2015, but the low sulphur surcharge increased (from 3SEK to 22SEK for one line meter of truck). Despite a significant decrease of BAF surcharge (from 14 SEK in December to 8 SEK in January) the total price increased by 5%. The third carrier tariff is designed differently. It consists of basic charge and bunker surcharge. In this case in 2015 the bunker surcharge has not change significantly, while the basic fee has increased by almost 30%. Although this increase is significant, the total price for carriage on the analyzed route is lower than the offer of the other carriers (TT Line ferry Świnoujście-Trelleborg route was lauched in January 2014 and the low price in 2014 was a form of incentive to attract new customers).



PF – Polferries; UL – Unity Line; TT – TT Line

Figure 6: The freight prices for self-propelled and non-self-propelled units on Świnoujście-Trelleborg/Ystad routes

Source: author's research based on: TT Line, Unity Line, Polferries ferry tariffs.

Despite the fact that in 2015 the cost of ferry freight has increased, with a decline in the cost of road transport, resulting from fuel price decrease, a modal shift should not be expected. This is due to the role that ferry services play. The vast majority of ferry services have mandatory character (they represent 3/4 of European ferry shipping lines), for which there are no alternative road routes (eg. shipping lines connecting islands with the mainland). The other ferry services are optional. They can be divided into types:

- bridge type shipping lines - short lines of up to two hours of haulage time, they make natural extensions of land roads,
- transverse type shipping lines, where the voyage lasts over two hours but shorter than via the alternative road haulage, they are mainly lines connecting ports located on the opposite coastlines of confined water areas, e.g. the Baltic Sea, the Adriatic Sea and the northern part of the Mediterranean Sea (Kotowska, 2014)

Because of these features of ferry shipping, particularly small substitutability of ferry lines and high correlation with road transport, the tightened rules of sulphur content in fuel oil should not affect the modal shift to road transport. Confirmation of this thesis is the dynamic ferry traffic in SECAs in 2005-2013 period. (Fig. 7) Tightening the sulphur rules in 2010 did not lead to ferry traffic decrease. The opposite phenomenon was observed, most likely due to the development of Eastern European countries. In 2010 the ferry traffic increased by almost 50% compared to 2009. Similar phenomena are observed in 2015. In January ’15 the volume of cargo on Świnoujście-Ystad/Trelleborg ferry connection rose by almost 4% compared to January '14.

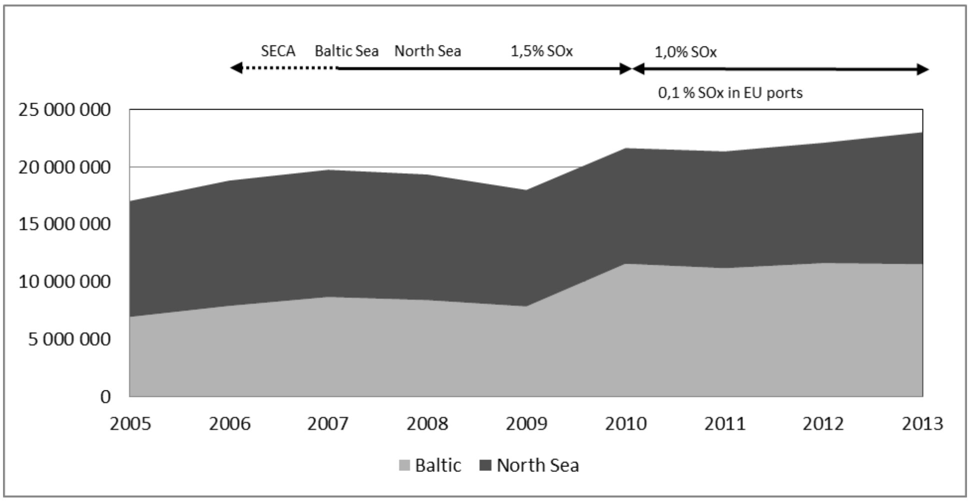


Figure 7: The ferry traffic in 2005-2013 in the North and Baltic Seas (number of trailers)

Source: author's drawing based on ShipPax Data.

4 CONCLUSIONS

The level of freight rates, which increased significantly at the turn of the year, is slowly returning to normal. The differences between the cost of freight to various European ports: the Mediterranean, the North Sea and the Baltic Sea, slowly reach the level existing before the introduction of the new sulphur restriction. Hence, the restrictive Sulphur Directive should not significantly affect the container shipping market or redesign transport chains, such as expected shortening of maritime links to end at Mediterranean ports.

The similar situation is observed in ferry shipping. Despite the increase of freight costs, the modal shift from sea to land should not be expected, simply because Most ferry routes cannot be replaced (or it is unprofitable) by road transport. This conclusion is confirmed by the latest statistics of ferry traffic on the analyzed routes, which reveal a slight increase after the introduction of the new sulphur restrictions. However, it should be remembered that the effects of the provisions of the Sulphur Directive have been significantly mitigated by the fall in fuel prices. Nevertheless, even if fuel prices return to the level before August 2014, the freight rates should not rise more than 10-15% compared to those in December 2014. In summary, the fear that the directive will affect the modal shift does not seem to be fully justified.

ACKNOWLEDGEMENTS

The project was funded by the National Science Centre allocated on the basis of the decision DEC-2012/05/B/HS4/00617.

REFERENCES

[1] Bengtsson, S. K., Fridell, E., & Andersson, K. E. (2014). Fuels for short sea shipping: A comparative assessment with focus on environmental impact. *Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment*, 228(1), 44-54.

[2] Bonney, J. (2014). Finnish short-sea line orders two more LNG-fueled ships. *The Journal of Commerce*. [on line: http://www.joc.com/maritime-news/container-lines/finnish-short-sea-line-orders-two-more-lng-fueled-ships_20140925.html]

[3] Brett, D. (2015). Cost of ocean transport down on last year despite sulphur regulation. *Loading List Daily News Bulletin*. [online: http://www.lloydsloadinglist.com/freight-directory/ adviceandinsight/Cost-of-ocean-transport-down-on-last-year-despite-sulphur-regulation /61606.htm?utm_source=Lloyd%27s+Loading+ List+Daily +News+Bulletin &utm_campaign =5537bd7dfa-Wed_30_July 7_30_2014 &utm_medium=email&utm_term =0_1a5c244239-5537bd7dfa-256684157#.VNXDi0eG_X5]

[4] Bunkerworld (2015). viewed 4.02.2014. http://www.bunkerworld.com/prices/ (access:)

[5] De Meyer, P., Maes, F., & Volckaert, A. (2008). Emissions from international shipping in the Belgian part of the North Sea and the Belgian seaports. *Atmospheric Environment*, 42(1), 196-206.

[6] Directive 2005/33/EC of the European Parliament and of the Council of 6 July 2005 amending Directive 1999/32/EC (OJ. L 191, 22.7.2005).

[7] Directive 2012/33/EU of the European Parliament and of the Council of 21 November 2012 amending Council Directive 1999/32/EC as regards the sulphur content of marine fuels 2012/33/EU Directive (OJ. L 327, 27.11.2012).

[8] Dore, A. J., Vieno, M., Tang, Y. S., Dragosits, U., Dosio, A., Weston, K. J., & Sutton, M. A. (2007). Modelling the atmospheric transport and deposition of sulphur and nitrogen over the United Kingdom and assessment of the influence of SO_2 emissions from international shipping. *Atmospheric Environment*,41(11), 2355-2367.

[9] Doudnikoff, M., & Lacoste, R. (2014). Effect of a speed reduction of containerships in response to higher energy costs in Sulphur Emission Control Areas. *Transportation Research Part D: Transport and Environment*, 27, 19-29.

[10] Ducruet C., Notteboom T., 2012, Developing Liner Service Networks in Container Shipping, [in:] Song D.W., Panayides P. (eds.), *Maritime Logistics: A complete guide to effective shipping and port management*. Kogan Page, London, s. 77-100.

[11] EIA (2015). The U.S. Energy Information Administration. viewed 4.02.2015. [online: www.eia.gov].

[12] Eurostat Database, Maritime transport - Goods - Quarterly data - Main ports - Containers only - years 2000-2013.

[13] Gilbert, P. (2014). From reductionism to systems thinking: How the shipping sector can address sulphur regulation and tackle climate change. *Marine Policy*, 43, 376-378.

[14] Holmgren, J., Nikopoulou, Z., Ramstedt, L., & Woxenius, J. (2014). Modelling modal choice effects of regulation on low-sulphur marine fuels in Northern Europe. *Transportation Research Part D: Transport and Environment*, 28, 62-73.

[15] Hongisto, M. (2014). Impact of the emissions of international sea traffic on airborne deposition to the Baltic Sea and concentrations at the coastline. *Oceanologia*, 56(2), 349-372.

[16] IMO. (2008) Report Of The Marine Environment Protection Committee On Its Fifty-Eighth Session, Marine Environment Protection Committee, MEPC 58/23/Add.1.

[17] Kehoe, J., Nikopoulou, Z., Liddane, M., Ramstedt, L., & Koliousis, I. G. (2010). Impact Study of the future requirements of Annex VI of the MARPOL Convention on Short Sea Shipping: Task 2 Report, SKEMA Consolidation Study. Nautical Enterprise (Commissioned by the European Commission), Cork.

[18] Kotowska, I. (2014). Short Sea Shipping in the light of the idea of sustainable development of transport, Scientific Publishing House of the Maritime University, Szczecin 2014 [In Polish].

[19] Martin, F. (2013). DFDS to invest £34 million in scrubber technology. [on line: http://www.ferrynews.co.uk/news/dfds-invest-%C2%A334-million-scrubber-technology]

[20] Notteboom, T., Delhay, E., & Vanherle, K. (2010). *Analysis of the consequences of low sulphur fuel requirements*. ITMMA–Universiteit Antwerpen Transport&Mobility.

[21] Panagakos, G. P., Stamatopoulou, E. V., & Psaraftis, H. N. (2014). The possible designation of the Mediterranean Sea as a SECA: A case study. *Transportation Research Part D: Transport and Environment*, 28, 74-90.

[22] Pawłowska, B. (2000). *External costs of transport*, University of Gdańsk., Gdańsk. [In Polish].

[23] Polferries (2014). Freight Tafiff 2014. Polferries. viewed 10.12.2014. [online: http://www.polferries.pl]

[24] Polferries (2015). Freight Tafiff 2015. Polferries. viewed 12.02.2015. [online: http://www.polferries.pl]

[25] Porter, J. (2014a). Customers recognize the environmental benefits of reduced emissions. *Loading List Daily News Bulletin* [online: http://www.lloydsloadinglist.com/freight-directory/news/shippers-accepting-sulphur-surcharges-says-msc/20018121353.htm? Source =ezine&utm_source=Lloyd%27s+Loading+List+Daily+News+Bulletin&utm_campaign=5c9da2c6f9-Wed_30_July7_30_2014&utm_medium=email&utm_term=0_1a5c244239-5c9da2c6f9-256698001#.VIm9nDGG_X4]

[26] Porter, J. (2014b). 2M adds nine new ports to Maersk's east-west services. *Loading List Daily News Bulletin*. [online: http://www.lloydsloadinglist.com/freight-directory/sea/2M-adds-nine-new-ports-to-Maersks-east-west-services/60942.htm#.VNXCPEeG_X4]

[27] Roueche, L. (2013).Color line to retrofit exhaust gas scrubbers. *Interferry News*. [online: http://www.interferry.com/node/2634].

[28] Shipowners under pressure of ecology (2012). *Marine Observer*, 2012.08.09 [online: http://www.obserwator-morski.pl/artykuly/146/Armatorzy-pod-presja-ekologii] [In Polish]

[29] ShipPax Data. Statistical Yearbooks of ShipPax Information (2006-2014), Halmstad, Sweden: ShipPax Information.

[30] ShippingChina (2015). viewed 12.02.2014. http://en.shippingchina.com.

[31] Stena Line introduces methanol-fuelled ship (2014). [online: http://www.bairdmaritime.com /index.php?option=com _content&view=article&id=16255 :stena-line-introduces-methanol-fuelled-ship&catid=96:cruiseferry&Itemid=116]

[32] TT Line (2014). Freight Tafiff 2014. TT Line Cargo. viewed 10.12.2014. [online: http://www.ttline.com]

[33] TT Line (2015). Freight Tafiff 2015. TT Line Cargo. viewed 12.02.2015. [online: http://www.ttline.com]

[34] Unity Line (2014). Freight Tafiff 2014. Unity Line. viewed 10.12.2014. [online: http://www.unityline.pl]

[35] Unity Line (2015). Freight Tafiff 2015. Unity Line. viewed 12.02.2015. [online: http://www.unityline.pl]

[36] Viana, M., Hammingh, P., Colette, A., Querol, X., Degraeuwe, B., de Vlieger, I., & van Aardenne, J. (2014). Impact of maritime transport emissions on coastal air quality in Europe. *Atmospheric Environment*, 90, 96-105.

CONTROL OF BACK-TO-BACK INVERTERS EXCITING SYNCHRONOUS AND SQUIRREL-CAGE ELECTRIC GENERATORS IN PARALLEL CONNECTION

Maciej Kozak, PhD
Artur Bejger, PhD
Maciej Gucma, PhD
Maritime University of Szczecin
Wały Chrobrego 1-2, 70-500 Szczecin, Poland
m.kozak@am.szczecin.pl, m.gucma@am.szczecin.pl

ABSTRACT

The paper covers background and chosen experimental results for voltage source inverters VSI working in parallel with two types of electrical generators. Squirrel cage generator and synchronous generator are connected in parallel to power network with means of back-to-back voltage source inverters. Chosen real-time control algorithm of digital signal processor DSP and field-programmable gate array FPGA is used to achieve proper excitation of machines and maintain high enough level of direct current link voltage. Windings of both generators are fed with use of so-called machine side inverters. Asynchronous generator is VSI driven with use of sensorless algorithm based on multiscalar machine model, while field oriented controlled inverter excites synchronous generator. Proper control of line side inverters allows smooth distribution of active and reactive power on alternating current side. Line side inverters can be synchronized with ship's electrical network with means of software phase locked loop PLL or by voltage zero crossing sensing. To robustness of chosen algorithms, different types of load were applied while parallel work of generators and inverters..

Key words: Back-to-back, active power, reactive power, power distribution, VSI, inverters, FOC, multiscalar.

1 USE OF INVERTER FED GENERATORS IN SHIP'S ELECTRICAL GRID

1.1 Introduction

According to new regulations and rules there is urgent need to cut down emission of toxic gases produced by maritime Diesel engines. One of the strategies is using existing technologies of auxiliary combustion engines with new methods of connection electric generators and electrical power distribution. Up to date most of generators used in ship's are constant speed synchronous machines but it can be seen great advance in shaft generators grid inverters development. Next step for designers is creation of electrical system controlled along with electronic management of Diesel engines to improve reduction of fuel consumption and emission of exhaust gases.

Current work of group scientists and engineers in Institute of Electrotechnics and Automation is focused on parallel work of different types of generators connected thru inverters. In the lab called "Green Energy" there are three types of generators connected to main switchboard (MSB) with means of widely used marine synchronizers. Electrical generators are driven by squirrel cage motors, which are fed by vector sensorless commercial inverters. In classic ships designs MSB is main point where all electrical sources and consumers are tied up together.

There are installed protection units, power distribution devices along with circuit breakers, voltage regulators, monitoring and alarm systems in ship's main switchboard.

1.2 Two generator-inverter sets in parallel work concept

Proposed strategy of electrical generators control is based on assumption the every inverter unit assigned to it's own generator can act as power management system. While communication means of i.e. Modbus network are assured, system can easy cooperate with Diesel control unit to maintain optimal point of combustion engine work.

Main issue while connecting alternating current sources to parallel work is proper setting of parameters to achieve most optimal active and reactive power sharing. In most of solutions this is done by control over rotational speed and voltage regulators. In standard solutions there's a possibility to change active power load ratio simply by increase of fuel consumption of one generator, which takes more of electrical load. Reactive power sharing is fixed and proportional to nominal values so it cannot be changed in easy way by operator.

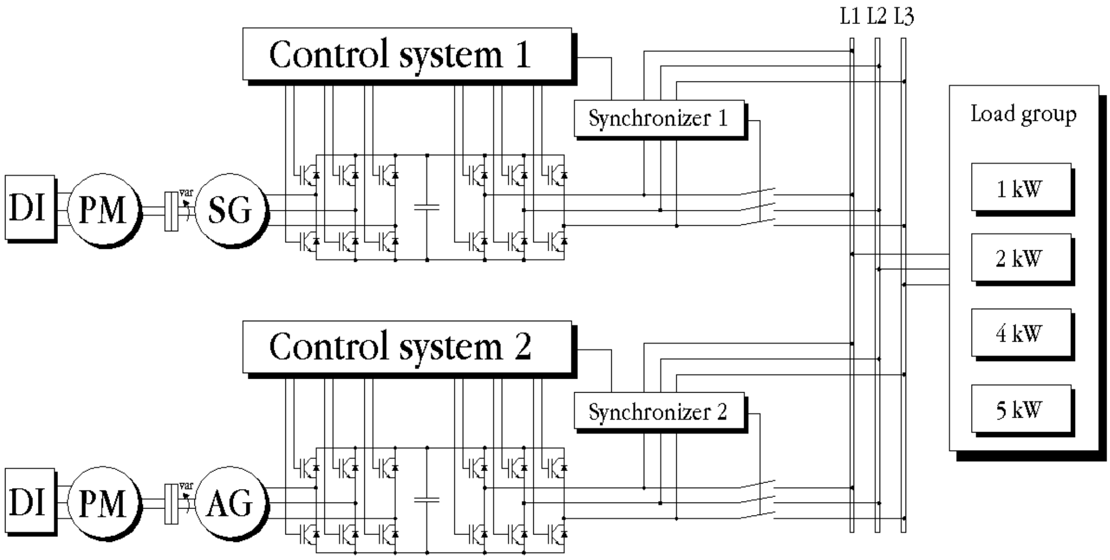


Figure 1: Block scheme of tested system

Source: Author

In presented solution as alternating voltage sources there are used self-excited synchronous generator denoted as SG and asynchronous squirrel cage generator marked as AG. Both generators are driven by prime movers (PM) powered by drive inverters (DI). Such a solution allows convenient driving of generators in wide range of RPM's thus working parameters testing become easy. As it can be seen in fig. 1. both inverters are in back-to-back connection which can be extremely useful in case of power transfer in/out with variable speed shaft generator use.

The synchronizers were used mainly for visualization of synchronization process and to give information of actual circuit breaker state (close or open). In presented system features of frequency control while synchronizing process were not utilized. As long as all data outputs are in digital form it can be easily distributed to data inputs of power converters controllers. In lab workbench all synchronization actions were made by changing frequency and amplitude of line inverters output voltages by hand input data modifications.

Important role of automatic synchronizers is to prohibit on bus connection of generator with misaligned frequency and amplitude to prevent huge values equalizing currents occurrence. When any of these parameters is not proper, closing of circuit breaker in automatic mode is not possible.

2 CONTROL OF MACHINE SIDE AND LINE SIDE INVERTERS

Proposed system consists of two real-time controlled inverters where digital signal processor can be freely programed with use of VisualDSP++ language while FPGA (field-programmable gate array) is programmed by Altera Quartus software. In most modern real-time power converters this type of control is recognized standard. FPGA digital circuit controls switching strategy of IGBT (insulated gate bipolar transistor) transistors (SVPWM - space vector pulse width modulation in this case) and provides handling of analog to digital sensors. DSP circuitry calls it in it's running real-time software interruptions and reads values of measured current and voltages for control and protection purposes. Moreover after calculation loop, digital signal processor sends voltages data in α-β coordinates to execute by FPGA. Logic unit controls switching of transistors constantly taking care of power electronics dead time.

Proper operation of line side inverter is ensured while direct current link voltage is maintained at desirable level. In tested system, DC voltage was set on 700V and it was kept almost constant by machine side inverters.

2.1 Self-excited synchronous generator control strategy

The 5,5 kW slip-ring synchronous generator (SG) driven by prime mover (PM) was used as one of test objects. As control algorithm the field oriented control (FOC) was chosen to utilize. In a manner of this method there can be independently controlled active and reactive currents. Active current i_{sq} control loop in d-q coordinates provides constant DC link voltage U_{DC} value, while reactive current i_{sd} is set to zero.

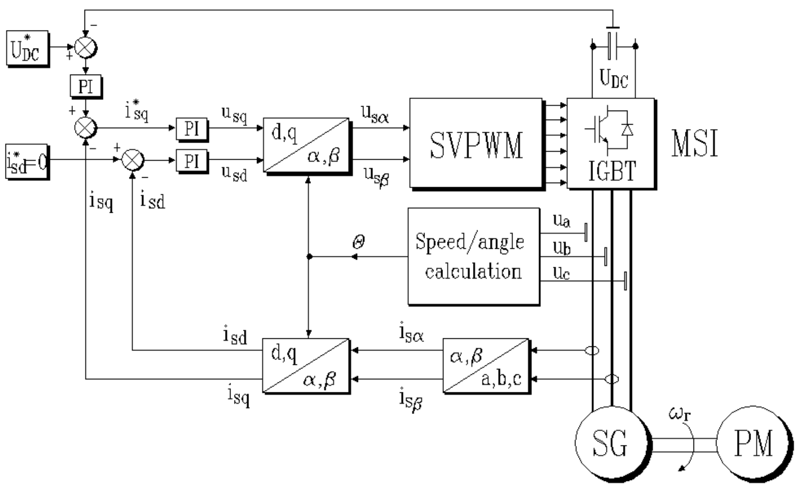


Figure 2: Scheme of synchronous generator control

Source: Author

The FOC control method is well known since it was introduced back in 1971 and is used mainly in AC electrical drives speed control algorithms.

The core of FOC is use of transformations calculated in DSP in real-time. With properties of space vector there's possibility of projection sinusoidal balanced three phase quantities as easy to control with PI regulators constant values of currents, voltages and fluxes. For example space vector $\overline{x}_s$ representing aforementioned quantities can be expressed by two-phase magnitudes called x_α and x_β in the real-imaginary complex plane. Mathematically this relationship can be written as:

$$\overline{x_s} = x_\alpha + jx_\beta = \frac{2}{3}\left(x_a + ax_b + a^2x_c\right) \tag{1}$$

The α-β components of the space vector can be calculated from the *abc* magnitudes according to:

$$x_\alpha = \mathrm{Re}\left\{\overline{x_s}\right\} = \frac{2}{3}\left(x_a - \frac{1}{2}x_b - \frac{1}{2}x_c\right) \tag{2}$$

$$x_\alpha = \mathrm{Im}\left\{\overline{x_s}\right\} = \frac{2}{3}\left(\frac{\sqrt{3}}{2}x_b - \frac{\sqrt{3}}{2}x_c\right) \tag{3}$$

These two relations can be represented in matrix form as follows:

$$\begin{bmatrix} x_\alpha \\ x_\beta \end{bmatrix} = \frac{2}{3}\begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix}\begin{bmatrix} x_a \\ x_b \\ x_c \end{bmatrix} \tag{4}$$

For practical use it is convenient to define matrix given in (4) as follows:

$$T = \frac{2}{3}\begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \tag{5}$$

This transform is referred as Clarke transformation named for the person who developed it Edith Clarke.

Other very useful transformation, transforms stator phase quantities from the stationary *abc* reference frame to the *dq0* reference frame which rotates with the rotor is called Park transform.

$$\begin{bmatrix} x_d \\ x_q \\ x_0 \end{bmatrix} = \frac{2}{3}\begin{bmatrix} \cos\theta & \cos\left(\theta - \frac{2\pi}{3}\right) & \cos\left(\theta + \frac{2\pi}{3}\right) \\ -\sin\theta & -\sin\left(\theta - \frac{2\pi}{3}\right) & -\sin\left(\theta + \frac{2\pi}{3}\right) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix}\begin{bmatrix} x_a \\ x_b \\ x_c \end{bmatrix} \tag{6}$$

Equations given in 4-6 are hard coded into VDSP++ and executed in real time just to obtain values of currents, voltages and fluxes needed for easy control machine side inverter and DC link voltage. To proper operation of algorithm there is need for rotating frame angle θ calculation. It is done in sensorless way by measurement excited generator terminal voltages. Those voltages are sinusoidal waveforms so by applying PLL (phase locked loop) or zero-crossing sensing it is possible to calculate rotational speed and frame reference actual angle. For preparation of inverter control signals inverse Park and Clarke transformations must be applied.

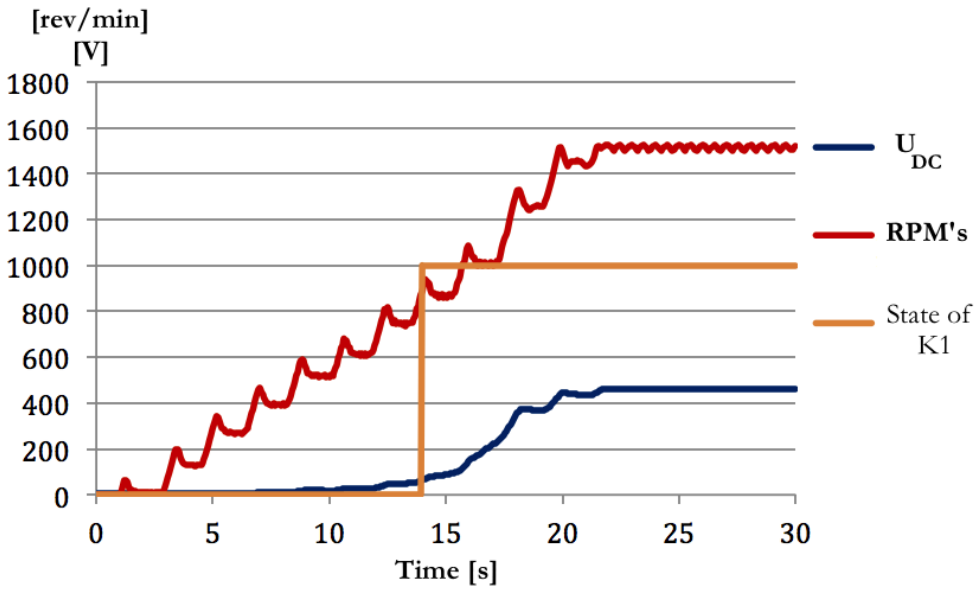


Figure 3: Process of charging DC link capacitors of synchronous generator without action of machine side inverter

Source: Author

To effective control of line side inverter connected to synchronous generator DC link capacitors must be initially charged to minimal required voltage level. Signal from voltage sensor makes contactor denoted on figure 3 as K1 closed, and after this action machine side inverter can be switched on and put into operation. Time of whole process depends highly on generator's rotational speed. As it can be seen on figure 3 when rotational speed is too low, voltage may not reach needed value at all and generator's machine side inverter will not become into operation. Great advantage of this system is lack of external circuitry for preliminary capacitors charging – self-excited synchronous generator does it all.

2.2 Squirrel cage asynchronous generator control method description

In case of asynchronous cage generator (AG), which in fact is regular 5,5 kW squirrel cage motor task of excitation and stable work, is far more complicated than in self-excited synchronous generator. First of all, DC link capacitors must be charged from some external source. Similar to previous case contactor must be closed while DC voltage is high enough. When it is done running generator is put into operation and initially takes energy stored in caps for magnetization purposes. To control asynchronous generator in that manner algorithm for machine side inverter is necessary, which supports decoupled control of magnetizing and active current. Similar to synchronous machine it can be FOC, which is suitable for such purposes. To get a complete system it must be supplemented with some numerical procedures to handle sensorless operation and flying-start mode.

However, in this particular solution sensorless, multiscalar model was chosen because of it's robustness and good dynamic response.

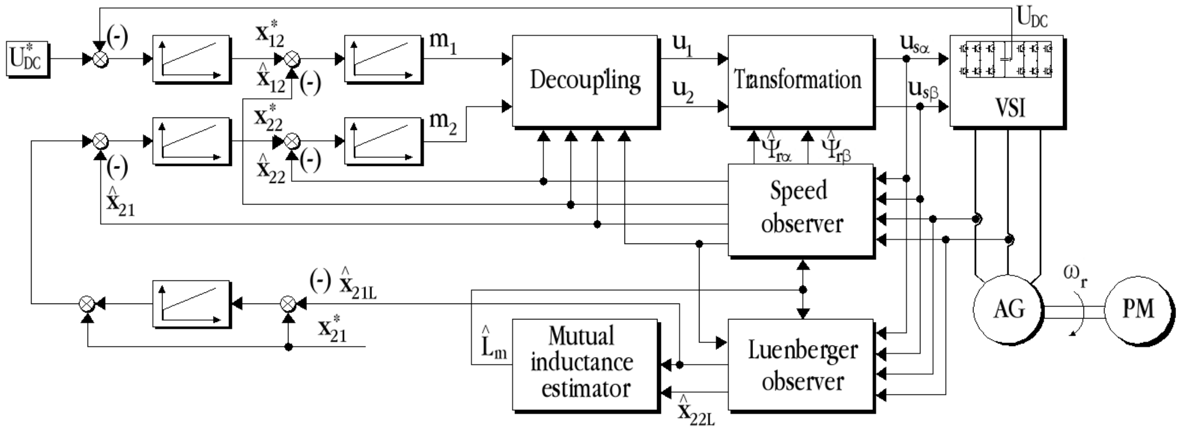


Figure 4: Block scheme of asynchronous cage generator control working on the basis of multiscalar model induction machine

Source: Author

Variables independence is one of advantages that come with use of multiscalar model while FOC method suffers from its dependence on the machine parameters. Machine model is discretized with means of Euler method and runs as DSP program in parallel with real machine. To proper execution of software currents on at least two phases must be measured and in digital form delivered to DSP. There's no need to measure AC voltages since machine inverter generates them. The only voltage measurement is made at DC link in order to execution main control loop.

Actual value of constant DC link voltage taken from LEM voltage transducer is compared with voltage set point. Error signal feeds voltage regulator of PI type that generates the output value denoted as x_{12}, which is proportional to electromagnetic torque. This is compared with value calculated with means of speed observer and result goes to regulator generating output signal named m_1. As it can be seen in figure 4 this value is used for control of decoupling equations subsystem. In addition value denoted, as x_{21} is squared rotor flux and after a regulation process creates variable m_2 also needed in decoupling subsystem. After decoupling process obtained values of control voltages u_1 and u_2 are passed to transform subsystem. Voltages in a form of α-β coordinates are passing to FPGA and at the end TTL pulses are formed to control arms of VSI (voltage source inverter), which is machine side inverter.

Quantities used for multiscalar induction machine real-time model are described in the following equations [3]:

$$\begin{aligned} x_{11} &= \omega_r \\ x_{12} &= \Psi_{rx} i_{sy} - \Psi_{ry} i_{sx} \\ x_{21} &= \Psi_r^2 \\ x_{22} &= \Psi_{rx} i_{sx} + \Psi_{ry} i_{sy} \end{aligned} \tag{7}$$

where: ω_r – shaft rotational speed, Ψ_{rx} – rotor flux in x axis, Ψ_{ry} – rotor flux in y axis, i_{sx} – stator current in x axis, i_{sy} – stator current in y axis.

Additional mechanical motion equation completes machine description, which is coded in Luenberger observer and is used to determine the angular speed and actual angle of shaft.

$$\frac{d}{dt}\omega_r = \frac{1}{J}\left(T_e - T_L\right) \quad (8)$$

where: J – rotor moment of inertia, T_e – electromagnetic torque, T_L – shaft load torque.

2.3 Line side inverters control methods

Voltage line side inverters are main source of alternating current for ship electrical grid. It is crucial to maintain constant value of DC link voltage to ensure stable work and proper power distribution. Both of line inverters have implemented the same control algorithms. There are provided two modes of operation: island type (one generator/inverter set feeding grid) or work in parallel two inverters. In the first mode when only one generating set power up the grid, line inverter has to control over the frequency and amplitude of resulting voltage. When there is increase of demanded power, another generator set is started. After a synchronization process, which ends with closing circuit breaker, control algorithm of one inverters changes. One of parallel working inverters holds frequency and amplitude on constant level, while second one carries out an algorithm of active and reactive power distribution. All the power demand not covered by generator working in power sharing mode is covered by the second one. For proper operation of power distribution regulators actual value of net frequency must be provided constantly. For this purpose in presented system phase locked loop algorithm was used once again.

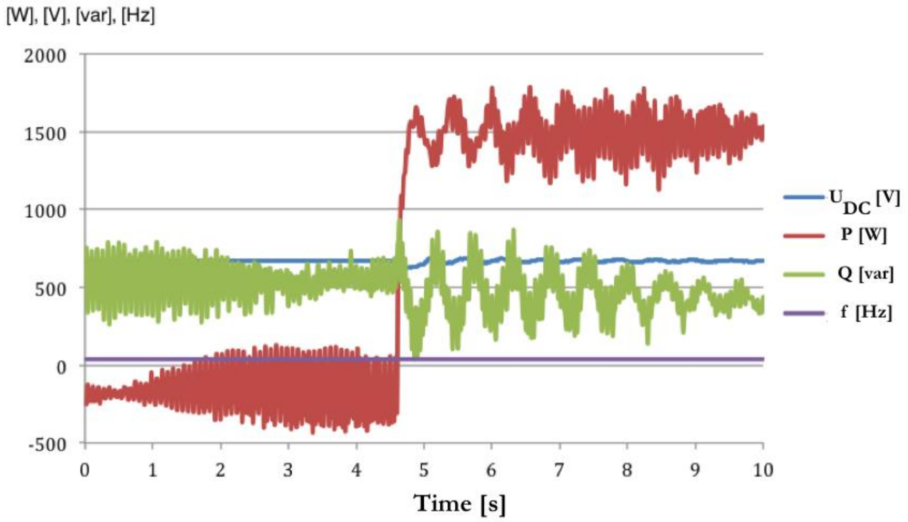


Figure 5: Experimental results of applying active power load while parallel operation of squirrel cage generator along with synchronous generator

Source: Author

As it can be seen in the figure 5, there are some oscillations of active (P) and reactive (Q) power. These oscillations occurred while active power load take over due to improper settings of PI regulators especially proportional gain setting. There have been conducted extensive tests on lab test bench for load takeover and load drop (both active and reactive) which have shown good properties of investigated system. Some tests of parallel operation of two generators along with inland power grid were performed and results showed near excellent control of active and reactive power distribution, which may be very useful while cold-ironing.




Figure 6: Experimental test bench in "Green Energy" laboratory

Source: Author

3 CONCLUSIONS

Presented system allows easy distribution of active and reactive power and long-term cooperation of different electrical sources such as electric generators of different types working in parallel with changing in wide range angular speeds. System is still under development by adding new sources (e.g. double fed asynchronous generator with rotor connected inverter), better control algorithm design and testing under various load types. It is a starting point for the design of ship electrical systems including distributed voltage sources where energy distribution is carried out by use of direct current.

REFERENCES

[1] Fatu M., Blaabjerg F., Boldea I. (2013). Grid to Standalone Transition Motion-Sensorless Dual-Inverter Control of PMSG With Asymmetrical Grid Voltage Sags and Harmonics Filtering. IEEE Transactions on Power Electronics, Volume 29 Issue 7, pages 3463 – 3472

[2] Krzemiński Z. (2000). *Cyfrowe sterowanie maszynami asynchronicznymi*. Gdańsk, Wydawnictwo Politechniki Gdańskiej.

[3] Orłowska-Kowalska T. (2003). *Bezczujnikowe układy napędowe z silnikami indukcyjnymi.* Wrocław, Oficyna Wydawnicza Politechniki Wrocławskiej.

[4] Kozak M., Zawirski K. (2010). *Starting Operation of Induction Squirrel Cage Generator Rotating with Variable Speed.* 14th International Power Electronics and Motion Control Conference EPE-PEMC 2010.

EFFECTIVE SHIP – SHORE MANAGEMENT: ENSURING SAFETY AND BUSINESS OPTIMIZATION

Urša Kralj, B.Sc
Obala 128, Portorož, Slovenia
kralj.ursha@gmail.com

Petra Bizjak, B.Sc
Parecag 3a, Sečovlje, Slovenia
petra.b.bizjak@gmail.com

Edi Debernardi, B.Sc.
Korte 13F, Izola, Slovenia
edi.debernardi@zua.si

ABSTRACT

The operations of individual ships, as well as the shipping industry in general, are a broader process than merely a transport service. In addition to the fact that ship owners want to make the best use of the ship`s capacity and optimize services to obtain the greatest possible impact and benefits, they must also ensure human safety and environmental protection. Ship owners are required, when carrying out activities in international maritime traffic, to follow strict regulations on safety imposed by the International Maritime Organization (IMO) through a number of conventions. With the introduction of the International Safety Management Code (ISM Code) in the 1990s, shipping companies were forced to integrate into their business safety management imposed on them by international rules.

The whole organization of the shipping company, both in the economic and logistical perspective, is subordinate to the implementation of international regulations. In order to comply with regulations and at the same time to maintain a successful business they have to establish effective ship - shore management. This should cover all areas of activity, such as maintenance, procurement, financial management, human resource management and supervision of the implementation of international regulations. The purpose of this paper is to show how effective ship - shore management operates and what the advantages are of properly set up ship - shore management.

During the establishment of ship - shore management the ship owners raise the issue of how to develop an effective system that would provide economic and logistic support and at the same time satisfy the need for safety. The tendency is to maximize automation and the use of information technologies. Ship owners could choose between two alternatives; creating their own information system for ship - shore management or purchase already existing software in the information technology market. In deciding between alternatives it is important to take into account several aspects, such as the cost of production/procurement, quality and reliability of the system and in particular, the time needed for the system to be complete and start operating efficiently. The second objective of the paper is to analyse the advantages and disadvantages of both abovementioned alternatives of establishing ship - shore management.

Key words: Shipping industry, ship owner, international regulations, ship - shore management, safety, effective system, information technology.

1 SHIP – SHORE MANAGEMENT AS A BASIS FOR SHIPPING BUSINESS

Maritime trade represents an important part of the world economy. It covers a major area of all exports and imports. Not just vessels, but also many other shore facilities, such as ports, shipping companies, coastal and governmental authorities, support maritime trade. This paper addresses the aspect of shipping companies supporting ships in obtaining good trade and complying with coastal and governmental requirements.

There exist various types of ship management companies. Bigger ship owners are usually owner-operator companies, which own the ships and also manage them. Then there are some ship owners that manage their ships and charter them out. The major part of that market is covered by third party ship management companies, which provide ship management services to ship owners.

In the last century, as a result of various accidents and other events numerous international regulations were adopted to ensure human safety and environmental protection. Ship owners are required to comply with and observe all the regulations and rules imposed by the IMO and integrate them into their business organization. A well-organized ship owner, both in the economic and logistical perspective as well as in the area of compliance with international regulations can provide properly established and effective ship - shore management, covering all areas of activity, such as maintenance, procurement, financial management, human resource management (crewing), document control and supervision of the implementation of international regulations.

1.1 The role of ship – shore management

Ship - shore management represents the company`s organization (ship owner`s organization or the organization of the company managing the ships). It represents the connection between shore-based offices and vessels. This connection can be on a basic level or more sophisticated with the use of the information technologies. Nowadays the tendency is to use as much as possible information technologies (IT) and automation. In such a way companies can have full control of vessel`s operations and dealing with vessel`s needs such as procurement of spare part and services, control of other vessel`s requirements, needs of crew changes, maintenance, quality control and safety.

Some companies (especially smaller one) are using a basic approach to ship - shore management. They apply IT just to certain areas of activity, and for the rest they use simple tools such as Word and Excel, for instance in dealing with order requisitions, maintenance plans and accounts control. For communications they are using only telephones and e-mails.

Instead of paper records, several companies are using software technologies that provide them with more effective management and control over all areas of operations. They also have direct exchange of data through software via satellite between the shore-based office and vessels. In this way they have at every moment the most updated information, and the communication between the shore-based office and the vessel is very fast and provides vital support.

1.2 Advantages of properly set up ship – shore management

The aim of each company is to have all business operations under control. The most effective control can be achieved with the use of software with a number of modules that cover each specific area. The modules should be linked to each other in order to have a complete overview of operations and the business itself.

The management should cover the following main areas:

- Technical management and procurement
- Crewing management
- Quality and safety management
- Financial management

1.2.1 Technical management and procurement

Technical management and procurement is a central point and the widest area of the business. The effects of the Technical management and procurement have an important impact on the other areas of operations.

To ensure good technical conditions of vessels and consequently smooth business operations and compliance with all safety regulations, management companies should establish an effective Planned Maintenance Plan (PMS). “It is not just an onboard documentation of jobs, but a central communication platform for all technical matters and tasks” (Best Practice Ship Management Study 2013). This can be achieved with effective software. Large Excel spreadsheets and programs in Excel do not ensure enough control over the state of maintenance and assets.

Software must allow:

- Planning of maintenance (define regular works and maintenance schedules as per maker`s recommendations, detect future maintenance work and deal with unexpected maintenance, and working instructions can also be incorporated)
- Reporting of maintenance (generate various reports as performance of planned maintenance, other maintenance records, keep records for inspection authorities such as Class Register, Flag State and Port State Control, create work orders and dry dock specification repair lists)
- Inventory control (inventory lists of each storage area, automatic update of inventory after maintenance and purchase, alerts about the level of items in stock, all information about suppliers, prices and units in order to calculate future costs in advance)
- Asset control (overview of all assets and their condition, maintenance schedules)
- Monitoring of maintenance and inventory, and history of maintenance done, replaced spare parts etc.
- Users should have access to all data, but they cannot change the basic data.

Maintenance and related tasks represent a significant cost, so it is important that procurement/purchasing is working hand in hand with technical management. In this way management companies can obtain a better overview of purchased orders, enquire about quotes in time, ensure deliveries in time and reduce the overall costs. Procurement/purchasing should also be supported with software that enables the receiving of order requisitions from vessels or the creation of own orders, requisition enquiries, receiving quotes in the system and comparing them (save the data for future purchasing), purchase tracking (status of the purchased order, expected time of delivery etc.) and costs and budgets tracking.

1.2.2 Crewing management

Crewing management is managing the crew on board vessels. Crews working on vessels must be properly trained for their respective positions. They must have the relevant certificates to comply with international regulations.

Any non-conformity with the STCW regulation (Standards of Training, Certification and Watchkeeping) and MLC 2006 Convention (Maritime Labour Convention) can lead to sanctions given by the authorities, or in the worst case even detention of the vessel. Ship management companies must therefore keep accurate records of crew certificates and ensure that all conditions of the MLC 2006 Convention are fulfilled.

The crew management software module should provide:

- Records of crews with the company and their positions (personal data, medical information, documentation, contract details, appraisal reports)
- Crew certificates records (control/alerts on expiry, listing of required certificates)
- Planning crew changes and preparing embarkation and repatriation itineraries
- Preparing travel documents and guarantee letters for authorities
- Keeping track of supernumeraries on board
- Connection with accounting for salaries calculation and payments
- Personal and safety uniforms records
- Production of various reports, such as crew list, leave request, sea service certificates.

1.2.3 Quality and safety management

The shipping business must follow strict international regulations and also class and flag requirements. To comply with all the requirements and standards, ship owners and management companies have to establish a quality and safety control system. In this way the management can ensure that all the areas of the organization follow the correct procedures.

Since 1994, it has been compulsory for all shipping companies to comply with the International Safety Management Code (ISM Code) for the Safe Operation of Ships and Pollution Prevention. While Quality addresses how ship management companies should ensure customer satisfaction, the ISM Code specifies how ship management companies must ensure that they operate their vessels both safely and in an environmentally conscious manner. Like most compliance programs, the ISM Code requires companies to demonstrate how they comply with the standard through both action and evidence. However, this has led to problems with Safety Management System (SMS) maintenance.

According to the ISM Code, management companies must develop, implement and maintain a Safety Management System (SMS) that ensures compliance with mandatory rules and regulations and also applicable codes, guidelines and standards recommended by the authorities. The SMS includes a safety and environmental protection policy, instructions and procedures to ensure safe operation of vessels, defined levels of authority and lines of communication between shore and ship staff, procedures for reporting: system performance (audits and reviews), incidents and non-conformance, hazard identification, risk assessment, preventive and corrective actions and any statutory (legal) requirements, procedures to prepare and respond to emergency situations.[1] The ISM manuals issued by the company should comply and be approved by the class authorities. Vessels must be maintained in conformity with all relevant rules and procedures and also any additional requirements which may be established by the company.

The ISM Code documentation can also be integrated into software, together with all international regulations that must be observed and they can be linked to other modules (management departments) to provide compliance with all requirements at any level of operations. The manuals can also be accessible through the software at any time. The frequent problem of management companies is that persons in charge are not familiarized correctly with the company's ISM Code. The electronic version is more easily accessible than the hard copy and the company can expect more consistent application of the rules and procedures.

The requirements for the SMS closely match the requirements for the Quality Management System (QMS), albeit with a different focus. The same tools and processes that are used to manage quality, are also applied to safety (and environmental) management systems, documentation and document control, incident/non-conformance reporting, maintaining records, managing training, and maintaining equipment.

For both management standards, the scope of what the management system will cover must be defined, and both require a policy. In terms of safety management, it means the company must have a process in place to identify and control risks and hazards and also a process to identify legal requirements. In a quality sense, the focus shifts are to determine customer requirements for the service, but requirements are also regularly included in the quality planning process.

1.2.4 Financial management

The financial department is not directly related to the vessel`s operations, but nevertheless has an important role in the management company organization. Financial management should be integrated into business operations, especially to ensure proper budgeting.

The financial management is usually done by trained accountants, but they have a strictly accounting perspective over management company operations. It would be appropriate to include a person with maritime field experiences in the financial department. However, in order to ensure correct costs allocation and effective allocation of financial resources, it is necessary to introduce the use of software, which should be directly connected to all other departments through modules.

The financing software module should allow:

- Direct connection to all other modules and importation of costs and cost allocation
- Cash flow controls
- Making financial plans and budgeting
- Cost estimates
- Accounting and cost controls
- Reporting
- Preparing payments and importation of payment files into the banking system

[1] IMO; ISM Code and Guidelines on Implementation of the ISM Code 2014

2 BUILD UP SHIP – SHORE MANAGEMENT

Due to the current situation in the maritime market, where the number of international regulations is increasing, the lack of qualified shipboard personnel, higher fuel prices and the slashing of charter rates because of overcapacity in the market, ship owners face the problem of financing vessels. For this reason ship owners are looking for management companies that provide them quality and safety operations, qualified and competent crew and transparency of costs.

Nowadays there is no longer any place for paper records-based processes (although there is still surprisingly a lot of paper-work in the maritime industry), and the need for information technologies and automation is growing fast. Management companies are trying to adapt to the new situation and establish as much as possible effective ship - shore management.

Although some management companies still mainly use paper records based processes and use software just for certain segments, a large part of the management companies is trying to establish effective ship - shore management by using information and communication technologies.

Some companies decide to create their own in-house produced software and some rely on the already verified and certified software on the market.

Below we show a case study of a company trying to establish its own model for management and the analysis of what is more effective through three main aspects: cost, quality and reliability, and time needed for the system to become operative.

2.1 Create own software for ship - shore management

Small management company X (name withheld for privacy reasons) manages the vessels of a small ship owner. They manage just two vessels at the moment.

Ship - shore management condition:

The management company is structured into five departments:

- Technical department (three employees, contractors)
- Purchasing (one regular employee)
- Crewing department (two employees; one regular and one contractor)
- Financial department (two employees; one regular and one contractor)
- IT department (two employees; one regular and one contractor)

The technical and purchasing department uses a paper record based process with no use of any software. For planned maintenance, maintenance control, purchasing uses Word and Excel. For communication between vessels and the shore-based office, the shore-based office and supplier/authorities use telephones and e-mails.

The crewing department uses in-house produced software. The software is used only in the shore-based office, because it does not support direct exchange of data from/to the vessels. The software provides:

- Personal data records of the crew and appraisal reports
- Crew certificates records and control/alerts of their validity
- Personal working and safety uniform records.

- Planning crew changes and preparing embarkation and repatriation itineraries and travel documents
- Printing various documents (contracts of seafarer`s employment, sea service, application forms for flag required documents and endorsements)
- Crew salaries calculation and payments (the system generates a payment order file to be imported into the banking system)

The company needed two years to produce and test the software and for it to become completely reliable.

In the financial department some work is done with software, and some in the old way with Excel spreadsheets. They produced an in-house accounting tool, which provides posting of invoices, accounts control, simple reporting, preparing payments and importing of payment files into the banking system.

The accounting software was produced in approximately one year, but it is still subject to improvements. At the moment they are formulating software for financial management, which will facilitate the production of financial plans, cost estimates and more sophisticated reports.

The IT department is responsible for purchase and maintenance of the equipment and IT support in the office and vessels. They produce software applications according to plans and needs.

2.2 Purchase software in the market

In the market there are already many providers of maritime software for ship management, such as Spectec, BASS, DNV-GL, and Norcomms.

They provide ship managements with software solutions featuring many modules designed for each department and fully integrated into the system. Ship managements can perform integrated management of planned maintenance, purchasing, accounting, crew management, document control, and safety management as described in chapter one. Such software ensures that shipping companies comply with maritime regulations and perform safe, reliable, effective and profitable ship operations and improve their operations.

Initial investment in such software is usually high, but over time this is recouped due to transparency and process efficiency, better cost control, better communication flows and better compliance with regulations as a result of effective implementation.

2.3 Comparison of the two possibilities

The analysis involves a comparison of the three main aspects companies consider when they opt for more integrated solutions for their operations and use of information technologies.

Cost

The cost of purchasing existing software and communication systems for management companies in the market is relatively high, but includes a lot of hardware. The price depends on the size of the company, i.e. on the number of required units and the range of software systems they want to acquire. Once the software and required hardware is installed, the companies have to pay yearly subscription, maintenance and upgrades. In the long run the costs for such system become quite reasonable.

In the case of company X the two IT employees are paid approximately EUR 84,000 per year (on the basis of their gross salaries/overall cost for the company). For such an amount per year it is possible to purchase high-quality software and maintenance.

Quality and reliability

Software systems on the market are already verified and most of them also certified.

The in-house software must be tested and needs time to be fully effective and completely reliable. Its quality is closely linked to this.

Time

Purchased software becomes operable and effective in a few weeks, while in-house software needs time to be built and tested. This could take months, even years, and as already mentioned above, needs a lot of time to be fully effective and reliable.

3 CONCLUSION

The current situation in the maritime market is such that ship owners and shipping companies face the problem of financing vessels. Moreover, there are a large number of new regulations and compliance requirements. Management companies must provide adequate supervision of their operations and documentation, especially in the technical, purchasing and crewing area. Only in this way can they control and try to reduce costs while ensuring compliance with all regulations. Every detention of a vessel because of non-compliance represents an additional and substantial cost for the ship owner.

According to the analysis made it is more appropriate to use already tested software from the market and adapt it to the needs of the company. This is also useful for smaller companies. It is important to provide software to the most critical areas of the business, and these are certainly the technical/purchasing department and crewing department. The case study of company X shows that despite the fact they want to establish their own IT support, their attention has been insufficiently devoted to the technical department where actual large costs arise. The technical and purchasing departments need control and monitoring of effective maintenance works in order to reduce costs.

REFERENCES

[1] Prof. Dr.-Ing. Jahn, C., Dr. Büssow, T. (2013). Best Practise Ship Management. *Study 2013*. Available online at: http://www.cml.fraunhofer.de/content/dam/cml/de/documents/Studien/Best-practice-Studie-2013.pdf

[2] Jeppesen (2013). Ship Operating Safety and Efficiency Management Solutions. *Jeppesen Marine Professional Services.* Available online at: http://ww1.jeppesen.com/documents/marine/commercial/white-papers/Ship_Operating_Safety_and_Efficiency_Management_Solutions.pdf

[3] International Chamber of Shipping (2013). Implementing an effective safety culture. *IMO Symposium on the Future of Ship Safety, 2013*. Available online at: http://www.ics-shipping.org/docs/default-source/resources/safety-security-and-operations/implementing-an-effective-safety-culture.pdf?sfvrsn=8

[4] IMO. *ISM Code and Guidelines on Implementation of the ISM Code 2014*. Available online at: http://www.imo.org/OurWork/HumanElement/SafetyManagement/Pages/ISMCode.aspx

[5] IMO. *Development of the ISM Code*. Available online at: http://www.imo.org/OurWork/HumanElement/SafetyManagement/Pages/Default.aspx

[6] Naski, V. (2013). Management of shipping. *Publication of the centre for maritime studies, University of Turku 2013*. Available online at: http://www.merikotka.fi/cafe/images/stories/Naski_ManagementOfShipping.pdf

[7] Spectec. AMOS Business Suite version 9.0. *Brochures*. Available online at: http://www.kjradio.co.kr/kjc/data/AMOS_BS9_Full_Brochure_Eng_low.pdf?ckattempt=1

IMPACT OF TECHNOLOGICAL ENVIRONMENT ON STRATEGIC DEVELOPMENT OF MARITIME COMPANY

Maja Krčum
University of Split
Faculty of the Maritime Studies
Zrinsko –Frankopanska 38, Split, Croatia
mkrcum@pfst.hr

Marina Brodarić
Brodospas d.d. Split
Obala Lazareta 2, Split Croatia
marina.brodaric@gmail.hr

Veljko Plazibat
University of Split
Faculty of the Maritime Studies
Zrinsko –Frankopanska 38, Split, Croatia
vplazibat@pfst.hr

ABSTRACT

New technologies in shipping fundamentally alter the activity of the maritime economy, and changing the world of maintenance and maintenance philosophy. Competition on the global shipping market, great complexity and dynamism of the ship and its environment, require efficient management and effective decision-making. Based on the information about the technology used by maritime companies and data on the impact of technology on business and strategic development of companies in the shipping industry analysis will determine the extent of the technological environment in the strategic development of companies in the shipping industry. The analysis will show the importance of technology for business, the risks that entails, and the connection between technology and strategic development of the company. The aim of this paper is to analyse the impact of technological environment on business strategy of shipping company i.e. to analyze the impact of new technologies on decision-making and business management which is reflected in the overall operations and the development of enterprises. Also, the aim of this paper is to explore, evaluate and define the methods and computational procedures that will improve management strategies for maintenance of ships and manage risk and improve performance information support.

Key words: Technological environment, strategic development, maritime company.

1 INTRODUCTION

The aim of this paper is the analysis of impact technological environment on strategic development of maritime companies, i.e. analysis impact of new technologies on decision-making and business management which is reflected in the entire business and enterprise development. Also, the objective of the paper is to explore, evaluate and define methods and computational procedures that will improve the management strategies of vessel maintenance and risk management, and increase the success of impact technology (IT) support.

The objectives are:

- Analysis of movement of progress and technology trends in shipping,
- Determine the impact of technological environment on the strategic development of companies in the shipping industry.

Application of new technologies in marine systems, particularly software – such as neural networks, expert systems, fuzzy logic, genetic algorithms, pattern recognition, information fusion and the like – provides new possibilities in terms of signal processing, management and diagnosis of marine processes and full supervision, management and guiding the ship as a single integrated system, i.e. realization of the idea of intelligent ship. It is important to notice and identify which factors have the greatest impact on business processes. The result of the research will give more importance to the impact of technology on business strategy, decision-making and the business enterprise. It is important to point out companies that they should more attention focus on technology. The final contribution of this paper is in the understanding of the importance of technology and the intensity and direction of its impact on the strategic development of companies in the shipping industry.

2 ANALYSIS OF THE IMPACT OF INFORMATION TECHNOLOGY ON THE STRATEGIC DEVELOPMENT OF THE COMPANY IN SHIPPING INDUSTRY

At the present time, characterized by the explosive development of new technologies based on the use of modern means of information technology (computer and other equipment, program funds and tools that are at a relatively high level of development), computer aided design is no longer a futuristic idea, but realistically grounded scientifically – technical discipline, which in modern conditions of production and business turns into essential need. Management of business processes has an important task in contributing to the fulfilment of the mission of the organization. Neglecting the business results and aspirations for its quality, would bring into question the fulfilment of the requirements of stakeholders in the marine business.

Today information systems are socio-technical systems. Although they are composed of computers, devices, and "severe" physical technologies, they require basic social, organizational and intellectual investment in order to function correctly. Information systems for decision support have task to assist in decision-making.

Computerization of shipping organization can be defined as the use of computers and other information and communication means and devices in the automation of information processes and flows, and automation of information’s, communication organization with its relevant environment [4]. The aim of the computerization of shipping organization is automation of basic processes (service, business, information ....) [7]. Among the basic long-term goals of process automation of modern shipping organization, belongs achievement of internal information integration of organization and its external information integration with the relevant environment. In this regard, an integrated information system of the shipping organization in its context includes [7]:

- Automation of all business processes of the organization;
- Management information system that provides data, information, and other fundamentals for the management of the organization at the strategic, tactical and operational level;
- Automation of the process in the preparation and making management decisions;
- Automation of the process in developing information systems, automation of the process in engineering design, process automation in planning and quality control;

- Automation of document management process in the organization and
- Automation of office duties at the highest level.

In order to determine which information resources are needed in ship maintenance management strategies, it is necessary to consider the perspective of a shipping organization as a whole, i.e. acquire strategic vision of the shipping organization [7].

It is necessary to adequately access the planning and strategy of development of information systems by creating a conceptual project of information system. This stage within the life cycle is often neglected, and one of the reasons for this situation is the fact that the largest part of these projects were done insufficiently professional, without methodological foundation, so it is created image that such projects should not be realized. However, conceptual design information system is certainly the first and most important step that defines the structure and determines goals and priorities in the development of the information system[7]. Experts for maintenance of ships often seek information systems for project planning that can work directly with the data from their system for maintenance, in order to obtain project planning function without loss of detail about each element of the ship. Practice in the world is rich of examples that speak about the problem of connecting the project planning software with existing systems for ship maintenance [7].

The task of management is to do everything for the maintenance of ship in order to avoid unexpected intermission or to reduce time of intermission, because every hour of intermission brings huge costs to ship owner. Mastering the present means quality, efficiently and effectively manage existing processes of maintenance of the ship. Although each system will eventually have to change, in the meantime, while the change does not occur, it is necessary to act more efficient, profitable and successful.

In order to get more effectively monitoring the process of maintenance of the ship, it is necessary to select and introduce a specialized information system to support maintenance management that will enable: determining the current state of business resources (staff, spare parts and materials, tools, etc.), the introduction of preventive maintenance and its monitoring, and analysis in order to plan future activities and related costs, so-called cost-effective maintenance.

The quality of decision-making in the business process is closely associated with quality of the information base. In order to do the main activity more effectively, it is necessary for managers of different levels to provide accurate insight into business associates; therefore, it is necessary to provide a simple, effective and quick way to access information that are circulating in the business system. This is one of the important prerequisites that enable managers to bring opportunely and correct decisions in dynamic business environment. To ensure accuracy, which is required for this solution, it is absolutely necessary to applicate the modern information and communication technologies, as well as adequate informatics integration. The implementation should be based on the efficient organization of human and material resources, their better redistribution within and outside the company, and reducing costs, which results in an increase of income in enterprise and leads to even better results of business, as the premise of business in conditions of constant economic changes. It can be seen how technology affects all aspects of the business and finally to the financial results of enterprise business.

The information is necessary to recognize and generate alternative solutions to the problem of ship management strategies, as well as to identify the circumstances of decision making. Information is the most important management resource. Manager of the maintenance of the ship shall timely and accurately respond what he does it just on the basis of timely and accurate information. Information means information about the facts, report on something, the element of knowledge, basic information that can be transferred and counted thanks to the marking procedure and the respective devices. Information is also any message a subject in the form of signals, which can decipher and interpret information and to find a minimum of news. Information is a resource indispensable for the conduct of any business process, including the work of the maintenance management of the ship. Ensuring information requires the ability to apply the methods and procedures, specific time, labour and financial resources, and built an information system.

Management of business process has an important task in contributing to the fulfilment of the mission of the organization. Neglecting the business results and aspirations for its quality, would bring into question the fulfilment of the requirements of stakeholders in the marine business. And the decision of management of the ship maintenance affects the total business enterprise, and is indispensable well-built information system that will help it in making decisions about the business of the shipping enterprise. On the quality of information that is necessary to the process management of the maintenance the vessel in decision-making, are influencing both components of information requests. The absence of natural or valuable components makes information insufficiently quality for making good decision. Only in constantly interaction, natural and value expression of the information in the business process produce a synergistic effect that gives characteristics of usability the information, as a base in decision-making.

It is estimated that the construction of a quality system can achieve substantial savings through proper management of maintenance of the ship, which means a very fast return of money invested in the information system. For the accomplishment of the following tasks for the information system, support or integrated logistics support is necessary, which is a set of activities, mostly technical, economic and organizational, and which are taken on the ship to ensure the necessary conditions for the performance of the projected objective function of the ship.

In addition to providing information on the state of resources information system maintenance ship the information system should be allowed to solve complex problems faced by managers. The information system of the ship shall give an example of how responses to implemented management information system determines predictive scheduling of periodic maintenance and routine maintenance of the ship or how to reduce the shortcomings of manual handling and the human error or to schedule maintenance. It is important to improve the decision making with some of the techniques such as Monte Carlo techniques, game theory, decision tree (risk conditions), Brainstorming and make decisions in terms of security, decision-making under conditions of risk and decision-making under uncertainty. It is understood that the complexity of certain methods of managerial decision making increases with increasing uncertainty and risk affecting the managers and decision-making.

The necessity to develop and introduce special labelling systems for business factors, which are now called tagging systems and whose necessity is as present as the growth of the number of business factors in the business system is faster, and whose application in real systems is as easier as the application of modern means of information technology is more present.

When designing an information subsystem maintenance of the ship, then shall be applied flexibility in designing; on the one hand, must be developed a long-term global concept with built-in organizational aspect, on the other hand, shall be developed a small applications to solve specific operational problems, which do not disturb the global concept and that can, when the conditions are met, fit into the global development concept of integrated information systems. That information system should serve different, but interrelated, parts of a whole business system of shipping companies, such as: business, decision-making and management, communication and collaboration. This means that modern information system includes and connects system for transaction processing, which supports regular business and decision support system, which supports all levels of management and decision making, as well as a system for communication and collaboration, which may use information from all parts of the information system, and at the same time it can generate data and information to support the management of shipping maintenance. This information system integrates its parts into a harmonious whole, and then we are talking about a complete integrated information system. The key advantage of such a system is that the data of the business areas are well connected with each other, i.e. integrated, and in that way it is easy to realize the functional and procedural coherence within the organization, making it possible to effectively manage and decide on strategies for the management of shipping maintenance, as well as at the level of the whole of shipping companies.

3 SWOT (STRENGHTS, WEAKNESSES, OPORTUNYTIES, THREATS) ANALYSIS

A SWOT analysis is applied as a tool for defining the framework and the possible directions of strategic decision-making on the basis of information foundations to the management maintenance of the ship [1].

Table 4: SWOT analysis

STRENGTHS	**WEAKNESSES**
- Improved accuracy and reliability of data, increasing the speed of processing, control and transparency of operations, and increasing the efficiency of the process of maintaining the ship; - Better communication between the ship - administration; - Maintenance planning based on relevant data; - Planed procuration and optimal use of it equipment; - Cost management and investment management of shipping maintenance; - Handling customer relationships; - Handling relations with suppliers; - Team quality for the development and maintenance of the system, extremely user satisfaction with quality of the it support; - The introduction of innovative solutions; - Good relationship of the management and understanding of the needs of innovation investments and development of information systems; - Positive users mood to introducing new solutions for better business support; - Enthusiasm and willingness of informatics for education and specialization in order to	- Computerization is not an integral part of the long-term development strategy of the company; - No formal methodology for developing applications for the maintenance of the ship; - Poor coordination and control of it staff work; - Inappropriate management of human resources; - Dependence on key seafarers; - Inappropriate distribution of the scope of work; - Undocumented existing enterprise information system; - Non-integrated application system that does not allow for quickly getting critical information for decision-making in processes of the shipping maintenance; - Non-standard technological equipment; - No contracted service levels expected for suppliers; - No plan of training of users and it; - Investment in the development of information systems significantly lower than average; - Significant scope of work for the implementation of initiatives to improve decisions-making information substrates to maintaining the ship; - Lack of internal knowledge, experience and resources to manage development projects;

introduce and maintenance new solutions.	- It professionals have not the experience and knowledge necessary for the implementation and maintenance of new application systems and technologies in the maintenance of the ship; - Need to adapt business processes and business models for the successful implementation of information system; - Ready solutions have not functionality "according to the concept of enterprise business processes, but the company must adapt.
OPORTUNITIES - Increasing competitive advantages by better exploitation readiness of ships; - Creating a basis for e-business - On the supplier side; - On the user side; - Creating and maintaining relationships with business systems from the environment (banks, institutions, insurance ...).	**THREATS** - Greater competitors supply and lower rental costs of ships; - Better communication of competitors to the environment; - Faster responses of competitors to user requests.

Under conditions of great uncertainty in the market, crisis situations – when a large number of maritime companies are really struggling for survival – maintenance managers need to make decisions by using analytical, quantitative methods, i.e. they need to decide rationally. In addition, many decisions are still made by intuition and/or experience. Rational decision-making is based on data and information gathered from various data sources, both from the various databases and data warehouses of the company, as well as from data collected from external sources, such as the internet, magazines, advertising materials, etc.

Modern information technology by the concept of a data warehouse provides building the modern decision support systems and affects the development and improvement of information systems of the enterprise that must provide quality information for management strategy for the maintenance of the ship. Network information points to the need of each organizational unit for searching and giving information as a condition for their effective exchange (balancing organizational potentials). It is a good method for detecting bottlenecks, and after their identification by using the network information, it is possible to more accurately arrange activities and remove bottlenecks in the process of maintenance of the ship.

In that way it is possible to accelerate troubleshooting because of the fast access to information. One of the weakest points of the proposed system could be a decision maker: the indifference and ignorance of ship maintenance system can result in the new IT system are not used. Some maintenance managers still rely only on their intuition and experience, and often make decisions without consulting the information system for decision support. On the other hand, there are those who rely only on the information system for decision support, while ignoring their knowledge and experience. Only the combination of personal evaluation, experience and knowledge of maintenance managers with decision support information systems, can result in high-quality decisions, based on the information and analytical scientific methods.

Possible estimate of future researches should be focused on the installation of elements of human intelligence in programs that help developing systems capable of independent work and decision-making in complex, incompletely characterized and/or indistinct situations that are often the reality of maintenance management in shipping. Formal systems (mathematical logics) are universal language and a powerful tool for describing human knowledge, especially in the field of qualitative and quantitative modelling of uncertainties, beliefs, decision making, and so on. These systems are the theoretical basis for the development of intelligent software systems, such as information systems and Internet agents, who are capable of independent action in an unpredictable and complex environment of maintaining the ship. Algebraic and fuzzy methods, and neural networks, can be used to optimize decision diagrams, data processing, designing, reliability analysis and testing possible solutions in the management strategies of maintenance of the ship.

Quality information system should enable the taking data at the time of their creation, a complete evidence and fast data processing, and forwarding information to the place for analysing and making management decisions. It is estimated that the construction of a quality system can achieve substantial savings through proper management of maintenance of the ship, which means a very fast return of money invested in the information system.

Except the providing information about the state of resources, i.e. objects of interest of competent decision makers, information system of the maintenance of the ship should allow solving the complex problems faced by managers, and improve decision-making, with the help of available techniques, methods of different power and generality, the developed methodology and models, and the commercial and purpose developed software.

4 CONCLUSION

By applying computational techniques to decision making system facilitates the selection of options and reduces the risk for the decision maker. Combined with a system for decision support is provided and timeliness of decision-making, reduce costs and reduces cognition limitations of subject-making. In terms of the development of such support are increasingly used techniques of artificial intelligence and expert systems to automate the process of making a decision. Decision-making for solving business tasks, it is easier to improve operations and achieve higher levels of business and organizational efficiency. The top management of the company needs the necessary information, considering the decisions they are making (mainly strategic). The aim is that decisions should be more formalized, i.e. to make them on the pre-set programs, so they can be adopted more quickly and with lower expenditures of capital and labour.

The expected implementation of the model of the information support strategy management – is a key factor that affects the efficiency of the maintenance system. If the number of maintenance actions is reduced by about 40 percentage, the availability of the ship can be increased by about 30 percentage (as less maintenance actions, as greater availability), and the number of jobs in maintaining reduced by up to 10 percentage [6]. This conclusion is logical clear because it is clear that the commitment to the strategy of maintaining will influence the nature, scope and frequency of maintenance works that should be done in this particular system.

Among individual factors, the largest contribution will be shortening the administrative time by changes in the type and form of organizational – management structure, and application of modern technology for the collecting, transmission, processing and using information. Increasing the number of works performed for the same time, in that case is about 15 percentage, a growth indicator of availability is for about five percentage [6]– that, and the next attitude of the requests, except the redesigning the organizational structure, processes and procedures for managing and implementing appropriate information system at the level of the company.

The implementation of the information maintenance system increases the degree of reliability and reduces the number of hours of downtime. It certainly leads to costs reduction. The proposed conceptual information system solution of the maintenance of the ship enables that information of the ship, sets of machinery and devices, spare parts, maintenance plans, testing facilities, as well as checks of the uptime and downtime of the ship – stay connected and in one place. It allows for the automation in the warehouse of the spare parts, as well as in the procurement process. Receivers, order-sheet and delivery notes are mutually associated with the necessary equipment and work orders.

That enables assistance in optimizing maintenance works on ships. All information about facilities, preventive and corrective maintenance, working hours and downtime, testing the ship's equipment, procurement, spare parts warehouse, work orders and expenses, are stored in the computer. It is possible to realize planning of the preventive and corrective maintenance, work orders, planned spare parts, planned operations as planned professions of the workers and a reminder for the performance of the planned preventive maintenance works.

At the end of the above, it can be concluded that the new technologies, in this case information technology, largely affects the business strategy of the enterprise, the strategic development, decision-making, and the financial result of the business, i.e. the entire business of shipping companies. The goal was just to point out the importance that technology has on the company's business, the advantages and the risks that entails. Management of shipping companies should give more attention to the development and adaptation of new technologies.

REFERENCES

[1] Buble, M. (2006). Osnove menadžmenta, *Sinergija*, Zagreb, 2006.

[2] Crljenko Perković, L. (2009). DSS sistemi za racionalno donošenje poslovnih odluka – temelj procesa odlučivanja. ***Open InfoTrend***. Zagreb , Croatia

[3] Srića, V. (2001). *Menadžer i informacijski sustav.* Poslovna knjiga, Zagreb

[4] Stazić N. (2010). Računalni programi u održavanju broda, diplomski rad, Pomorski fakultet, Split

[5] Šarić, T., Majdandžić, N. (2003). I*nteligentni sustav za predviđanje i potporu odlučivanju u održavanju po stanju*. 9. međunarodno savjetovanje HDO, Održavanje. Opatija, Croatia

[6] Tomas, V., Šegulja, I., Čišić, D., (2005). *Mogućnosti i problemi primjene suvremenih strategija održavanja u pomorstvu,* Pomorstvo, god. 19., Pomorski fakultet Rijeka, Rijeka

[7] www.etfbl.net/.../VI%20Informacijska%20podrska%20procesnoj%20organizaciji.pdf. (12.02.2015.)

THE IMPACT OF THE NOISE IN THE FIBERS TO VESSEL'S COMMUNICATIONS

Ivica Kuzmanić, M.Sc.
Igor Vujović, D.Sc.
Joško Šoda, D.Sc.
University of Split
Faculty of Maritime Studies
Zrinjsko-Frankopanksa 38, Split, Croatia
ikuzman@pfst.hr

ABSTRACT

Optical communications are widely spread in computer and integrated networks, LANs, WLANs, and Internet. These networks are present also aboard vessels of various types, from bulk carriers through cruisers to war ships. Although ships appear relatively small in length, considering e.g. losses per length of cables, actual length of all cables aboard is much longer. Hence, it would be interesting to see how AWGN and Rayleigh fading influence BER of ship's communications. This paper presents such research with simulation results obtained in Simulink. A model of fiber optic communication channel has been developed in Simulink environment. Change of Doppler shift in range from 10 to 10000 results in BER change of 0.0082 or 0.85%. Change of SNR from 1 to 1000 results in change of BER of about 0.0011 or 0.11%. We can conclude that optical communication channel is very robust to noise in the communication channel in case of fiber optic cables.

Key words: Optical link, communication channel, BER, Rayleigh fading, AWGN.

1 INTRODUCTION

Fiber optic links become popular media for communication. There are a lot of general advantages of such communications. Fiber optic systems were firstly introduced aboard navy vessels. Due to increase of usage of the integrated ship's systems, number of optical networks aboard ships is rapidly increasing. There are several reasons for optical technology useage aboard vessels: high reliability (there is no need for grounding, no worries of short circuits, overvoltage, fire, and similar), reduction of volume and weight up to 90% in comparison to cooper wires, simple self-diagnostics (reflectometer), integration of all ship's systems and subsystems by FOLAN (Fiber Optic Local Area Network), support of increase in capacity, long lifetime, resistivity to EM (Electro-Magnetic) disturbances and interferences, cheep and simple installation, and maintenance cost reduction [1]. Fiber optic media became an optimal media for application in dangerous, explosive and high temperature environments as in ships.

Optical fiber communication systems' performance depends on many factors. Influence of nonlinear effects was presented in [2]. Detail analysis of all parts of the optic communication system is presented in [3], with emphasize to application in Simulink. A simulation platform for photonic transmission systems is presented in [4]. Simulink was a software base for this platform. This paper aims to analyze influence of noise in the communication channel, which consist of fiber optic. Section 2 describes a model of the optic communication system in general. Section 3 presents actual simulation model and simulation results. Conclusions are provided in the last section.

2 MODEL OF OPTIC COMMUNICATION SYSTEM

Every communication systems consist of transmitter and receiver part, and the model of optic fiber. Transmitter part consists of signal's source, modulation block, transmit filter, and optic transmitter. Model of fiber optic media must contain any shifts and changes, which could be found in operation of the communication system. We used AWGN (Additive White Gaussian Noise) and Rayleigh fading to simulate all influences. Finally, receiver part consists of optic receiver and demodulator. This is schematically shown in Fig.1.

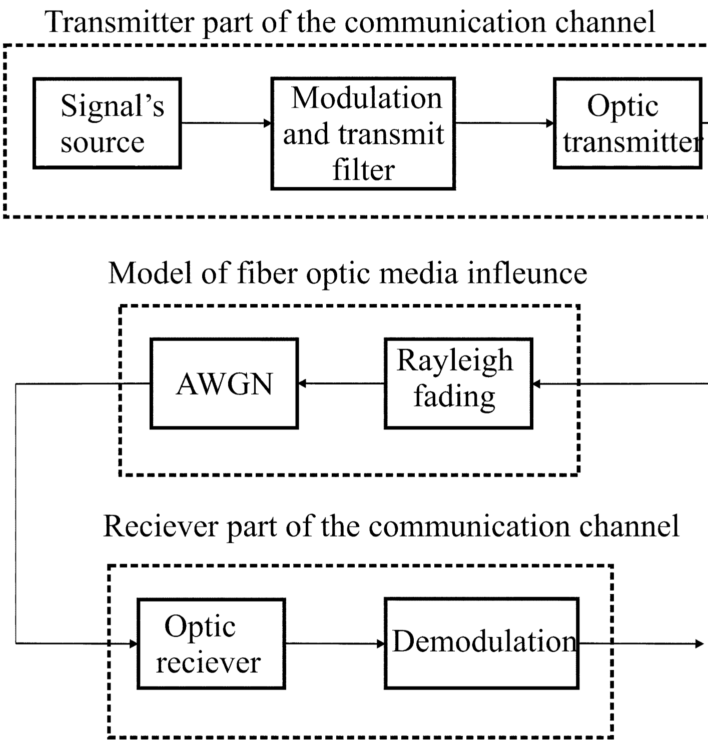


Figure 1: Modeled fiber optic communication system

Since there are several options in building simulation model in Simulink for the system in Fig. 1, next section gives the precise description of blocks.

3 SIMULATION RESULTS

Figure 2 shows used Simulink simulation model. "Fiber optic channel" is generated subsystem, which we can for this research represent as single input single output block system. The input signal is the output of the transmitter antenna. The output signal is the input to the optic receiver. "Fiber optic channel" block includes blocks for AWGN and Rayleigh fading.

Figure 3 shows simulation results of BER (Bit Error Rate) in time domain. Different curves correspond to different Doppler shift in block "Rayleigh fading" (in the "Fiber optic channel" mask, Fig.2). Maximum Doppler shifts in our experiments were 10, 100 and 10000 [Hz]. Doppler spectrum type was flat.

Figure 4 shows curves for different SNR in AWGN block (in the "Fiber optic channel" mask, Fig. 2). Curves shows cases of SNR for 0.1, 1, 100 and 1000 [dB].

From Fig. 3 and 4, it can be seen that change of parameters influences the BER's value, but not waveform of the curves. So, every curve has similar waveform. From Matlab Command

Window, it is possible to calculate mean value of curves. Mean of the curve for 10 [Hz] in Doppler and 100 [dB] SNR is equal to 0.957. Mean is equal to 0.9573 for the curve obtained with 100 [Hz] shift and 100 [dB] SNR. Mean is equal to 0.9652 for the curve obtained with 10000 [Hz] shift and 100 [dB] SNR. When Doppler shift is changing (form 10 to 10000 Hz), the change in BER is 0.85%.

We can conclude that disturbance in the Doppler shift has higher impact to BER than disturbance in SNR of AWGN.

On the other hand, if a Doppler shift is constant, then BER increases with increase of SNR. Namely, for SNR=0.1 [dB], mean value of BER is 0.9584. For SNR=1 [dB], mean value of BER is 0.9585. For SNR=100 [dB], mean value of BER is 0.9573, which leads to the conclusion that we have one window. For SNR=1000 [dB], mean value of BER is 0.9595. For constant Doppler, we obtained with simulation that BER is changing for 0.11%.

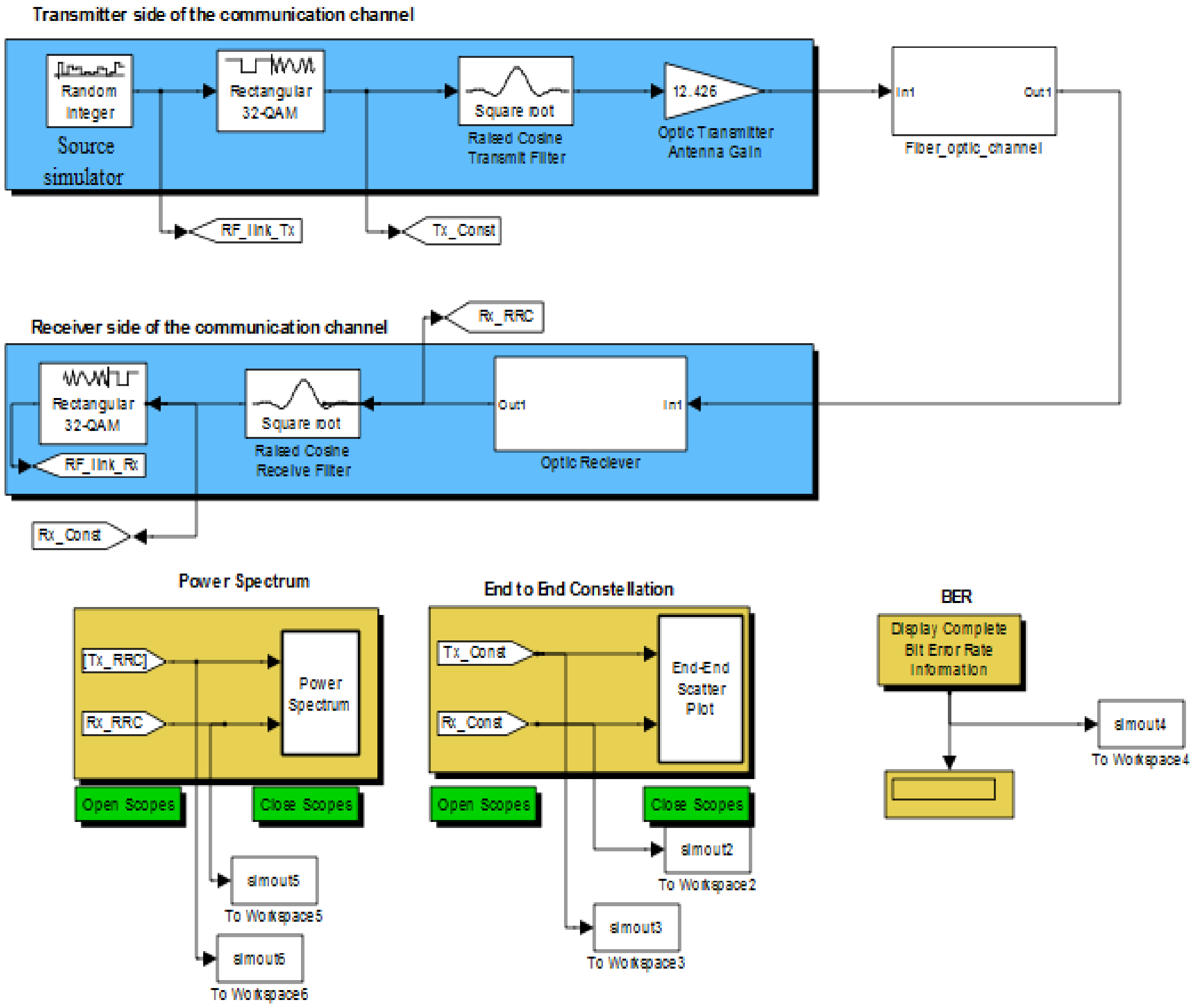


Figure 2: Simulation model in Simulink

We also tired to simulate the change in the fain of the optic transmitter antenna. We obtained the same results for BERs in cases of gains between 1 and 100.

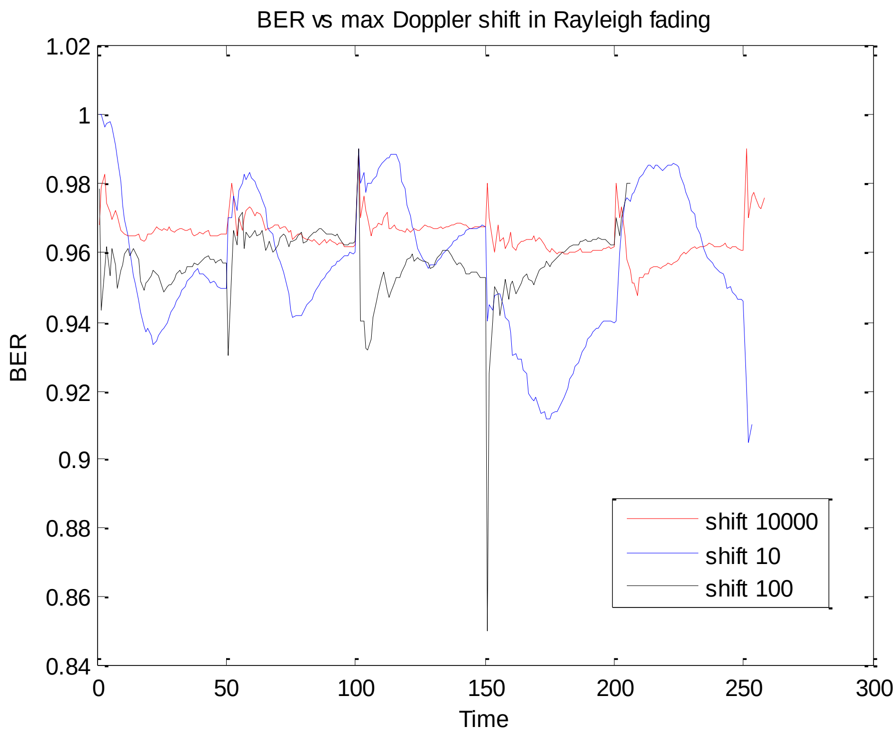
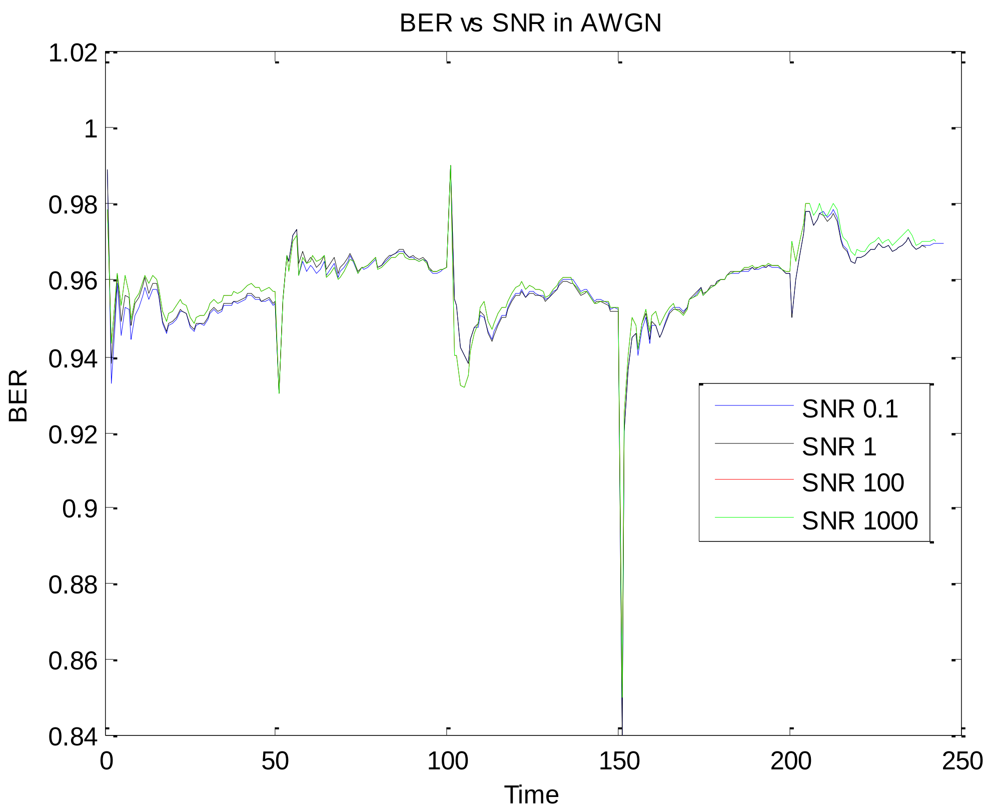
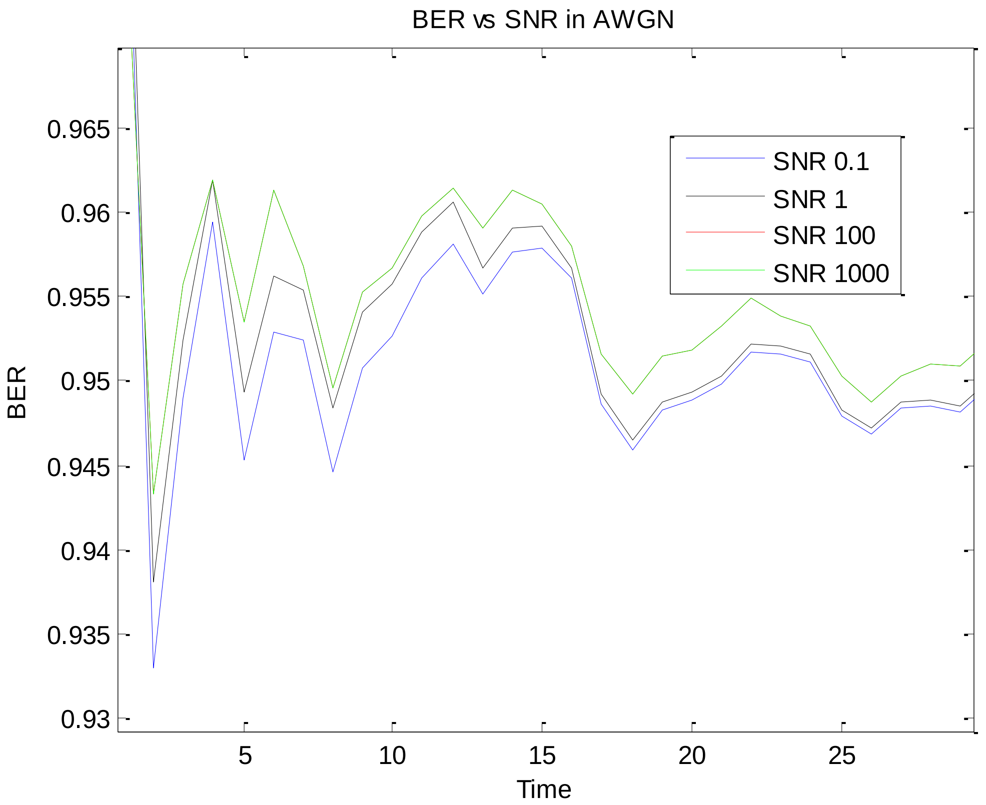


Figure 3: Simulation results – BER vs Doppler shift introduced through Rayleigh fading



a)



b)

Figure 4: Simulation results: a) BER vs SNR introduced in AWGN block, b) enlarged part of a)

4 CONCLUSIONS

This paper presents the research of the impact of the noise in the fibers to vessel's communications. Research has been conducted by using fiber optic channel model and it is represented as single input and single output system in Simulink. For disturbances the Adaptive White Gaussian Noise model and Rayleight fading have been used.

From used model it can be concluded that disturbance in the Doppler shift is closely correlated with BER than disturbance in SNR of AWGN. As experimentally validated, BER is not in the relationship with the gain of the optic transmitter antenna for gains between 1 and 100.

REFERENCES

[1] Kuzmanić, I., Vlašić, R., & Vujović, I. (2001). *Materials in electrical engineering*. (in Croatian), Split: Faculty of Maritime Studies.

[2] Bel Hadj Tahar, J. (2007). Theoretical and Simulation Approaches for Studying Compensation Strategies of Nonlinear Effects Digital Lightwave Links Using DWDM Technology. *J Comp Sci,* 3(11), 887-893.

[3] Binh, L. N., & Armstrong, J. (2004). A Simulink Model for Simulation of Optical Communications Systems: Part I – Single-channel Transmssion. Technical Report MECSE-31-2004, Monash University.

[4] Binh, L. N. (2009). MATLAB Simulink Simulation Platform for Photonic Transmission Systems, *I. J. Comm Netw Syst Sci*, 2, 91-168.

A CASE STUDY ON THE STABILITY ANALYSIS OF A PASSENGER SHIP IN LAKE KOMAN IN ALBANIA

Kristofor Lapa, PhD
Blenard Xhaferaj, PhM
University "Ismail Qemali"
Skele, Vlore, Albania
kristoforlapa@gmail.com

ABSTRACT

Navigational safety is an important aspect of the operation of every boat in open as well as internal water. This aspect is more important in the case of passenger ships. Koman Ferry is a passenger ferry service operated by two local companies along the Koman Reservoir (also known as Lake Koman) in Northern Albania. Lake Koman was formed when the rugged Drini valley was dammed in the early 1970s, thus Albania to quickly develop its own industrial base and become an energy exporter. Nowadays Koman the large lake stretches 30 km eastward to the town of Fierza. Actually in the lake operate different boats for passenger transport, some of which lack the information about the characteristics of the stability and others lack the necessary technical documentation to be classified by the Albanian register of Shipping. In this paper will be presented a case study of the stability analysis of a boat that operates in Lake Koman and the attainment of stability characteristics. The procedures in this study case have these steps: measurements to define the ship offsets, geometric modeling of ship hulls in CAD software, hydrostatic and stability calculations, and the verification of stability criteria. The procedures in this study case will be used in other similar Albanian boats operating in internal lakes.

Key words: CAD software, geometric modeling, ship stability, passenger ship.

1 INTRODUCTION

The geographical position of the Koman region is considered a connecting nodal point for the development of northern Albania. 'In Lake Koman many boats about which knowledge is lacking or full documentation regarding navigation safety is missing exert their activity. For this reason, this study was conducted upon request of the owner of the vessel Dragobia for the completion of the necessary documentation from the Albanian Maritime Administration for exerting the activity [1].

The difficulties that existed in the writing of this paper were associated with the ship itself, namely the lack of technical drawings that would facilitate it and with the Albanian Naval Registry stemming from the lack of authentic normative for ships in internal transport. These difficulties were overcome through ship inspection for several successive days for the realization of all measurements and physical controls on the ship, necessary for the reconstruction of the ship hull, as well as through collecting all the information needed as predicted by the classification societies (members of IACS - International Association of Classification Society) for vessels operating in inland waters. In the following paragraphs the procedure followed for the verification and fulfillment of stability criteria for this vehicle will be given in detail.

The drafting of flow charts and algorithms for modeling and 3D-CAD building of the hull has been designed to assist in the modeling of the hull ship. Through the exchange of information between PREFIT and MAXSURF programs, part of the computer FORMSYS package [2] the preliminary design of the hull surface was prepared and then, the optimizing of the surface to achieve the best surface.

2 REBUILDING AND 3D CAD MODELING OF THE SHIP HULLS

Traditionally the hull shape is defined by the lines drawing [3], that is body plan, sheer plan (profil) and waterlines plan, all together are collectively known as the lines drawing of the ship (figure 1).

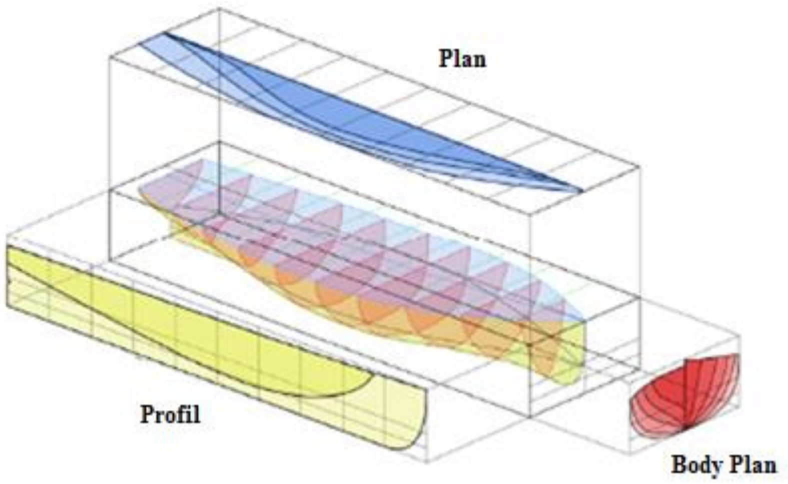


Figure 1: Illustration of the lines drawing

3D CAD model of a ship hull can be rebuilt according to the rebuilding of the 3D model of the ship hull using measurements on physical objects or according to technical drawings.

This process is similar to the process of Reverse Engineering (RE). Practically RE can be defined as: "the design of a product through a digital model taken starting from a “cloud” of points which can be taken with the help of 3D scanning of a physical object" [4].

In our case we are dealing with the Re-engineering of curves and surfaces of the ship hull as a problem for determining the curve or surface that interpolates or approximates a cloud of points.

The formulation of the process of re-engineering of the curve/surface of the ship hull can be considered as an optimization problem and it consists of three basic elements: design variables, objective function and constraints.

In our case, the design variables are offsets 2-D of the ship hull along with control points that serve to build the curves / parametric surfaces (B-spline, NURBS). The objective function is the taking of curves and surfaces in such a way that the distance between the curves (surface) and offset certain points is minimized. Restrictions are related either to the geometric constraints or to the performance of curves and surfaces.

In the case of the ship’s surfaces and curves as geometric constraints and performance may be included:

- achieving a satisfactory level of smoothing of the curve / surface;
- maintaining of ship’s coefficients of form;

- vertical position of the hull center.

Maxsurf program is the main program of Maxsurf Formsys computer package. It is a very versatile program for designing new hull surfaces, but it seems to be problematic in terms of adapting the surface of the hull under a given offset set, thus adapting the surface under a given cloud of points.

Alternatively within the Maxsurf computer package is Prefit program which is very versatile to adapt the hull surface under a cloud of points, but there are a lot of problems when it comes to local or general modifications of the previously designed surface.

Therefore Prefit-Maxsurf combination is a very convenient combination because the surface is preliminary generated in the Prefit program and is later optimized with the help of the Maxsurf program [5].

The first action to be done, starting from the traditional drawing (real measurement of the points), is the individualization of a series of characteristic points. In such a case we are dealing with the identification of half-breadth plan. In order to have a better line between the real hull and the 3D model to be built it is better that the number of ordinates to be measured be as large as possible. Special attention should be paid to areas where the vessel hull presents more complexity.

In this way the main objective of these measurements is the creation of the cloud of points that will be used to rebuild the ship hull.

Rebuilding of the 3D model of the ship hull based on real measurements the scheme must be followed (1-7 steps) and figure 2 shows a general flow chart of steps to be followed for the rebuilding of CAD models of the hull [5,6].

1. The necessary measurements in the line of Keel, extreme parts of the hull and its sections are taken.
2. On the basis of measurements and the hull drawing the dimensionless frame of half-breadth of this hull is compiled.
3. Prepare and compile the cloud of points, following the requirements of CAD model, which contains the coordinates of points derived from the measurements in the drawing.
4. On the basis of the cloud of points the preliminary generation of the hull surface is made.
5. Comparative analysis of the ship hydrostatic characteristics to be generated by the CAD model.
6. The smoothing of the surface of the CAD model is done until the required level of compliance with hydrostatic characteristics is achieved.
7. The drawing of the CAD model of the modeled hull is carried out.

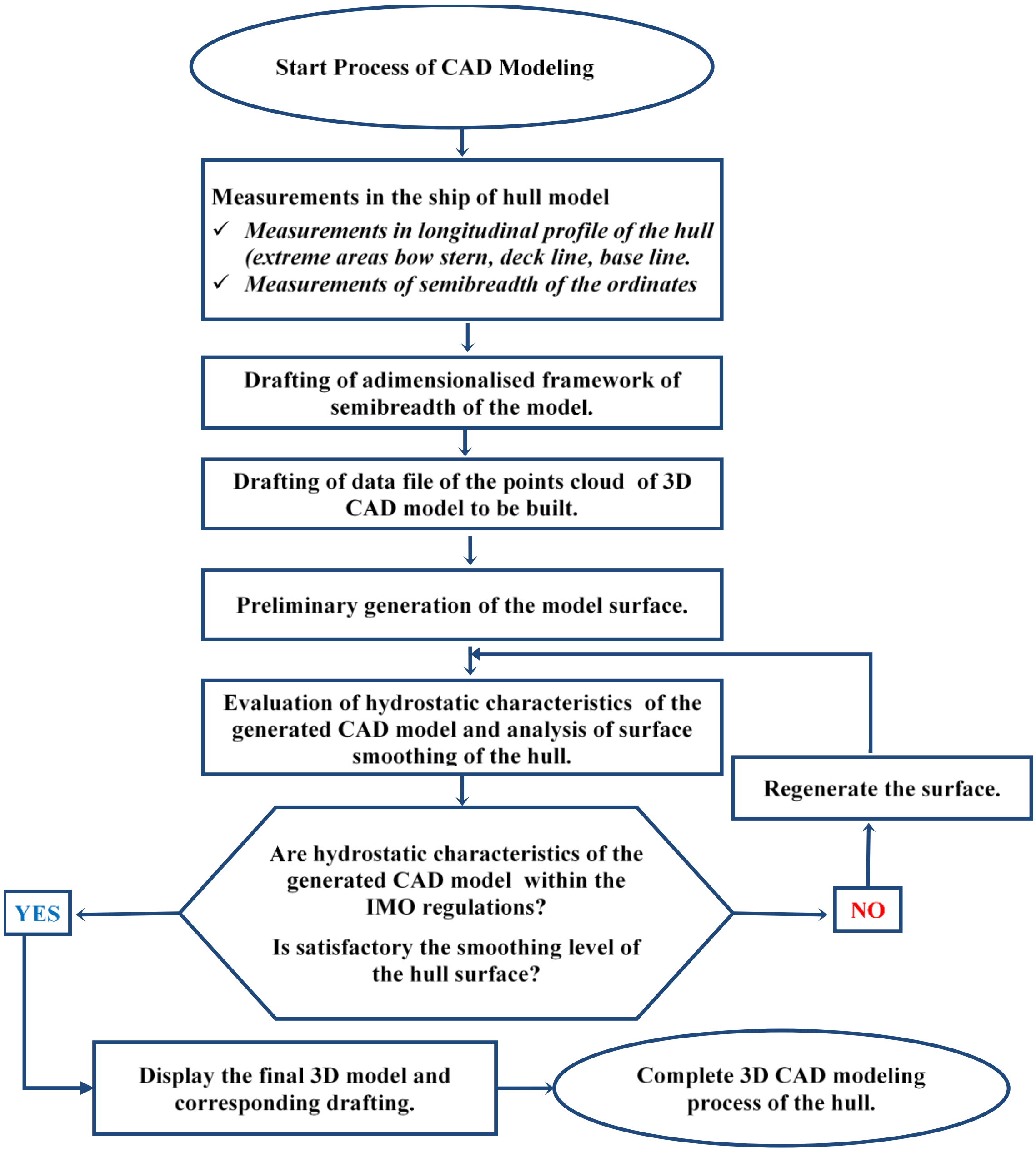


Figure 2: General flow chart of the process of rebuilding the hull

2.1 Measurements in reality for building the lines drawing of the hull to be modeled

The starting point which unquestionably has significant impact on the final result of the process 3D CAD modeling of a ship is the realization of real measurements of the ship hull that will be modeled. The process of measurement is related to measurements for the determination of bow-stern extreme parts, baseline and deck line, measurements for each water line and for each ordinate. To obtain accurate results, the measurement process of half-breadth ordinates is realized in the physical ordinates of existing watertight in the ship: 1, 4, 10, 28, 31, 55 and in ordinates 0, 2, 5, 15, 20, 25, 30, 35, 40, 45, 50, 60 with the help of measuring instruments (meter, sextant, level). From the measurements a new cloud is built in AUTOCAD program and then in determining the coordinates of the cloud of points to be used for modeling of the hull.

We measure water lines in every $\Delta T = 10cm$, from baseline (BL) to design water line (DWL). In the out of water ship part, the distance between the lines is taken twice $2\Delta T = 20cm$. Upon completion of measurements in relation to the ordinates, profile line, and extreme parts for getting database (Data Base) in "Excel Sheet" the opportunity for setting up an dimensionless half-breadths of the model that we need to build is created.

Table 5: Main dimensions of "Dragobia" ship

Length Overall	**LOA = 12.90 m**	**Passenger Number**	**46**
Length between perpendiculars	LBP = 11.70 m	Main Engine	260 HP FIAT
Breadth Overall	BOA = 4.50 m	Construction Material	Stee
Depth	D = 1.85 m	Year of Construction	1982
Draft	T = 1.25 m	Place of Construction	Albania

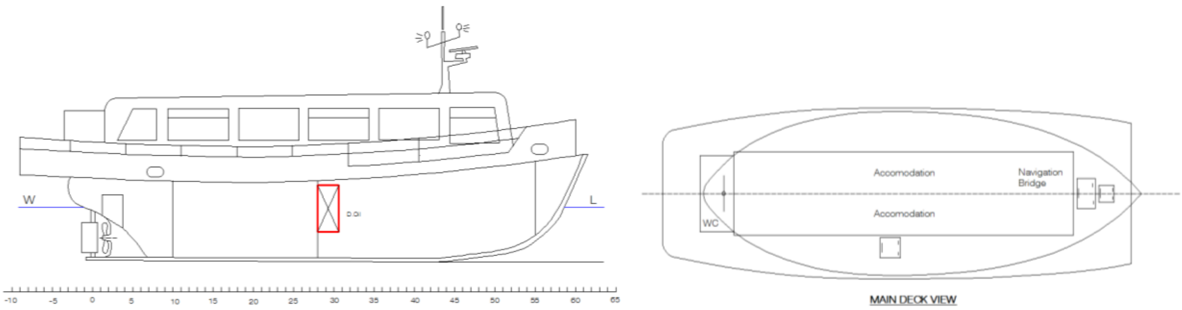


Figure 3: General arrangement of the Dragobia ship

After the initial setting of the coordinates of the cloud of points, we make its visualization. We identify possible errors in it during the insertion of coordinates, make appropriate modifications and eventually record the file that contains all the coordinates of the cloud of points necessary for the generation of the hull.

In Figure 4 are presented the cloud of points according the measurements.

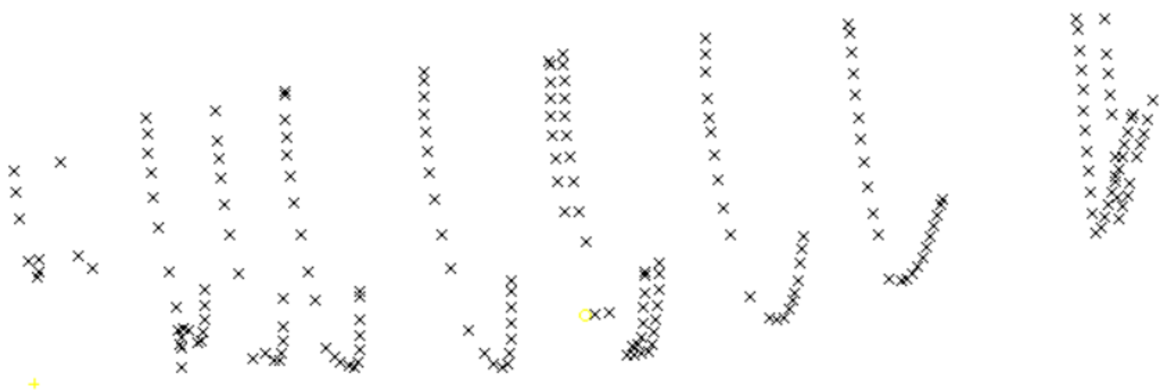


Figure 4: Cloud of points according the measurements.

2.2 Preliminary design of the hull surface of the model

Upon completion and adjustment of the cloud of points, the next very important step is the preliminary design of the model surface. The design process of the hull surface can pass into three phases [7], as shown in Figure 5.

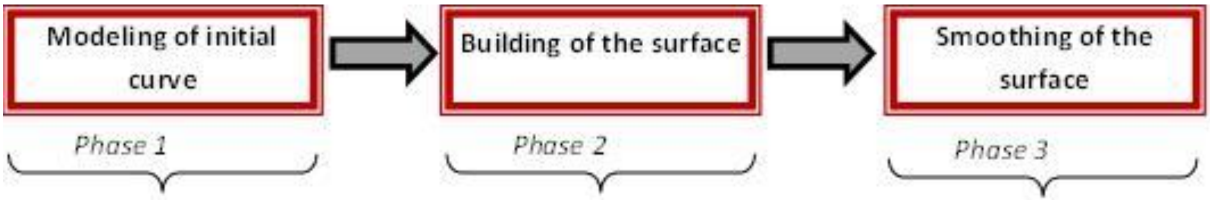


Figure 5: Stages, the process goes through the surface modeling

After the determination of the cloud of points, the eventual task of geometric modeling process is to design the surface of the model hull in order to better approximate the cloud of points specified in advance. For this, the first step is the determination of the surface control points, points which affect the form of curves and surfaces.

To obtain a surface as appropriate as possible, within certain limits and restrictions imposed in advance, the following should be done [2]:

1. The restrictions taken for control points, aim at improving the regularity of the control points network that will be generated, forcing them to lie in some determined areas.
2. The limits of Convergence deal with two elements:

- Maximum error, which would mean that the maximum deviation of the approximate surface in each of the coordinates of the cloud of points should be smaller than a preset value.
- Iteration number that indicates the maximum number of necessary iteration for obtaining the corresponding area.

Upon fixing the distribution of control points and choosing the flexibility of B-spline curve, the curve is automatically adapted to the points of section, by the Prefit program. After the adjustment of all the curves with the cloud of points is complited, the surface generation of the hull model is made. In this case it is a B-spline surface forced to adapt to a certain tolerance (specified by the level of convergence) the border curves of the sections.

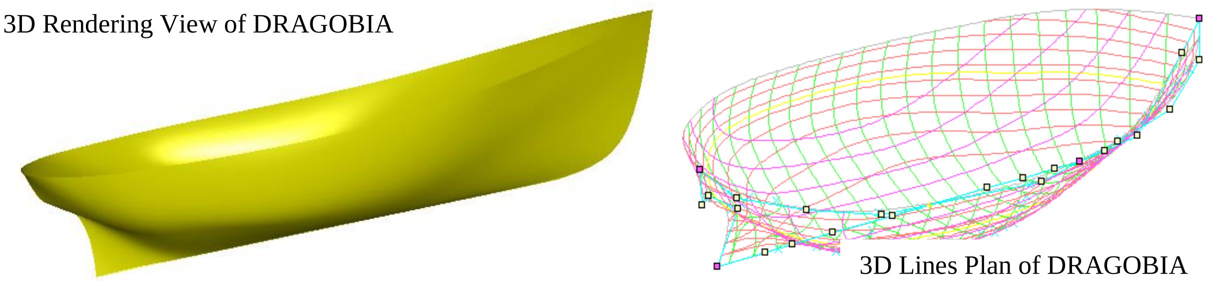


Figure 6: The final form of the ship model after the consecutive iterations

3 EVALUATION OF STATIC AND DYNAMIC STABILITY AND VERIFICATION OF GENERAL AND METEOROLOGICAL CRITERIA OF THE DRAGOBIA SHIP TAKEN IN THE STUDY

3.1 Hydrostatic DATA

Hydrostatic data are calculated with the help of Maxsurf and Hydromax Software. Here we present the data of the vessel with full load, that correspond waterline DWL=1.25m.

Table 2: Hydrostatic DATA of "Dragobia" ship

Draft Amidsh. M	DWL=1.25	Block Coeff.	0.429
Displacement tonne	27.4	Midship Area Coeff.	0.725
Draft at FP m	1.25	Waterpl. Area Coeff.	0.717
Draft at AP m	1.25	LCB from zero pt. (+ve fwd) m	-0.563
Draft at LCF m	1.25	LCF from zero pt. (+ve fwd) m	-0.702
WL Length m	11.635	KB m	0.792
WL Beam m	4.176	BMt m	1.413
Wetted Area m^2	46.728	GMt m	0.905
Waterpl. Area m^2	34.839	Immersion (TPc) tonne/cm	0.357
Prismatic Coeff.	0.6	MTc tonne.m	0.217

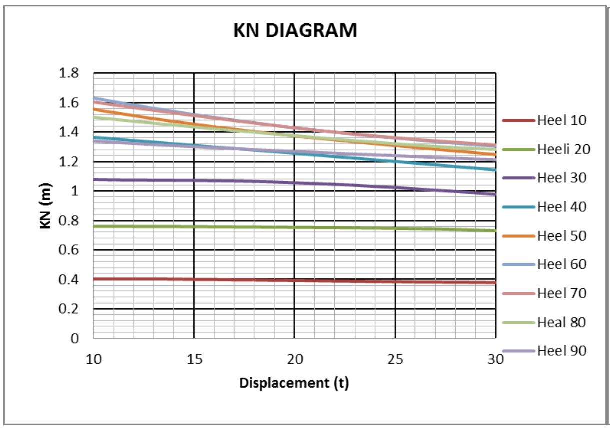
Also, the vertical center of gravity of the ship is calculated as: KG = VCG = 1.45m taking into account that:

- The maximum number of passenger on board is 46 people. The weight of each passenger is taken as 75 kg [8].
- The height of the center of gravity for passenger is taken 0.3 m above the seat [8].

3.2 Stability DATA

Stability data are calculated with the help of Maxsurf and Hydromax Software. Here we present only the diagram KN depending on displacement Δ for any heel angle φ.

Also is presented graphically static stability curve of the hull in the right position of the ship taken in the study.



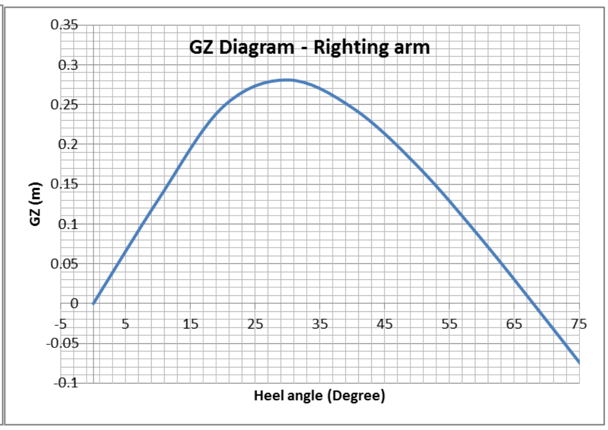


Figure 7: KN diagram depending on Δ for any heel angle φ and GZ diagram of the hull in the right position of Dragobia ship

3.3 Dynamic stability calculation

As we know the lever of dynamic stability is expressed by the definite integral of the lever of static stability. From this import property of the lever of dynamic stability we can deduce that the ordinate of dynamic stability represent, to a certain scale, the areas under the diagram of statistical stability bounded by the curve, the axis of abscissa and the corresponding ordinate.

From these properties and from the curve of static stability lever we have calculated the lever of dynamic stability

The graphical representation of dynamic stability curve is presented in the following figure.

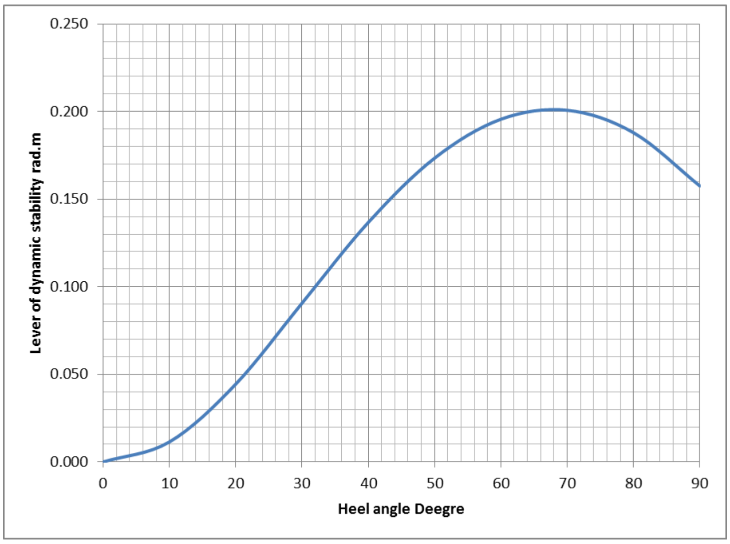


Figure 8: The graphical representation of dynamic stability curve

3.4 Fulfillment of criteria regarding righting lever curve properties

For the verification of the stability criteria are used criteria set forth in the IMO stability code and regulations provided by the classification societies and literature [8,9,10]. The fulfillment of criteria regarding righting lever curve properties:

Ship Full load departure

Code	Criteria	Value	Units	Actual	Status	Margin
Code on Intact Stability 2008	Area 0 to 30	3.1529	m.rad	5.2166	Pass	+65%
	Area 0 to 40	5.1592	m.rad	7.8535	Pass	+52%
	Area 30 to 40	1.7197	m.rad	2.6369	Pass	+53%
	Max GZ at 30 or greater	0.200	m	0.281	Pass	+41%
	Angle of maximum GZ	25	degree	30	Pass	+20%
	Initial GMt	0.150	m	0.755	Pass	+403%
	Area 0 to angle of GZmax	3.1510	m.deg	5.3648	Pass	+70%

*Full-load arrival, with 10% stores and fuel

Code	Criteria	Value	Units	Actual	Status	Margin
Code on Intact Stability 2008	Area 0 to 30	3.1510	m.deg	5.3648	Pass	+70%
	Area 0 to 40	5.1570	m.deg	8.1285	Pass	+57%
	Area 30 to 40	1.7190	m.deg	2.7637	Pass	+60%
	Max GZ at 30 or greater	0.200	m	0.286	Pass	+43%
	Angle of maximum GZ	25.0	deg	30.0	Pass	+20%
	Initial GMt	0.150	m	0.769	Pass	+412%
	Area 0 to angle of GZmax	3.1510	m.deg	5.3648	Pass	+70%

** Full-load arrival, with 50% stores and fuel

Code	Criteria	Value	Units	Actual	Status	Margin
Code on Intact Stability 2008	Area 0 to 30	3.1510	m.deg	5.2721	Pass	+67%
	Area 0 to 40	5.1570	m.deg	8.1563	Pass	+58%
	Area 30 to 40	1.7190	m.deg	2.8843	Pass	+67%
	Max GZ at 30 or greater	0.200	m	0.296	Pass	+47%
	Angle of maximum GZ	25.0	deg	31.8	Pass	+27%
	Initial GMt	0.150	m	0.736	Pass	+390%
	Area 0 to angle of GZmax	3.1510	m.deg	5.2721	Pass	+67%

3.5 Weather criteria (wind and rolling criterion) [8,9,10,11]

The ability of a ship to withstand the combined effects of beam wind and rolling shall be demonstrated, with reference to the following figure, as follows:

1. the ship is subjected to a steady wind pressure acting perpendicular to the ship's centerline which results in a steady wind heeling lever (lw_1=0.046m);
2. from the resultant angle of equilibrium (φ_0=3.50), the ship is assumed to roll owing to wave action to an angle of roll (φ_1=19.290) to windward. The angle of heel under action of steady wind (φ_0) should not exceed 160 or 80% of the angle of deck edge immersion, whichever is less;
3. the ship is then subjected to a gust wind pressure which results in a gust wind heeling lever (lw_2=0.062m);
4. φ_2 = angle of down-flooding (φf) or 50^0 or φc, whichever is less,
5. and under these circumstances, area b shall be equal to or greater than area a,

$$\frac{S_b}{S_a} = \frac{2540}{912} = 2.78 > 1 \tag{1}$$

as indicated in the following figure below:

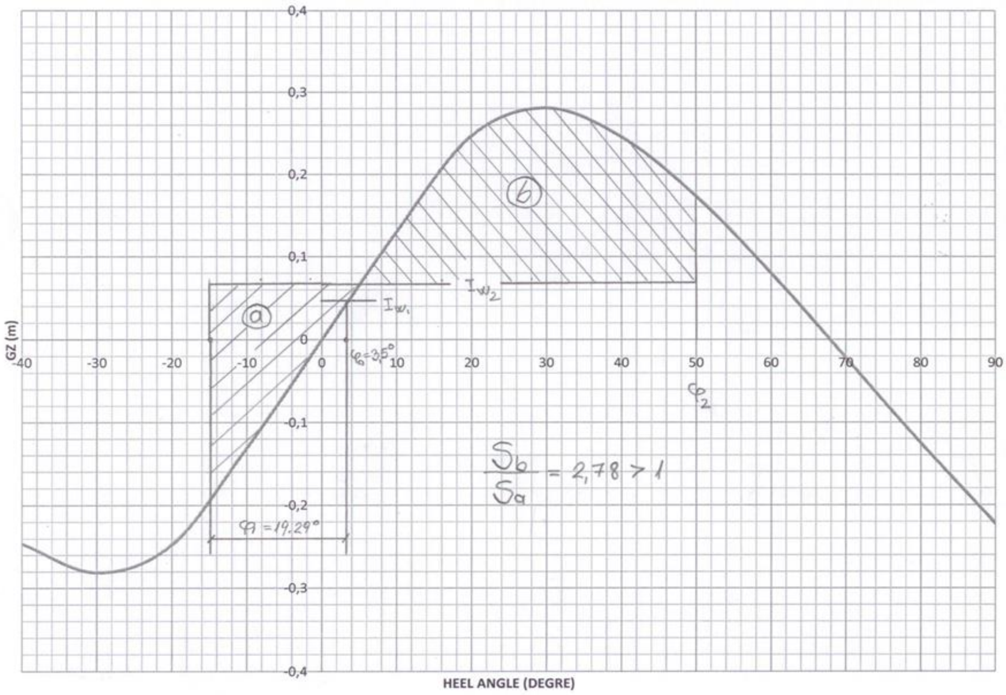


Figure 9: Stability diagram in which reflected the meteorological criteria

4 CONCLUSIONS

The study was conducted with the objective of completing the necessary documentation from the Albanian Maritime Administration for exercising of the activity of Dragobia ship in Lake Koman.

In this paper is presented a complete procedure of control and fulfillment of the norms of stability through the implementation of traditional and computer methods.

Compiled flow charts and presented algorithms ranging from real measurements on a ship, not only help 3D modeling and 3D CAD building of the ship hull, but they also present an working model to be implemented in similar cases of the ship.

FORMSYS computer package helps with a considerable reliability in achieving better surface of the ship hull.

Available in the Dragobia ship documentation are apart from the Lines Drawing of the ship also the hydrostatic data calculated with the help of Maxsurf and Hydromax Software.

The fulfillment of the stability criteria are verified according to the criteria in IMO stability code and regulations prescribed by the classification societies and in this study case result fulfilled.

REFERENCES

[1] Albanian Maritime Administration. (2009). *Albanian Regulation for Ship Inspection.* Durres, AL: AMA.

[2] Bentley. (2009). *Maxsurf.* Australia: Formation Design Systems Pty Ltd.

[3] Lapa K. (2003). *Gjeometria e Anijes.* Tirane, AL: SHBLU.

[4] Girace C. (2006). Rilievo di carene navali mediante techniche di riverese engineering. Napoli, Italy: Tesi di Dottorato

[5] Xhaferaj, B., & et al. (2008). Perdorimi i sistemeve te programeve Maxsurf per vleresimin e cilesive lundrimore te mjeteve te transportit detar shqiptar, (pp. 52-61). Vlore, Albania: Besueshmeria e Mjeteve te Transportit Detar.

[6] Xhaferaj, B., & et al. (2013). A case study on the prediction of some hydrodynamics characteristics of a small marine vehicle. (pp. 294-300). A Coruna, Spain: Proceedings of the 6th international maritime science conference.

[7] Xhaferaj, B., & et al. (1994). Design of hull surface using modern modelling technique. Aktet 2010. *Aktet 2010*, *III*(2), 260-266.

[8] Code on Intact Stability, IMO 2008

[9] Biran A. (2005). *Ship Hydrostatics and Stability*. London, UK: Butterworth Heinemann.

[10] Lapa K. (2004). Statika dhe Qëndrueshmëria e Anijes. Tirane, AL: SHBLU.

[11] Lapa, K., & et al. (2005). *The influence of Albanian sea winds on fishing-boat stability of FV 2KP-400 type* (pp. 1231-1237). Lisbon, Portugal: Proceedings of the 11th International Congress of IMAM 2005.

OPTIMIZATION OF OIL SPILL RESPONSE RESOURCES LOCATIONS ON THE EXAMPLE OF HEAVY OIL SPILL ON THE GDANSK BAY AREA

Kinga Łazuga, Msc
Lucjan Gucma, PhD.
Andrzej Bąk, PhD.
Maritime University of Szczecin
Wały Chrobrego 1-2, 70-500 Szczecin, Poland
k.lazuga@am.szczecin.pl, l.gucma@am.szczecin.pl

ABSTRACT

The safety of the navigation and response to the ships accidents are the priority for Baltic Sea region because of the specific conditions of the Baltic Sea and heavy traffic. Such large disasters like oil spill occur relatively rarely, but when it comes to a major spill, negative effects could be observed for years. In such event like an oil spill response action should be taken to collect the pollution. Such action should proceed smoothly and its duration should be as short as possible. Response actions involve the dispatching of cleanup equipment. This paper presents mathematical model designed to optimize the deployment of response resources to combat oil spills due to the cost of oil spill fighting action. Model is based on genetic programming and mathematical oil spill fate model. As the result of presented researches optimal allocation of oil spill response resources is obtained.

Key words: Oil spill response resources, genetic algorithm for optimal allocation of resources.

1 INTRODUCTION

The Baltic Sea is one of the most heavily trafficked seas in the world. There are around 2,000 ships at the Baltic Sea at any one time. Approximately, 20% of them are tankers, carrying as much as 166 million tons of oil per year . Each year there are 120-140 shipping accidents in the Baltic Sea area. According to the HELCOM statistics 150 ship accidents occurred in the Baltic Sea area in 2013, which is the highest recorded number in the last ten years (Fig. 1) [HELCOM, 2014]

The majority of accidents are groundings and collisions. Around 7% of the shipping accidents in the Baltic Sea results in some kind of pollution, usually containing small amounts of oil (0.1-1 tons). Despite this Baltic Sea is relatively safe comparing to other regions. The largest pollutions accidents are as follows [HELCOM, 2010]:

- 1990 'Volgoneft', 700-800 t. of waste oil; nearly all oil recovered at sea,
- 2001 'Baltic Carrier', 2,700 t. of oil; around 50% of oil recovered at sea,
- 2003 'Fu Shan Hai', 1,200 t. of fuel oil; around 1,100 tons of oil recovered at sea.

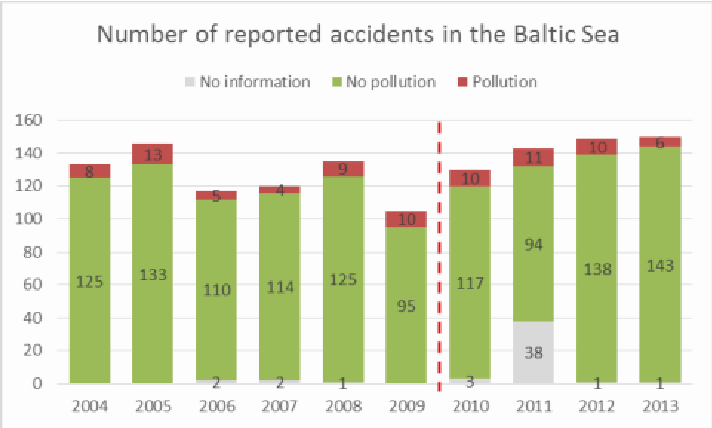


Figure 1: Number of reported accidents in the Baltic Sea

Source: HELCOM 2014, Annual report on shipping accidents in the Baltic Sea in 2013

2 ALLOCATION PROBLEM

In the past, attempts were made in order to formulate mathematical solutions to strategic problems and tactical planning rescue operations in case of oil spill at the sea. One of attempts in order to solve a problem the optimum-allocation of the emergency equipment made Harilaos & Psaraftis and Babis & Ziogas in 1985 . They developed the procedure of the optimization in order to support the decision-making of the land resort. The objective function was described as minimizing costs incurred and the indemnity caused by oil spill at the sea. Entries to the model are the information on the type of the leakage, the availability and the presentation of the available equipment, as well as transport and the operation of the equipment on scene. The algorithm is based on the linear programing, however, gives only approximate results. Creators of the algorithm are divided into the decision-making through the hierarchical structure for the analysis of business systems [Anthony'ego 1965] on three levels: strategic, tactical and operational.

Ziogas and Psaraftis algorithm refers to the tactical level of response and accepts that the strategic plan of action was finished. Of course, decisions undertaken on level of the tactical planning are limited by problems identified on the lower level.

Iakovou E. and others [1996] whereas the present model for the strategic level of response based on linear programming.

This model is determined by the optimum-number of rescue bases which should be built and the number of equipment. The objective function consists of fixed costs related to the build on shore bases, the cost of the storage of the equipment and transportating of the equipment from the base to the spill site. Similar attempts were made during the search of the best arrangement of police stations, the ambulance and the fire brigade. Church and Revelle [1974] propose a solution to the problem of deploying posts by greedy strategy using linear programming. This consists of following partial coverage areas of databases, every from which is limited to his range of activity.

The matter of the Location - Allocation (LA) is a strategic problem in the decision-making of the choice of the best arrangement of productive centres and the transport network connective with buyers. General definition of the problem is the choice of the optimal LA arrangements subset of the set of all possible combinations to meet the demand nodes [Rabbani M., Yousefnajad H 2013]. Sometimes this definition is extended to formulate CAL (called

Capacited AL), which is a problem AL with restrictions, such as a specific budget, which amounts to placing production facilities in existing locations and / or the creation of new locations, where they can be placed.

3 MODEL OF OPTIMAL ALLOCATION

3.1 Genetic algorithm

Genetic algorithm (or a variant thereof evolutionary algorithm) is a kind of algorithm, in seeking alternative solutions to the problem in order to find the best solutions based on the criterion (time, cost, profit). Genetic algorithms are widely used to solve complex optimization problems. Application of genetic algorithm to speed up the process of finding the best solution to the problem of the distribution of power and resources.

An evolutionary algorithm for the approximate algorithm, which uses stochastic mechanisms inspired by biological evolution, such as selection, reproduction and mutation. The population of the corresponding natural selection pressure forced and controlled environment of a specific objective function. Only the fittest individuals have the opportunity to start a new, usually improving population. The evolutionary algorithm, the problem to be solved is the environment in which the "life" of the population. Each item can be a possible solution to this problem. Evolutionary algorithm usually tend gradually to create new and better solutions, often used to solve optimization problems, because the optimization process by searching through the space of potential solutions to the problem in order to find the best solution.

3.2 The cost minimization

Created model of optimal allocation refers to the strategic level of response action and is designed to fit the deployment of such a rescue ships in sea rescue bases, in which the time of arrival of ships at the spill site, the cost of the shares and the environmental impact as a result of a failed rescue operation will be as small as possible (Łazuga & Gucma, 2014). It is so deploy ships to minimize the sum of the following costs:

- total cost of reaching the spill site,
- the total cost of collecting the spillage by involved vessels,
- cost of contamination on the environment as a result of a failed action,
- the cost of establishing a new port (if needed),
- the cost of buying new ships and their equipment (if none of the proposed arrangements vessels does not provide complete removal of the spill),
- cost of maintaining the ships in the harbour,
- maximize profits from the use of ships for other purposes such as tugs (multi-criteria optimization).

To find minimal cost of response action the following objective function is proposed:

$$Min \quad \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K} t_{ijk} c_{ik} x_{ij} y_{ik} + \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K} t_{ik} c_{ik} x_{ij} y_{ij} \tag{1}$$

where: I–ships, J–ports, K–pollutions, t_{ijk}–time of reaching k-th oil spill form j-th port by i-th ship, c_{ik}–cost of reaching the spill from given port by ship and cost of given spill cleaning up, x–logical variable (0,1) depending of ship allocation in given port, y–logical variable (0,1) depending of ship scheduling in given response action.

The created model using evolutionary programming methodology for optimization (minimization) the cost of response action (Łazuga i Gucma, 2014). The interface of this model is presetned in Fig. 2. It enables to observe during simulation the advance in cost minimisation throughaout generations (left upper panel) of given layout of ports and oil spills (right window).

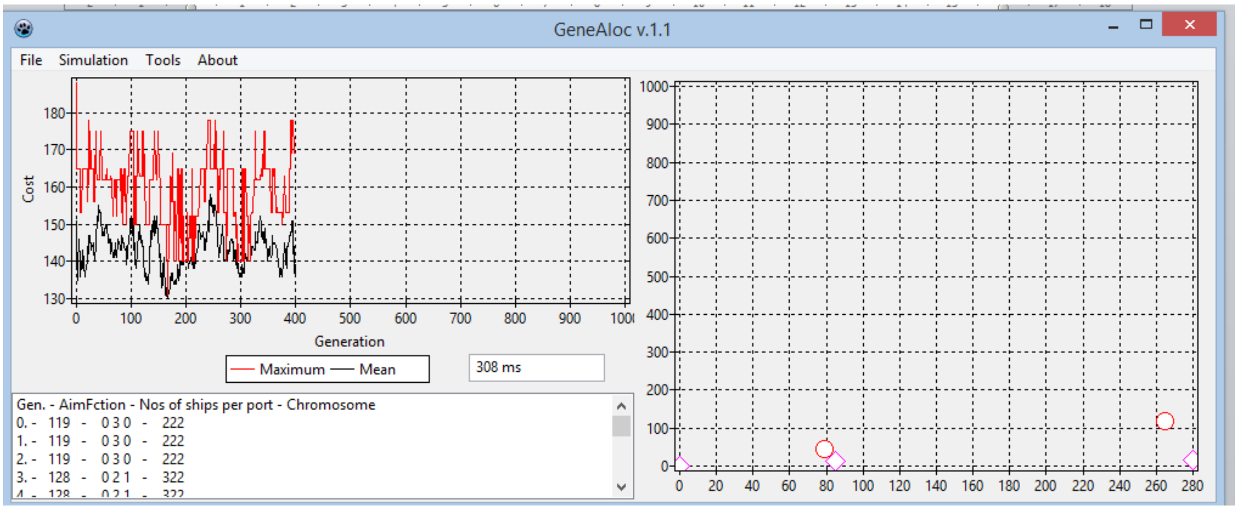


Figure 2: Computer interface of optimal cost model based on evolutionary programming

Source: Łazuga, K., & Gucma, L., 2014.

4 MODEL VERIFICATION ON THE EXAMPLE OF THE HEAVY OIL SPILL IN THE GULF OF GDAŃSK

Place of spill chose on the basis the stochastic model (Gucma & Przywarty , 2007). Oil spill accident can occur in arbitrary moment. Scenarios were simulated for risk of oil spill impact evaluation. Meteorological conditions represent average Baltic Sea conditions. On the base of wind and current data probable situations were formed. The data show simulated pollution zones.

The stochastic model output is long time spatial distribution of oil spills in given area (Fig.3). Averaging the results with consideration of simulation times it is possible to find mean probabilities and amount of oil spilled per year.

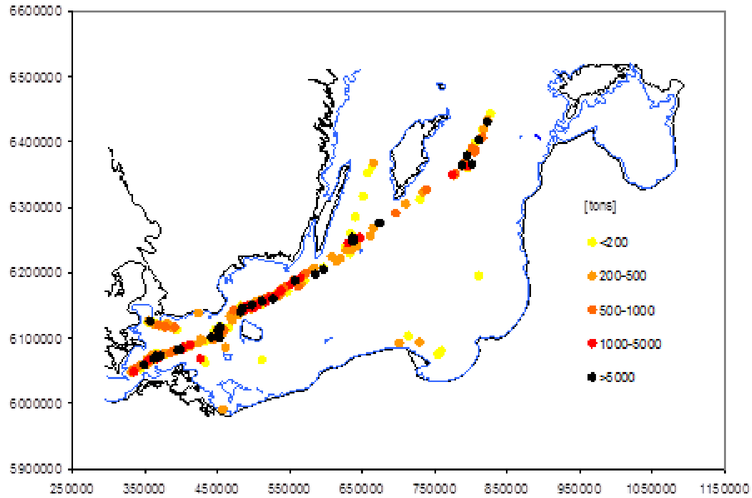


Figure 3: Simulated oil pollutions collision at the southern Baltic Sea (long time simulations results)

Source: Gucma, L. & Przywarty, M., 2007.

4.1 Simulations results

One carried out simulations verifying described model. Simulations concern the overflow 100 tonnes of the heavy fuel oil in characteristic for the summer season hydrometeorological conditions. In the simulation are taken under the attention three Polish ports (1-Świnoujście, 2-Kołobrzeg, 3-Gdynia), three possible places of the spill (Fig. 4) and three ships together with the equipment and the crew.

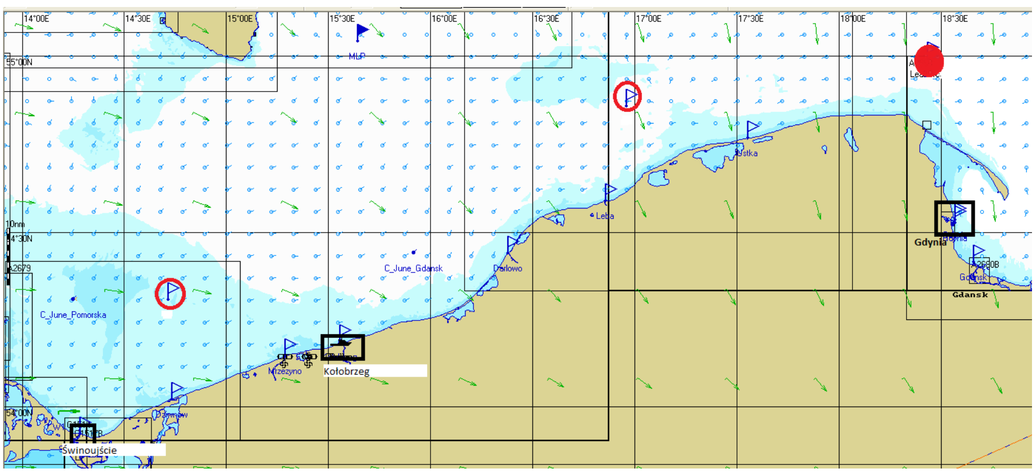


Figure 4: Ports and spills locations

A first step herein to the investigation is the settlement of the allocation of oil response ships in ports by means of remembered in previous step the application based on the evolutionary programming. A result of carried out simulation is the following arrangement of ships: all ships in the port No. 2 (the result of the algorithm 222) and the first ship in the port No. 3 and two ships in the port No. 2 (the result of the algorithm 322).

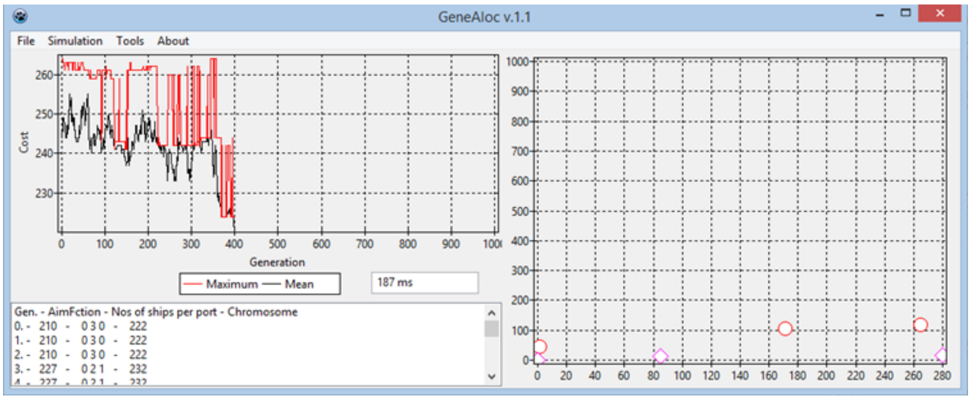


Figure 5: Application interface with simulation results

The paper presents results of the oil spill response action for third spill possible location near the Gulf of Gdańsk (Fig. 4).

For first result from genetic algorithm and above condition one simulation on simulation Pisces II were carried out. According to the genetic algorithm result all ships were located in port no 2 (Kolobrzeg).

Simulation input:

- amount of spilled oil: 100 t heavy oil,
- wind speed and direction:7-10 kts, 000°,
- current speed and direction: 0.25 kts, 045°,
- ships (recovery rate, type of oil, home port):
  - Kapitan Poinc: recovery rate 280 t/h, all types of oil, Kolobrzeg,
  - Czesław II: recovery rate 40 t/h, all types of oil, Kolobrzeg,
  - Zodiak: recovery rate 160 t/h, all types of oil, Kolobrzeg.

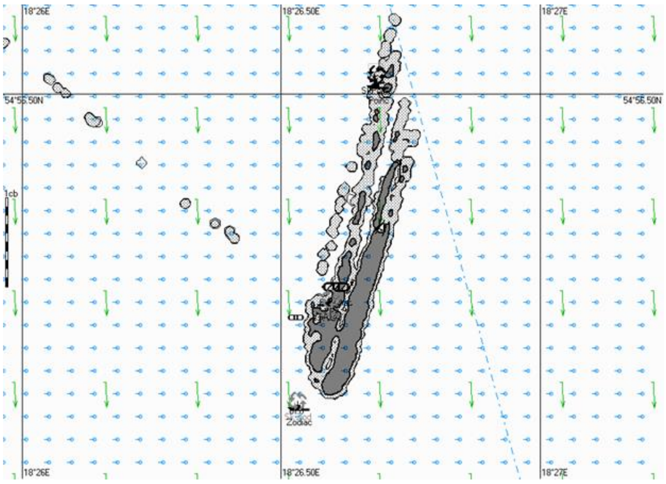


Figure 6: Ships moving along oil slick

Simulation result are presented in the table below (Table 1). 100 t of heavy oil were spilled, maximum slick area were 0,02 km^2 and all of oil has been removed from water surface. The cost of the entire action was 101000 PLN.

Table 1: Oil spill history- simulation results

#	Time	Amount spilled, lton	Amount floating, lton	Amount evaporated, lton	Amount dispersed, lton	Amount sunk, lton	Amount recovered, lton	Amount floating mixture, lton	Amount recovered mixture, lton	Max thickness, mm	Slick area, km2	Viscosity, cSt
1	"0:05"	3	3	0	0	0	0	3	0	3,5	0	47,6
2	"1:05"	42,3	42,3	0	0	0	0	46,4	0	14,5	0	58,9
3	"2:05"	81,7	81,5	0,1	0,1	0	0	98,3	0	14,1	0,1	75
4	"3:05"	98,4	98	0,2	0,2	0	0	137	0	4,2	0,1	110
5	"4:05"	98,4	97,8	0,4	0,3	0	0	163	0	3,9	0,1	179
6	"5:05"	98,4	97,6	0,5	0,3	0	0	192	0	4,1	0,1	282
7	"6:05"	98,4	97,3	0,7	0,4	0	0	221	0	4,2	0,1	426
8	"7:05"	98,4	97	1	0,5	0	0	247	0	4,3	0,2	594
9	"8:05"	98,4	96,7	1,2	0,5	0	0	268	0	4,3	0,2	763
10	"9:05"	98,4	96,4	1,5	0,5	0	0	284	0	4,1	0,2	922
11	"10:05"	98,4	19,5	1,7	0,6	0	76,7	60,9	216	3,4	0,1	1090
12	"11:05"	98,4	0	1,7	0,6	0	96,1	0,1	276	1	0	1201

5 CONCLUSION

Planning and organization of respons oil combating action is quite a complicated process, especially if it is planned to use the available resources in a local optimum. Therefore, it was decided to create a model to find the best possible solution for the question of the allocation of emergency. Model of optimal allocation of resources can improve the decision making process at the level of planning rescue operations. It is intended primarily for the effective implementation of the rescue vessels in various ports. The application described in this article is in the process of expansion and fulfillment of new features.

The model of the optimal allocation of oil spill response resources permits to choose the best arrangement of ships to fighting with pollutions at sea on the assumption probable places of overflows and the quantity and the kind of oil. After defining of above-parameters the programme stations the allocation of individual ships in defined earlier ports. After examining of the series of solutions the programme permits choosing of most profitable solution of the arrangement of ships due to the cost of the conduct of the salvage.

REFERENCES

[1] Davidson W.F., Lee K., Cogswell A.: Oil Spill Response: A Global Perspective. Springer 2008.

[2] Farahani R.Z., Hekmatfar M.: Facility Location. Springer 2009.

[3] Fingas M.: The basics of Oil Spill Cleanup. Lewis Publisher 2000.

[4] Fingas M.: Oil spill science and technology. Elsevier 2010.

[5] Gucma, L., & Przywarty , M. (2007). The model of Oil Spills Due to Ships Collisions in Southern Baltic Area. *Advances in Marine Navigation and safety of sea transportation*.

[6] HELCOM. (2010). *Maritime Activities in the Baltic Sea – An integrated thematic assessment on maritime activities and response to pollution at sea in the Baltic Sea Region. Balt. Sea Environ. Proc. No. 123.* HELCOM.

[7] HELCOM. (2014). *Annual report on shipping accidents in the Baltic Sea in 2013.*

[8] Iakovou E., Ip C.M., Douligeris C., Korde A.: Optimal location and capacity of emergency cleanup equipment for oil spill response. European Journal of Operational Research 96, 1996 (pp. 72-80).

[9] Łazuga, K., & Gucma, L. (2014). Model of optimal allocation of response (in print) Proc. of IMSC Conferenc. Split.

[10] Łazuga, K., & Gucma, L. (2014). The method of risk management of accidental oil spills at sea. *European Safety and Reliability*. Church R., ReVelle C.: Themaximal covering location problem. Papers Regional Sci. Appl. 32, 1974 (pp. 101-118).

[11] Michalewicz Z.: Algorytmy genetyczne struktury danych = programy ewolucyjne. Wydawnictwo Naukowo-Techniczne, Warszawa 1996, 1999.

[12] Mitsuo G., Runwei C., Lin L.:Network Models and Optimization. Springer 2008.

[13] Ornitz B.E., Champ M.A.: Oil Spills Dirst Principles:Prevention and Best Response. Elsevier 2002.

[14] Psaraftis, H.N., Ziogas, B.O.:A tactical decision algorithm for the optimal dispatching of oil spill cleanup equipment. Management science Vol. 31, No. 12, December 1985 (pp. 1475-1491).

[15] Psaraftis, H.N., Tharakan G.G., Ceder A.: Optimal response to oil spills: The strategic decision case. Operation Reserch 34, 1986 (pp. 203-217).

[16] Rabbani M., Yousefnajad H.: A novel approach for solving a capacitated location allocation problem. International Journal of Industrial Engineering Computations 4, 2013 (pp. 203-214).

RAIL FREIGHT SYSTEM IN CENTRAL EUROPE – SATISFICATION AND DEMANDS FROM THE USER'S PERSPECTIVE

Christoph Link, DI, Dipl-Geogr.
Regine Gerike, D.Sc.
Institute for Transport Studies
University of Natural Resources and Life Science
Peter-Jordan-Straße 82, 1190 Vienna, Austria
Christoph.Link@boku.ac.at, Regine.Gerike@boku.ac.at

ABSTRACT

EU regulation 913/2010 aims on establishing a competitive freight transport in Europe. Core element is a network of rail freight corridors promoting international freight transports. The Baltic-Adriatic Corridor (Rail Freight Corridor 5, RFC5) connects the Polish Baltic Sea harbors (Gdansk, Gdynia and Szczecin) with the Adriatic harbors Koper, Trieste, Venice and Ravenna. The RFC 5 passes Poland, Slovakia, Austria, Czech Republic, Slovenia and Italy. It will be operational in November 2015. In order to prepare the implementation of the RFC5, a transport market study had to be conducted according to the EU regulation. It includes a survey addressing demands on the RFC5. This survey was conducted by the Institute for Transport Studies in 2014. Target companies were shippers, logistic companies, railway undertakings and operators of terminals and ports from the six countries mentioned before.

One part of the survey referred to an assessment of several items of rail freight transport in the specific countries. Up to 16 items were taken into accounts such as transport costs, flexibility of trains, maximum permitted weight of trains, contact to railway infrastructure manager or access to terminals. Additionally, respondents were asked to rate the need of improvements for these items.

Distinguished by category, the current status was assessed particularly badly concerning "flexibility of train services", "rail transport time" and "rail transport costs" with the latter having by far the worst assessment. Contrary, particularly positively evaluated categories were "contact to infrastructure operator", "risk of damages/goods lost/theft" and "safety systems".

Key words: Rail freight transport, rail freight corridor, requirements, satisfication, survey.

1 ON THE WAY TO A MORE ENVIRONMENTAL FRIENDLY TRANSPORT SYSTEMS: RAIL FREIGHT CORRIDORS

There is no doubt that public transport has specific advantages compared to other modes of transport – this refers to both, passenger and freight transport. Switching transport from road to rail decreases the amount of greenhouse-gas emitted per person- or tonne-kilometre, helps avoiding traffic congestion and increases traffic safety. On the contrary, the use of public transport is less flexible, more expensive and often time-consuming. Obviously, the advantages of public transport are more or less societal benefits, while the costs are assigned to the individual person or company – this is a bad allocation for the promotion of public transport and contradicts the aims of the European Union regarding the contribution of the transport sector to climate protection [1]. These aims are formulated by the European Commission within the White Paper – Transport published in 2011 [2]. It calls for the reduction of at least 20% of emissions of the transport sector until 2030. The objectives concerning freight transport are even more straightforward: 30% of road freight transports covering a distance above 300 kilometres should be made by other transport modes in 2030 and 50% in 2050 (Objective 3). This should be reached without negative impacts on the economic development [2].

The White Paper also determines the path to reach its objectives regarding freight transport: By developing appropriate infrastructure and establishing a network of freight corridors. These European rail freight corridors are said to address a major common disadvantage of current rail freight transports and turn it into a comparative advantage: Rail freight transports are competitive when many (standardized) or heavy goods are transported over long distances. Examples are new vehicles or resources like coal or iron transported from a harbour to a far-distant agglomeration. This particularly refers to freight transports passing several countries. However, national borders often cut this advantage out of several reasons such as waiting times or required changes of locomotives, waggons or staff out of legal reasons at border crossing. Even more important are transaction costs and disadvantages when organising rail freight transports: a national authority has to allow a transport by assigning a requested train path. If more than one country is passed, the permission has to be given by each national authority. Obviously, finding a solution in terms of continuous train paths is getting the more complicated the more countries are passed. This requires time and money, while it decreases the flexibility of the rail system. These problems can be solved by implementing international rail freight corridors with a unique management.

There are two kinds of corridors to be implemented within Europe. The more popular ones belong to the Trans-European Transport Networks (TEN-T). It is based on “Decision No 1692/96/EC of the European Parliament and of the Council on Community guidelines for the development of the trans-European transport network”. The TEN-T-network will include all transport modes. A core network has to be developed until 2030; the entire network has to be implemented until 2050. Network development refers to the task of building and maintaining a high-level infrastructure [3].

The second kind is rail freight corridors (RFCs). They are based on EU regulation 913/2010 which aims on establishing a competitive rail freight transport in Europe. Core element of the regulation is a network of rail freight corridors promoting international freight transports. The implementation of RFCs does not include building and maintenance measures although the TEN-T-standards on infrastructural facilities are also used as informal benchmark for the RFCs. Instead, RFCs aim on promoting rail freight transports by implementing an improved corridor management. This includes facilitating the accessibility of the rail network, offering pre-arranged train paths (PAP) and implementing a central contact point responsible for a specific RFC (Corridor One Stop Shop, C-OSS). PAPs are continuous train paths between two stations (cities, terminals or harbours) allowing to use a train of a specific maximum length and weight at a given date, departure and arrival time. When using a PAP there should be no or nearly no waiting times at border crossings. A list of possible PAPs is developed by the C-OSS, companies can tender for a PAP. While until now only certain kinds of companies – mainly railway undertakings with specific licenses – could apply for a train path, this will be possible for all companies that become a so-called authorized applicant in the future. Authorized applicants can apply for a PAP and look for a railway undertaking operating on the corridor once they got the approval. This should foster the competition on the transport market and lead to lower transport prices. The C-OSS develops and allocates the PAPs for the entire corridor and acts as central contact point for all requests. A not ordered PAP becomes part of the so-called reserve capacity. This reserve capacity allows reacting on short-term demands for rail transports and thus increases the flexibility of rail transports. Thus, rail freight transports should become faster, cheaper and more flexible when using RFCs. There will be nine RFCs throughout entire Europe, which will be operational in 2015 or were already implemented in 2013. In order to prepare the implementation of the RFC5, a transport market study had to be conducted according to the EU regulation [4].

2 THE BALTIC-ADRIATIC CORRIDOR RFC5 AND THE BELONGING TRANSPORT MARKET STUDY

The Baltic-Adriatic Corridor (Rail Freight Corridor 5, RFC5) connects the Polish ports at the Baltic Sea (Gdansk, Gdynia and Szczecin) with the Adriatic harbours of Koper, Trieste, Venice and Ravenna. The RFC 5 passes Poland, Slovakia, Austria, Czech Republic, Slovenia and Italy. In more detail, it will include railway connections between Świnoujście / Gdynia – Katowice – Ostrava / Žilina – Bratislava / Vienna / Klagenfurt – Udine – Venezia / Trieste / Bologna / Ravenna / Graz – Maribor – Ljubljana – Koper / Trieste. It will be operational in November 2015 (Figure 1).

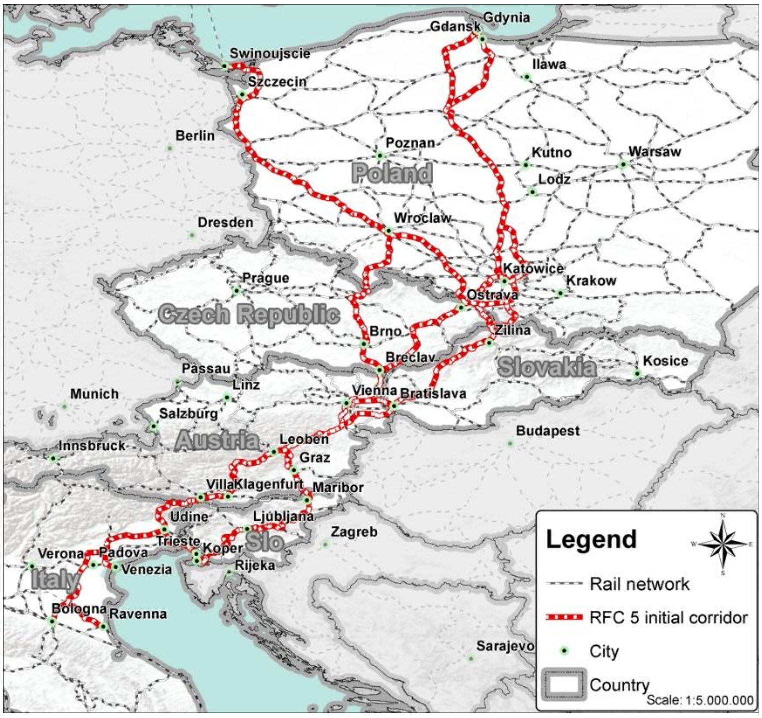


Figure 1: Preliminary course of the RFC5

Source: Kriebernegg et al. (2014).

The transport market study contains of several parts: (i) an analysis of the status quo including the available infrastructure, (ii) a survey addressing the current status of rail transports as well as demands on the RFC5 and a stated-preference survey on mode choice in freight transport, (iii) a forecast of the economic development and the transport volume and (iv) an assignment of the transport volume on the future rail infrastructure. This paper focuses on a descriptive analysis of specific parts of the survey.

3 THE SURVEY ON RFC5: CONTENT, PROCEDURE AND PARTICIPANTS

The survey for the transport market study was conducted by the Institute for Transport Studies in 2014. Target groups were the relevant decision makers in rail freight transport [5]: shippers, logistic companies, railway undertakings and operators of terminals and ports from the six countries Austria, Czech Republic, Italy, Poland, Slovenia and Slovakia.

All target companies were addressed by an announcement letter in national language. The letter also included a declaration of data security and an explanation of the survey procedure. Participation to the survey was possible via web or face-2-face for all target companies; railway undertakings and terminal and port operators could also fill-in a questionnaire by hand or attend a phone-based interview. Questionnaires in all languages were prepared for all four target groups. If a company did not react on the announcement letter, up to seven reminder calls were made and reminder e-mails were sent.

Target companies were selected based on a desk research, since a random selection was not possible due to missing registers of relevant companies in most countries. Identified companies are target companies when (i) they belong to the first or second economic sector, (ii) have a certain company size and (iii) import or export primary products, resources or goods that are either rail-affine or at least intermediate (rail share of the specific good is a maximum of 10 percentage points below the rail share on national modal split; this only refers to international transports). The adjusted gross sample per target group and country, defined as number of companies for which a valid address could be identified and which indicated to use rail transports at least sometimes also including those refusing to participate is shown in Table 6.

Table 6: Adjusted gross sample: number of identified target companies per country and target group

	AT	CZ	IT	PL	SI	SK	Total number
Shippers	58	45	52	33	40	47	275
Logistic companies	42	28	48	65	47	55	285
Terminal / port operators	17	14	33	24	10	10	108
Railway undertakings	14	16	9	17	4	8	68
Total number	131	103	142	139	101	120	736

Source: Own results, own illustration

Some companies from the adjusted gross sample refused to participate to the survey. The resulting number of completed interviews reaches 288 with a certain asymmetry towards Austrian and Slovenian companies as well as terminal and port operators and railway undertakings (Table). Additionally, 25 companies did not complete the entire interview.

Table 2: Number of conducted interviews per country and group

	AT	CZ	IT	PL	SI	SK	Total number
Shippers	29	14	15	11	18	21	108
Logistic companies	15	11	14	12	21	8	81
Terminal / port operators	9	7	15	11	6	7	55
Railway undertakings	12	11	4	6	4	7	44
Total number	65	43	48	40	49	43	288

Source: Own results, own illustration

A certain skew becomes even more obvious, if the participation rate is taken into account (Table). The overall participation rate reaches 39%. The rate varies between the specific target groups. It is lowest for logistic companies reaching a share of only 28%. This is somehow surprising since logistic companies were expected to be more interested in the topic than shippers. The highest commitment was reached among railway undertakings from which 66% participated to the survey. There are also large differences with regard to the countries with Austria and Slovenia companies having the highest willingness to participate by far. The participation rate might also have impacts on the results of the survey: A high participation rate may imply that companies with a low level of interest and knowledge on the RFC5 or degree of rail-affinity participated to the survey. This might produce below-average ratings in this specific country or target group.

Table 3: Participation rate

	AT	CZ	IT	PL	SI	SK	Total number
Shippers	52%	31%	29%	33%	45%	45%	40%
Logistic companies	36%	39%	29%	18%	45%	15%	28%
Terminal / port operators	53%	50%	42%	46%	60%	70%	50%
Railway undertakings	86%	69%	44%	35%	100%	100%	66%
Total number	50%	42%	33%	29%	49%	37%	39%

Source: Own results, own illustration

The location of the participating companies is shown for the example of Slovenia in figure 2.

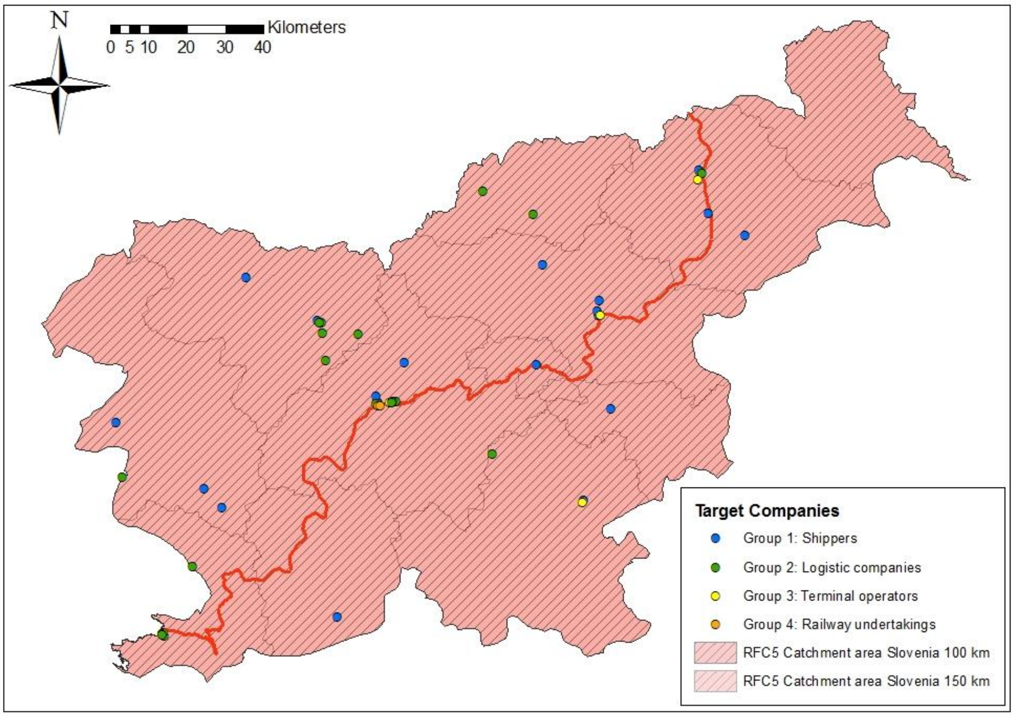


Figure 2: Preliminary course of the RFC5

Source: Own results, own illustration

4 SURVEY RESULTS: ASSESSMENT OF THE RAIL FREIGHT SYSTEM IN CENTRAL-EASTERN EUROPE

The results presented in the following mainly refer to the assessment of the current situation of the rail freight system in the countries passed by the RFC5 and the respective need for improvements. For this purpose, respondents were asked to rate the current status of up to 16 different items using a four-tier scale including bad, rather bad, rather good and good. Those items were “Contact to infrastructure managers”, “Harmonization of rules/processes”, “Crossing of borders”, “Network access”, “Safety systems”, “Risk of damages/goods lost/theft”, “Punctuality/reliability of train services”, “Rail network capacity”, “Rail transport costs”, “Total transport time (door-to-door)”, “Frequency of train services”, “Flexibility of train services”, “Information on goods shipped”, “Trains: maximum possible weight”, “Terminal access”, “Trains: maximum possible length” and “Others (Please define)”. Not all items were used for all target groups.

Additionally, the companies were asked to assess, if there is a need for improvements (serious needs, rather serious needs, rather no needs, no needs) for each item. Contrary to the previous question, this question aims to reveal the relevance of the single items. Thus, a bad status quo does not have to come along with a high need for improvements, while there might be a need to further improve an already good status quo.

Since there might be major differences between the countries, respondents were asked to select either the most relevant RFC5-country for the company or rate the entire RFC5-area. It was also possible to select Germany as reference area. Respondents could also select different reference areas for both questions. However, the Pearson correlation coefficient of 0.922 for the comparison of the selected country for both questions indicates that most companies selected the same country for both questions. The selected reference areas are shown in figure 3. Most respondents have chosen the entire RFC5 as rating area, those who selected a specific country decided for their origin country most often: 87 % of those not selecting Germany or the entire RFC 5 decided for their own country as reference for the rating of the current situation, while this share reaches 77 % for the rating of the needs for improvements.

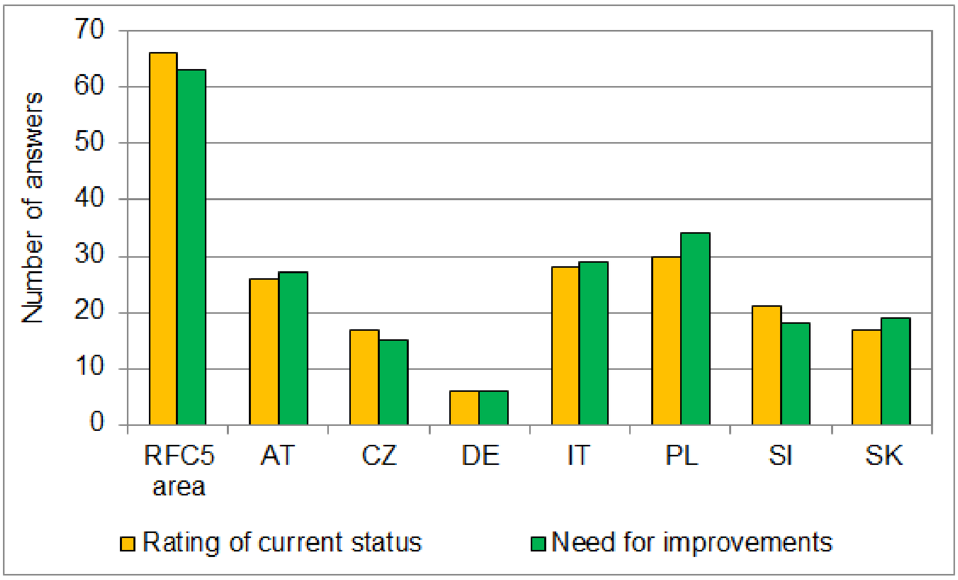


Figure 3: Reference areas for the rating of the current status and need of improvements

Source: Own results, own illustration

Two methodical remarks are worth mentioning. The following figures are percentage values of the answers “good” and “rather good” on all valid answers for the rating of the current status: If e.g. two of three valid answers rate a specific item to be “rather good” or “good”, it receives a value of 67%. The same refers to the share of “serious” and “rather serious” needs for improvements on all valid answers. Thus, a high value means either a good rating of the status quo or a high need for improvements. However, also a rating of 100% does not have to mean that the current status is perfect or a serious need for improvements exists, since this indicator includes also the second best or second worst answer opportunity.

Secondly, different target groups might have different perceptions of the current situation as well as the need for improvements; e.g., terminal operators might have the tendency to have a more optimistic view on the terminal access compared to other groups. To avoid a determination of the results by a varying number of respondents from the four target groups, a standardization of the results was conducted. For this purpose, the lowest number of completed interviews was taken as reference value meaning eleven interviews for the shippers, eight for logistic companies, six for terminal and port operators and four for railway undertakings. This reference values were applied on each item of each reference area: If, e.g., four logistic companies rated a specific feature for a given reference area, each of their answer was weighted by the factor 2.

4.1 Bad average ratings: rail transport costs, flexibility of trains, transport time

“Rail transport costs” receives by far the worst rating of all categories for the current status. This refers to all reference areas – the best rating is reached with a value of around 35% “rather good” or “good” ratings in Austria and Poland. In average, only every fifth respondent (22%) rate transport costs to be satisfying, for the entire RFC5 area this value reaches 19%. This is associated with a high need for improvements. 81 % of the valid answers assessed the needs for improvement to be “rather” serious” or “serious”. This concerns all reference areas: The minimum share of participants stating at least rather serious needs for improvements is measured in Poland with still 70%. This particular bad rating is a major problem since transport costs are the most relevant aspect when selecting the mode of a shipment [6; 7].

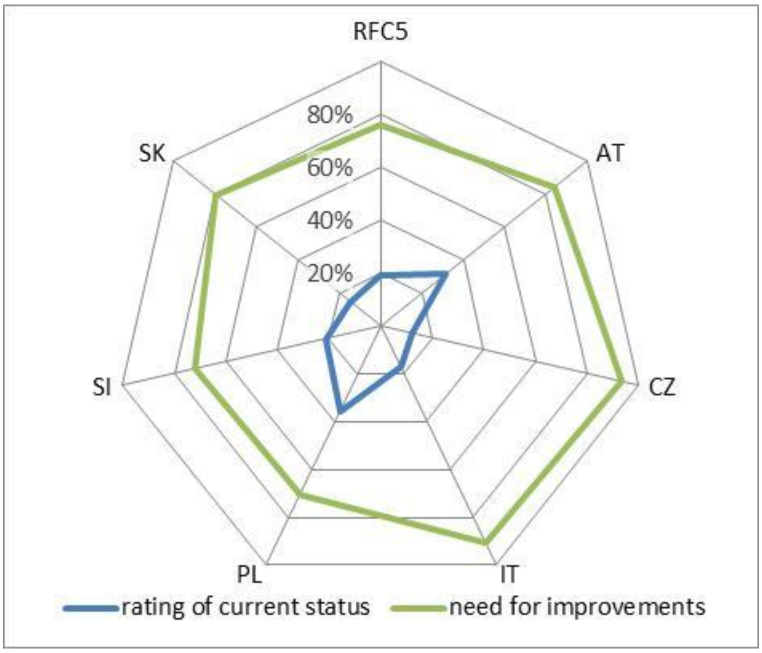


Figure 4: Assessment of the rail transport costs

Source: Own results, own illustration

Responsiveness is of major relevance in the freight logistic market, in particular with regard to just-in-time production. This responsiveness refers to the frequency of trains, but even more to the flexibility of the rail system. A sufficient flexible system can compensate disadvantages of a low frequency of trains.

The mean value of the rating of the flexibility is the second poorest with regard to both, the current status and the need for improvements. Exceptions are the Czech and the Austrian rail system. The rating of the current status reaches in all other reference areas a maximum value of around 40%, while the need for improvements accounts at least for 70%. The average rating of all reference areas is 77% - more than three out of four participants see needs to improve the flexibility of train services. For the flexibility and the transport costs, there is a clear correlation of the rating of the current situation and the need for improvements: A low rating comes along with a high need for improvements and vice versa.

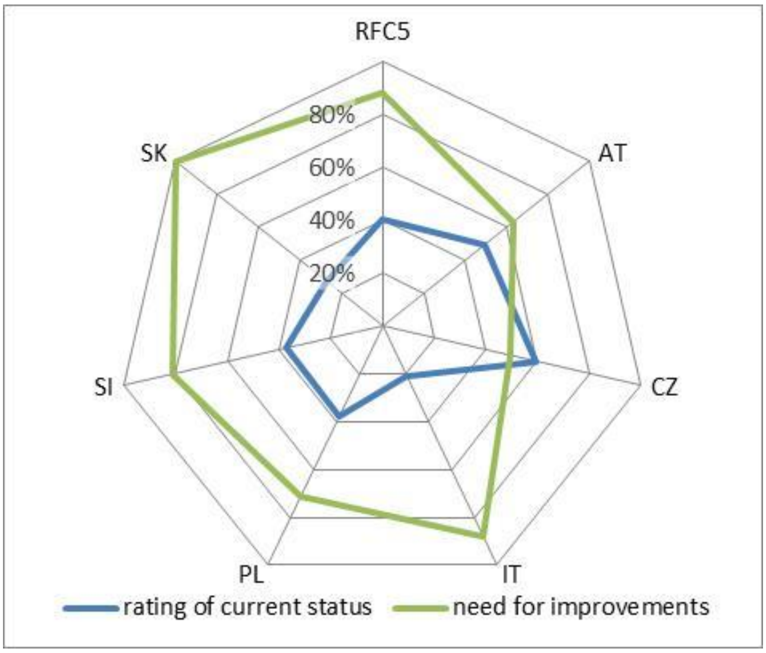


Figure 5: Assessment of the flexibility of the rail system

Source: Own results, own illustration

Among those features with the poorest rating – exactly with the third worst average rating – is the rail transport time. This is also an area – together with the frequency of trains – where the needs for improvements are particular high.

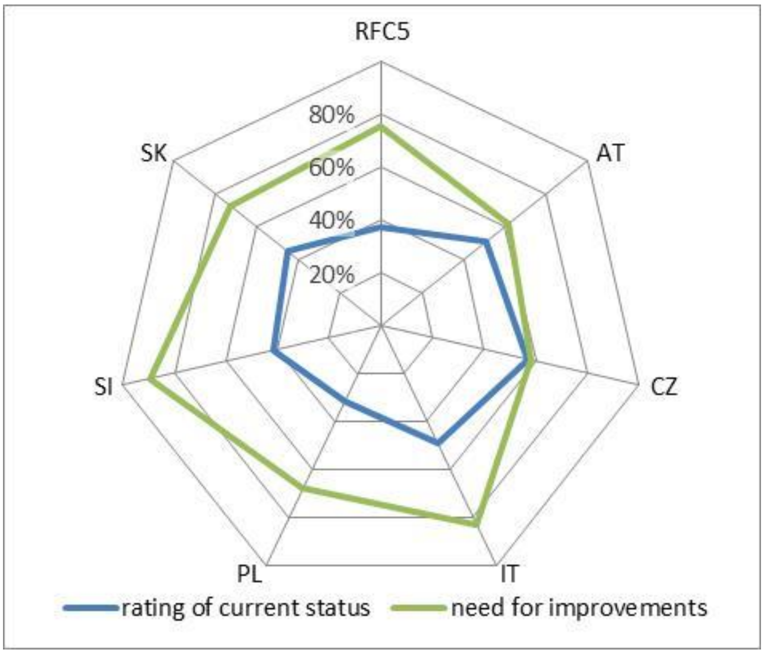


Figure 6: Assessment of the rail transport time

Source: Own results, own illustration

4.2 Good average ratings: contact to infrastrutucure operator, safety systems, damaged or lost goods

The three features with the best average rating are in ascending order “contact to the infrastructure operator”, “safety systems” and “share of damaged or lost goods”. With only few outliers the share of positive ratings of the current situation is above 70%. This correlates with a low need for improvements. Nevertheless, particular needs for improvements could be identified for the reference areas Slovenia, Italy and Poland for the contact to the infrastructure operator, in Slovenia and the entire RFC5 for safety systems and in Poland for the share of damaged or lost goods.

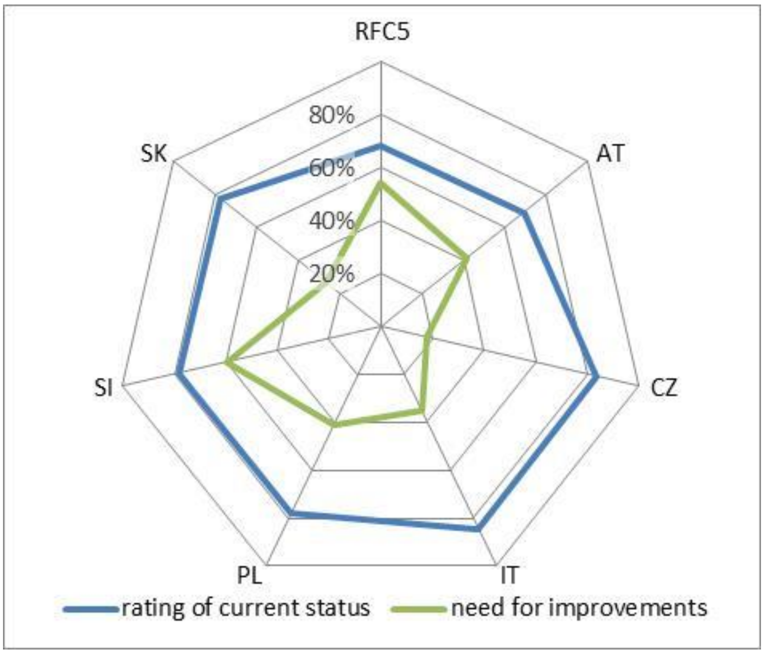


Figure 7: Assessment of the share of damaged or lost goods

Source: Own results, own illustration

4.3 Further aspects: punctuality and harmonization of rules

The results mentioned above show country-specific differences, but they remain limited. This draws the picture of a unique area with regard to advantages and disadvantages of the rail freight system. This does not refer to all items considered. The ratings for other items vary highly between the countries. This refers e.g. to the punctuality of trains. The situation in Austria and the Czech Republic receives extraordinary good marks, while the situation in Poland, Slovenia and the entire RFC5 is marked bad. Although this might depend on the devastating consequences of the cold spell in Slovenia, the situation has obviously to be improved.

Large difference can also be identified for the harmonization of rules. However, the interpretation is not that straightforward, since the assessment refers most probable to an adaptation of the standards of the reference country to the European level, but can also refer to the point of view of companies assessing the specific reference area towards the situation in other countries. If we follow the more probable first explanation, then there is a particular need to improve the current situation in Poland and Italy and also within the entire RFC5 area.

Particularly, the latter makes sense if the situation in Poland and Italy is regarded as limiting factor.

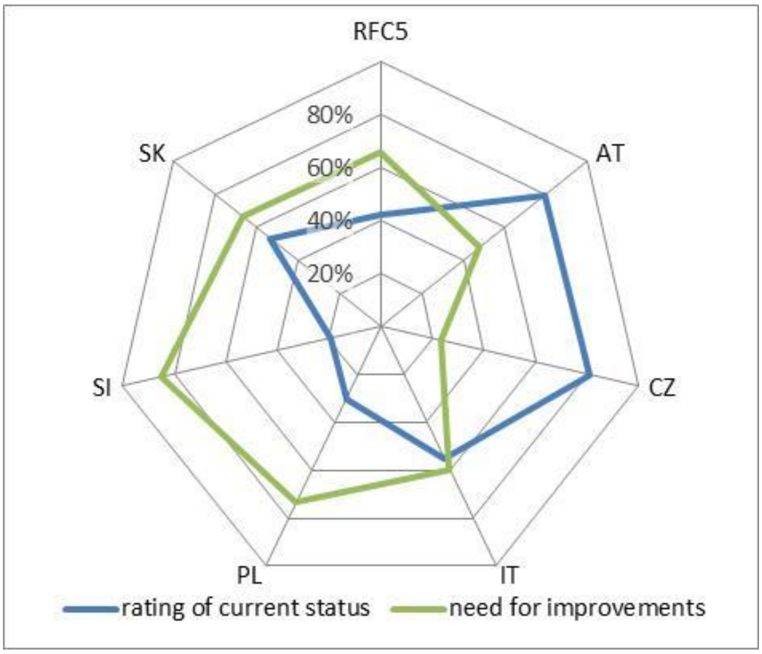


Figure 8: Assessment of the punctuality of trains

Source: Own results, own illustration

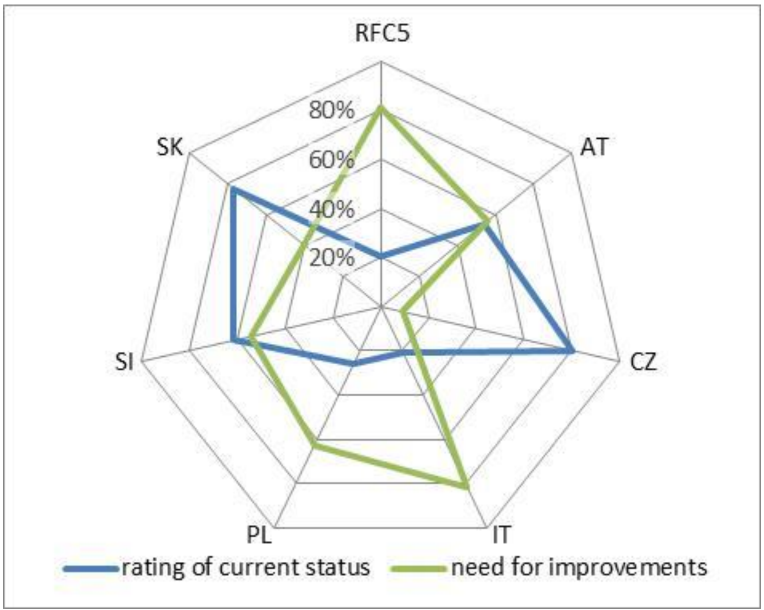


Figure 2: Assessment of the harmonization of rules

Source: Own results, own illustration

5 FURTHER SURVEY RESULTS

Respondents were asked about their expectations on the development of their transport or throughput volume until 2020. The answer should be distinguished by the transport mode and also by a comparison between transports in the RFC5 area and the entire transport volume.

Similar results were obtained for all groups of respondents for the future relevance of the RFC5 area: The expectations on the development of the transport volume for the RFC5 area lag behind the overall expectations for the entire transport volume (comparison of the first and the second as well as the third and the fourth group of columns in figure 9). Obviously, other markets are assumed to receive higher awareness such as Western Europe, Russia, but also Middle and Far Eastern Countries were mentioned.

If the development per transport mode is analysed within one area – either for the RFC5 area or the entire transport volume – there are varying results per target group. Terminal and port operators expect rail transports to get more relevant than other modes for both reference areas (comparison of the first and the third as well as the second and the fourth group of columns in figure 9). This also refers to the expectations of logistic companies, while there is no clear tendency for shippers. The number of shippers expecting a rather higher development is smaller for rail use than for other modes regardless the reference area, while the opposite picture is drawn when viewing on the category “higher development” where the expected rail use exceeds the other modes regardless the reference area.

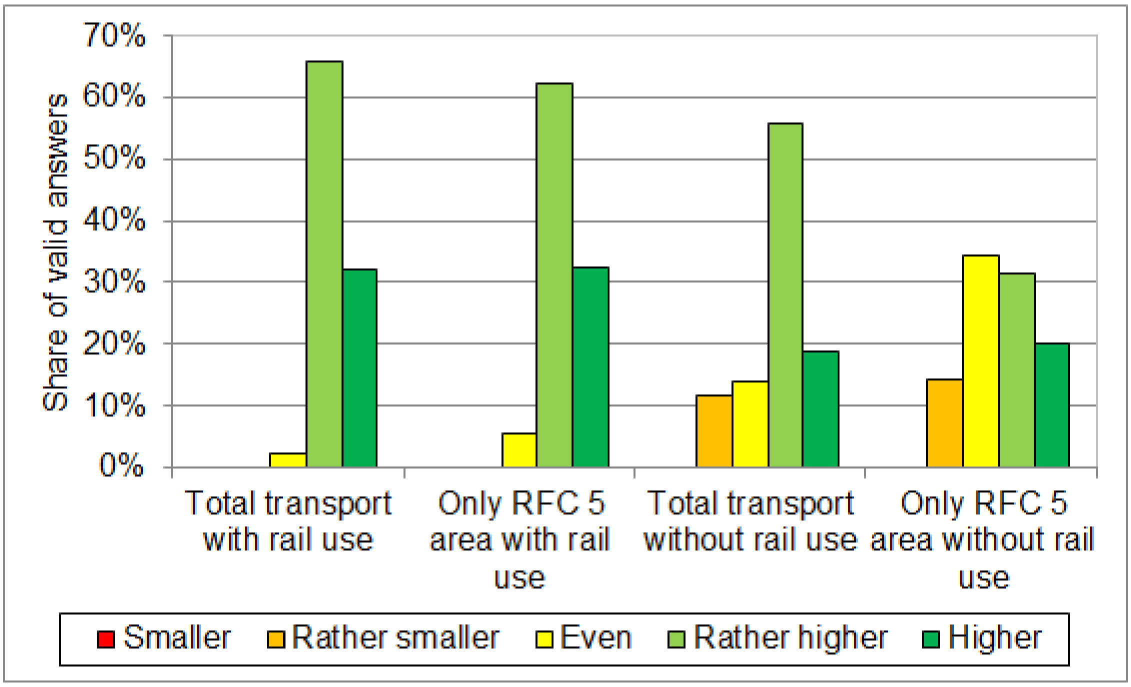


Figure 103: Expected development of the throughput volumne of terminal and port operators until 2020

Source: Own results, own illustration

6 CONCLUSION

The implementation of the Baltic-Adriatic rail freight corridor (RFC5) is assumed to improve the situation for rail transports in central-eastern Europe. In order to prepare the implementation of the RFC5, a transport market study including a survey was to be conducted. 288 companies from all affected groups (shippers, logistic companies, terminal and port operators as well as railway undertakings) participated to the survey. Their answers provide an insight into their perception of the rail freight systems, their needs for improvements and their expectations on the development of the rail freight system.

The rating of the current situation reveals major differences in the assessment of the items. The current status is considered to be particularly bad for the items flexibility, transport time and transport costs with the last receiving by far the poorest rating. Particular good average ratings were given for “share of damaged or lost goods”, “contact to infrastructure operator” and “safety systems”. Obviously, the aspects marked as most important in literature get the worst marks [8]. At least two of them – transport time and flexibility – are addressed by the RFC5 which might imply an improvement of the situation. However, additional efforts are needed in order to make rail freight transports more competitive in this area.

ACKNOWLEDGMENTS

This article is based on the transport market study for RFC5. We thank the clients of this study ÖBB Infrastruktur AG, SŽDC, RFI, PKP PLK S.A., ŽSR, SŽ-Infrastruktura, d.o.o. and AŽP as well as our project partners IKK ZT-GmbH Certified engineers, Institute for Advanced Studies (HIS) and the Centre for Transporteconomics and Logistics (ZTL).

REFERENCES

[1] Rich, J., Kveiborg, O., & Hansen, C. O. (2011). On structural inelasticity of modal substitution in freight transport. *Journal of Transport Geography, 19*(1), 134-146.

[2] Commission, E. E. (2011). WHITE PAPER roadmap to a single European transport area towards a competitive and resource efficient transport system. *COM (2011), 144*.

[3] Council, E. P. a. (1996). 1692/96/EC of the European Parliament and of the Council of 23 July 1996 on Community guidelines for the development of the trans-European transport network. *GU L, 228*(9), 11.

[4] Kriebernegg, G., Ferk, D., Piskaty, B., Gerike, R., Link, C., Koch, S., et al. (2014). *Transport market study on European Rail Freight Corridor 5. Final Report*.

[5] Willumsen, L. G., & Ortuzar, J. d. (2011). *Modelling transport*: Wiley.

[6] Meixell, M. J., & Norbis, M. (2008). A review of the transportation mode choice and carrier selection literature. *International Journal of Logistics Management, The, 19*(2), 183-211.

[7] Marcucci, E. (Ed.). (2013). Logistics Managers' Stated Preferences For Freight Service Attributes: A Comparative Research Method Analysis. Bingley: Emerald.

[8] WANG, Y. D., Chuan ; LIU, Chao; XIE, Binglei. (2013). An Analysis of Interstate Freight Mode Choice between Truck and Rail: A Case Study of Maryland, United States. *Procedia - Social and Behavioral Sciences, 96*, 1239 – 1249.

ENERGY LABELING OF ROAD NETWORK

Blaž Luin, D.Sc.
Stojan Petelin, D.Sc.
Franc Dimc, D.Sc.
Universitiy of Ljubljana
Faculty of Maritime Studies and Transport
Pot pomorščakov 4, 6320 Portorož, Slovenia
blaz.luin@fpp.uni-lj.si

ABSTRACT

Some roads connect traffic origins and destinations directly, some indirectly. Indirect connections result in longer distances driven by the vehicles and therefore in increased fuel consumption in order to reach destination. When driving on congested roads or curvy mountain roads emissions are higher than on flat roads. If traffic volumes are high, a lot of extra fuel is burned by the vehicles due to longer and more energy inefficient roads. Therefore we propose a framework to label road according to the energy labels that are used for vehicles and other devices as well. The framework should take into consideration traffic volume, vehicle type distribution, road geometry and energy needed for road operation and construction.

Key words: Traffic, energy, infrastructure construction, vehicle emissions.

1 INTRODUCTION

To analyze energy footprint of a road, geometrical and traffic data have to be obtained. We propose two parameters that can be calculated to measure energy efficiency of the road: energy ROI (return period of invested energy for road construction) and energy label. Usually ROI can be calculated because new roads provide more direct connections, less congestion and in most cases shorter routes with smaller longitudinal gradient which results in less energy consumed by the vehicles traveling from same origin to a destination.

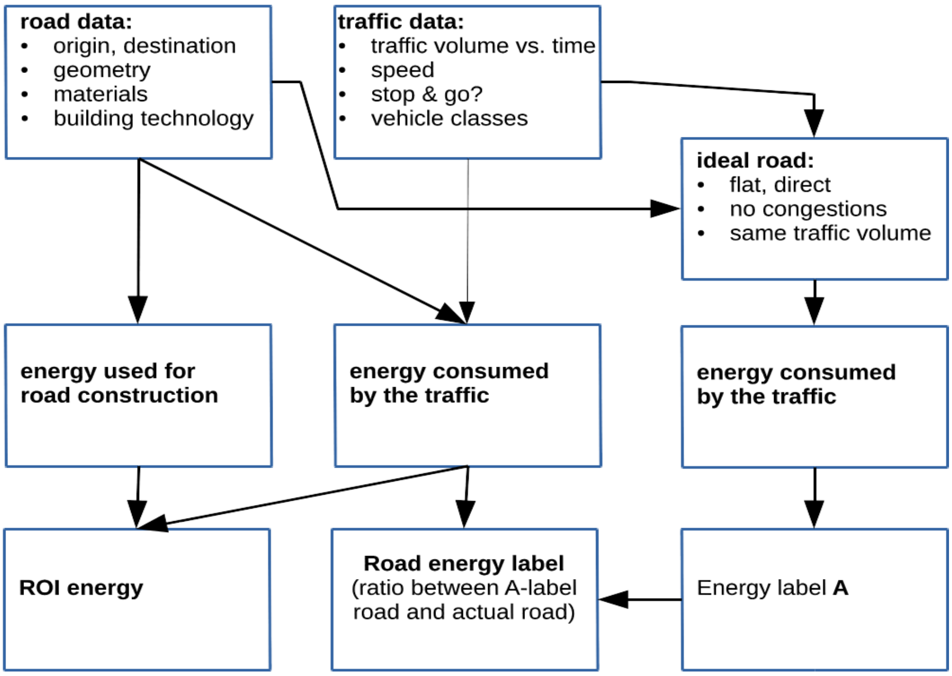


Figure 1: Energy analysis of a road section

Obtaining input data is the basis for estimating energy needed for road construction and the energy needed by the traffic passing through the road section. It was expected that largest share of energy needed for construction will be due to the ground works, tunnel and rock drilling due to high specific drilling energies of the rock (Bilgin, Copur, & Balci, 2013; Celada, Galera, Muñoz, & Tardáguila, 2009), but it was shown that, especially in case of tunnels, largest energy share was due the manufacture of Portland concrete.

For our purpose only rough calculations for using the drilling specific energy and excavation volumes were carried out. There are high uncertainties in input parameters, but using conservative approach by assuming worst case parameters, order of magnitude of energy consumption, CO2 emissions can be obtained.

On roads with large traffic volumes, largest input is traffic data that is used for estimation of energy used by the vehicle that travel through the tunnel. In our analysis we defined impact of the tunnel as a difference between fuel used as if there was no tunnel and fuel used on the tunnel route.

2 ENERGY FOR ROAD TUNNEL CONSTRUCTION

Energy needed for construction a road tunnel depends greatly on energy needed for excavation. Excavation energy depends on method of excavation and on ground hardness. Nowadays most common excavation approaches are (Bilgin et al., 2013; Celada et al., 2009; Heiniö, 1999):

- drill and blast
- roadheader (machine with rotating cutting head)
- TBM (Tunnel Boring Machine)

Apart from the excavation, energy is also needed for transportation of excavated material and for construction of tunnel support. Tunnel equipment installation is less energy intensive than other construction phases.

Drill and blast approach requires energy for drilling and the energy that is released by the explosive for fracturing the rock.

Roadheader is a machine with a rotating head. According to (Heiniö, 1999), largest rotating heads are driven with approximately 300 kW and total installed powers are around 500 kW. Energy that is needed for excavation is a product of installed power (as rotating head has to be moved during the excavation), excavation rate and excavation volume.

Net energy needed for the TBM based tunnel tunnel excavation depends greatly on rock structure, and can be between orders of magnitude of 0,001 GJ/m3 for coal to 2 GJ/m3 for schists. Net energy is energy supplied to the TBM, multiplied by the energy transfer ratio which is usually at the order of magnitude of 0,7 – 0,8. (Bilgin et al., 2013)

Therefore in order to asses amount of energy needed for tunnel construction of a certain tunnel, geological data must be obtained or one can rely on construction statistics. Since there are hardly any precise data on resources used for tunnel construction available, it is better to rely on estimates of:

- excavation volume
- specific energy for drilling
- energy for concrete installation
- energy for steel reinforcement manufacture and installation

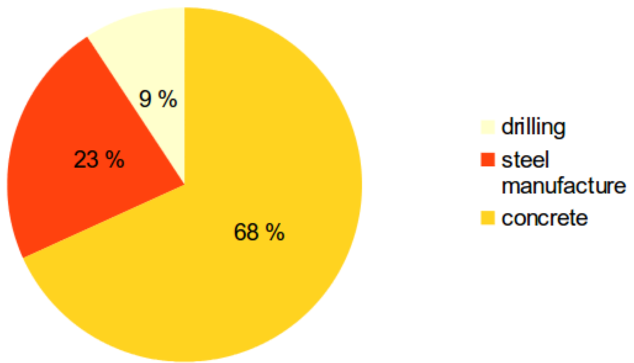


Figure 2: Construction energy distribution for tunnels in limestone rock

3 ENERGY CONSUMED BY THE TRAFFIC

3.1 Ideal Road Estimate

To assign road an energy label, we propose assumption of an ideal road between an origin and a destination. An ideal road should be a road with:

- Minimum longitudinal gradient
- No curves
- Smooth traffic flow

Minimum longitudinal gradient and no curves can be assured with straight road connection between an origin and a destination. In most cases this can be realistic estimate, but in rare cases, if longitudinal gradient is too high, curves will be needed.

Energy estimate needed by the traffic flowing through a real road is then compared with an energy needed by the traffic on an idealized road.

3.2 Traffic parameters considered

Estimates of traffic volume and vehicle types will be needed before conducting the analysis. We propose sorting the vehicle into the following classes: light vehicles, light commercial vehicles, heavy goods vehicles and buses.

Based on traffic volumes, a fuel consumed can be estimated using models of vehicle fuel consumption for each vehicle type. Among different models we found specific vehicle power model (Jiménez-Palacios, 1999) to be the most suitable. Vehicle specific power can be calculated as

$$VSP = \frac{\dot{E_k} + \dot{E_p} + F_{res}v + F_{aero}v + F_{inter}v}{m}, \quad (1)$$

where derivates of E_k and E_p represents power due to changes in kinetic and potential energy, F_{res} is resistive force, F_{aero} is aerodynamic resistance force and F_{inter} is internal resistance, v is vehicle speed and m mass.

However there is also Zhai's formula that has simpler formulation of kinetic and potential energy changes due to acceleration and road inclination (Zhai, Frey, & Rouphail, 2008)

$$VSP = v(a + gsin(\phi) + \psi) + \zeta v^3, \quad (2)$$

where □□is road gradient□□□□is air resistance and□□ is rolling resistance coefficient□

Vehicle specific power can be used to calculate emissions of vehicle on certain road sections. The method takes into consideration all necessary parameters except increase of rolling resistance due to curves is not considered. This is a parameter that could easily be measured based on road geometry.

In our simplified model we so far used only data on average personal vehicle and HGV fleets with distinction only between city and highway traffic. Enormous amounts of energy used by the traffic imply development of more detailed model that would be based on exact road geometry, vehicle data and weather conditions that would estimate used fuel on basis of microsimulation by evaluating fuel consumption as a function of vehicle mass, acceleration, road gradient, wind velocity and vehicle efficiency

$$\acute{m}_f = f(VSP(t), m_v) \quad (3)$$

We plan to implement such a model into road tunnel simulator. For preliminary calculations we used only average statistic data for daily fuel consumption that is a product between length of road section d and a sum

$$E_v = d \sum_i Q_{daily,i} e_i, \quad (4)$$

where $Q_{daily,i}$ is a daily traffic volume of i-th vehicle type and ei is fuel consumption per unit length of the road.

Total fuel consumption is directly related to the overall CO_2 emissions.

4 CASE STUDIES

We compared two very different tunnels in terms of construction and location. First tunnel is a Karavanke tunnel that is linking Slovenia and Austria through the Alps. It is a single tube tunnel with bidirectional traffic. Traffic volume is quite low at the moment. There are no convenient alternative routes available. Taking an alternative route results in a lot longer journeys and passing of serpentines on mountain passes that are unsuitable for cargo traffic.

Second tunnel is a motorway tunnel in the city of Ljubljana that is linking motorwey A2 to the Ljubljana ring bypass and connecting two parts of the city as well. A map of the route can be seen in the Figure 3. Daily traffic volume for 2012 was over 43000 vehicles which is a lot higher than 8155 in the Karavanke tunnel.

In the Table 1 traffic data and energy consumed by the traffic can be seen. It should be noted that the alternative route is not only longer in case of Šentvid, but also passes city streets with semaphores that cause congestions and fuel loss.

In case of Karavanke tunnel alternative route is a lot longer due to high mountains in the area. Data on fuel consumption and energy savings due to the tunnel can be seen in the Table 1. In the table 2 estimates of energy needed for the construction of the tunnel can be seen.

Table 7: Energy consumed by the traffic

Tunnel	**Šentvid**	**Karavanke**
Total average daily traffic	43.779	8.155
Personal vehicles/day	37.459	6.326
HGV/day	5.975	1.785
Route length (tunnel/ alternative) [km]	4,6 / 6,5	26 / 65
Fuel consumed (tunnel route)[l]	20307	23812
Fuel consumed (alternative route) [l]	35317	59530
Saved energy [MJ/day] $E_{v,tun} - E_{v,alt}$.	540.350	1.285.853

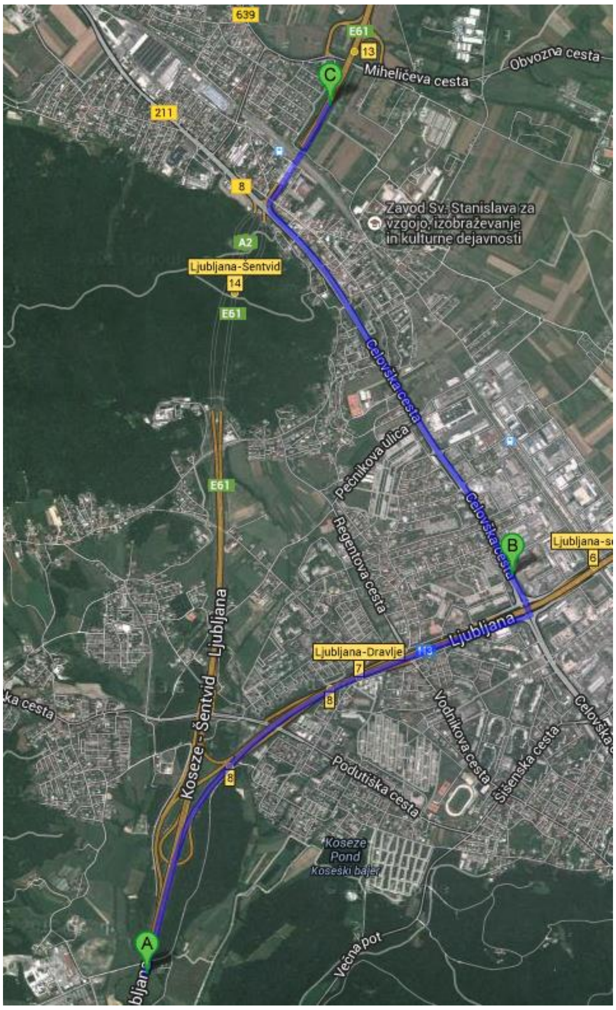


Figure 3: Šentvid tunnel alternative route

Daily savings of the energy can be calculated from the equation 5. For Šentvid tunnels, daily savings are 524.753 MJ or 1100 kg CO_2 and for Karavanke 1.268.400 MJ or 2616 kg CO_2 emissions.

Another interesting parameter is time of return of investment that is how much time it takes for the saved energy to compensate the energy that was used for the construction of the tunnel. For Šentvid tunnel it is 1529 days or 4.2 years and for Karavanke tunnel it is 853 days or 2.3 years.

Table 2: Energy needed for tunnel construction

Tunnel	**Šentvid**	**Karavanke**
Length of all tubes	1464 m main, 343 m , 1494 m main, 244 m (total 3545 m)	8019 m
Tunnel type	bidirectional, underground junctions	unidiractional
Excavation volume approx.	316.399 m^3	801.900 m^3
Net excavation energy	9.492 GJ	24.057 GJ

Tunnel	Šentvid	Karavanke
Gross excavation energy	39.549 GJ	100.237 GJ
Diesel fuel needed to power machinery	1.098.608 l	2.784.375 l
Energy for concrete production	654.946 GJ	738.089 GJ
Energy for steel manufacture	107861 GJ	243.989 GJ
Total	802.358 GJ	1.082.316 GJ

5 CONCLUSIONS

As the analysis shown, biggest impact on the overall energy consumption is due to the traffic. Energy consumed by the vehicles was historically not considered a problem by road operators, but as the analysis showed, large amounts of energy that can be saved with upgraded traffic infrastructure or even with better traffic control. As fuel consumption is lower on level roads and tunnels usually have smaller gradients than open roads in mountain areas, energy consumption could be lowered by replacing open routes with tunnels.

We plan to further implement a vehicle energy consumption model that will consider drag coefficient, vehicle mass, acceleration, road gradient and driving speed for different types of vehicles such as petrol powered, hybrid, personal and HGV. We expect to achieve this through vehicle specific power parameter.

Energy saving in the field of transport is implemented by promoting sales of more energy efficient vehicles by labeling them according to the CO_2 emissions level that depend of fuel consumption.

On the other hand impact of the roads was not addressed. We consider that there is need for implementation of road energy labels that would be defined on the basis of road geometry. Curvy roads with higher gradients would get worse labels than level roads. Same goes for roads with congested or free flowing traffic.

REFERENCES

[1] Bilgin, N., Copur, H., & Balci, C. (2013). *Mechanical Excavation in Mining and Civil Industries*. CRC Press.

[2] Celada, B., Galera, J. M., Muñoz, C., & Tardáguila, I. (2009). The use of the Specific Drilling Energy for Rock Mass Characterisation and TBM Driving During Tunnel Construction. In *ITA-AITES World Tunnel Congress* (pp. 1–13). Retrieved from http://www.geocontrolbrasil.com/publicaciones/use_of_specific_drilling_celada.pdf

[3] Heiniö, M. (1999). Rock Excavation Handbook for Civil Engineering. Sandvik, Tamrock.

[4] Jiménez-Palacios, J. L. (1999). *Understanding and quantifying motor vehicle emissions with vehicle specific power and TILDAS remote sensing* (Thesis). Massachusetts Institute of Technology. Retrieved from http://dspace.mit.edu/handle/1721.1/44505

[5] Zhai, H., Frey, H. C., & Rouphail, N. M. (2008). A Vehicle-Specific Power Approach to Speed- and Facility-Specific Emissions Estimates for Diesel Transit Buses. *Environmental Science & Technology*, *42*(21), 7985–7991. http://doi.org/10.1021/es800208d

[6] André, M., Keller, M., Sjödin, Gadrat, M., & Crae, I. M. (2008). The ARTEMIS European tools for estimating the pollutant emissions from road transport and their application in

Sweden and France. na. Retrieved from http://inrets.fr/ur/lte/publi-autresactions/fichesresultats/ficheartemis/report2/ARTEMIS_paper_M_ANDRE_et_Al.pdf

[7] Antonacci, G., Todeschini, I., & Cemin, A. (2008). Influence of Road Gradient on Emissions Factors. In Proc. of 21st TFEIP Meeting, Milan. Retrieved from http://www.tfeip-secretariat.org/assets/Transport/Expert-Meetings/TFEIP-Meeting-of-Transport-Expert-Panel-2008-10-11-November-2008-Milan-Italy/20081111Antonacci.pdf

[8] Carrese, S., Gemma, A., & La Spada, S. (2013). Impacts of Driving Behaviours, Slope and Vehicle Load Factor on Bus Fuel Consumption and Emissions: A Real Case Study in the City of Rome. Procedia - Social and Behavioral Sciences, 87, 211–221. http://doi.org/10.1016/j.sbspro.2013.10.605

[9] Franzese, O., & Davidson, D. (2011). Effect of weight and roadway grade on the fuel economy of class-8 freight trucks. Oak Ridge National Laboratory, Tennessee, USA. Retrieved from http://info.ornl.gov/sites/publications/files/Pub33386.pdf

[10] Predstavitev Markovec 02-slo_sep _10.pdf. (n.d.). Retrieved from http://www.dars.si/Dokumenti/2_AC_HC_v_gradnji_in_obstojece/H6%20Koper-Lucija/Predor%20Markovec/Predstavitev%20Markovec%2002-slo_sep%20_10.pdf

[11] Sandberg, T. (2001). Heavy truck modeling for fuel consumption simulations and measurements. Division of Vehicular Systems, Department of Electrical Engineering, Linköping University, Linköping.

[12] Struble, L., & Godfrey, J. (2004). How sustainable is concrete. In International Workshop on Sustainable Development and Concrete Technology (pp. 201–211). Retrieved from http://core.kmi.open.ac.uk/download/pdf/11346106.pdf#page=212

REALIZATION OF A BUDGETARY EXPENDITURES IN THE AREA OF TRANSPORT AND COMMUNICATION BY LOCAL SELF-GOVERNMENT UNITS IN POLAND

Justyna Łukomska-Szarek, PhD
Agnieszka Wójcik-Mazur, PhD
Czestochowa University of Technology
Faculty of Management
Al. Armii Krajowej 19B, Częstochowa, Poland
jlszarek@zim.pcz.pl, soklica@wp.pl

ABSTRACT

The main aim of this publication is an assessment of financial abilities to development of local self-government units in Poland in the area of transport and communication. In this approach, against the background of theoretical questions, empirical studies has been taken, involving analysis and assessment of budgetary revenues and expenditures of local self-government units, generated in chapter 600 of budgetary classification: "Transport and communication". Scientific considerations of this publication, focused especially on measurement and assessment of financial indicators for public services involving transport and communication, and realized by local government at local and regional level, additionally investment activity of these units has been investigated and financial indicators of development ability has been calculated. Analysis has been performed in dynamic terms, on the basis of historical data from Local Data Bank, investigations include 2008-2013 period.

Key words: Transport and communication, local self-government, budgetary revenues and expenditures.

1 INTRODUCTION

Public authority in Poland is also exercised by local governments which represent a form of decentralized public administration[1]. Local governments perform particular tasks based on legal acts, using their specific authority and on their own responsibility. These tasks are performed by local governments to the benefit of a particular community, which is regulated by the acts concerning individual levels of local governments, such as Act on Local Government in Gimnas, Act on Local Government in Powiats and Act on Local Government in Voivodeships[2]. This is caused by the three-level structure of local government in Poland, with 2749 gminas, which are principal unit of territorial division in Poland, 66 cities with powiat status and 16 voivodeships.

Entities of territorial division and their bodies perform a series of functions. They participate in making political decisions, with particular focus on administration policy, financial policy and budget economy. The principles of participation in these decision processes result from the Constitution and high number of local and regional public tasks to be performed. The

[1] Nowacka, E.J. (2005). *Polski Samorząd terytorialny*. Warszawa: Wydawnictwo Prawnicze LexisNexis, p.10
[2] Dylewski, M. (2007). Planowanie budżetowe w podsektorze samorządowym. Uwarunkowania, procedury, modele. Warszawa: Difin, p. 46

concept of a public task should be brought closer to the reader since all the tasks performed by the entities of local government have character of public tasks as they are oriented at meeting collective needs of the community - either local or, in the case of internal tasks or the whole society organized into the state with regard to contracted tasks.[3] Public tasks can be also considered as obligations which are legally imposed by public government. They are compared to traditional domains that relate to public authority.[4]

Specific characteristics of local government ensure appropriate competencies for performance of the tasks. According to the Constitution of the Republic of Poland, local government is responsible for performance of public tasks, not restricted for other forms of public authority. The tasks performed by the entities of local government can be considered using many criteria. The basic criteria are association and universality. According to the criterion of association, there are internal tasks, contracted tasks and entrusted tasks, whereas criterion of universality distinguishes between facultative and obligatory tasks.[5] Division into internal and contracted tasks results from local government acts, whereas the scope of tasks depends on the type of local government entity. Internal tasks concern activities aimed at meeting the needs of local government communities whereas the contracted tasks result from the needs of the state.[6] The types of tasks indicated in a budget of the entities of local government are organized according to the division of budget classification, with the main sectors that determine the type of activity being: agriculture and hunting, forestry, fishing, mining and quarrying, industrial processing, manufacturing and supply of electricity, gas and water, commerce, transport and communication, tourism, real estate economy, services, public administration, public security and fire prevention, various settlements, higher education, health care, education, social assistance, municipal economy and environmental protection, culture and protection of national heritage, physical culture and sport and other sectors. Among these sectors, number 600 is „Transportation and communication“. Entities of local governments are obliged, within the scope of the sector for performance of tasks connected mainly with infrastructure of inland transport[7], to build, rebuild, renovate, maintain and protect roads and manage them at the level of gmina, poviat or voivodeship[8].

Due to the topic of this study, it is justified to bring closer the information about budgetary revenues and incomes in the entities of local government connected with transportation and communication. The investigations presented in this paper attempt to answer to the following questions:

---

[3] Tarno, J., Sieniuć, M., Sulimierski, J., & Wyporska, J. (2004). *Samorząd terytorialny w Polsce.* Warszawa: LexisNexis, p. 39.
[4] Famulska, T. (2009) Gospodarka finansowa jednostek samorządu terytorialnego w warunkach integracji europejskiej. Katowice: Difin, p. 16.
[5] Dylewski, M., Filipiak, B., & Gorzałczyńska-Koczkodaj M. (2006). *Finanse samorządowe, Narzędzia, Decyzje, Procesy.* Warszawa: PWN, pp.23-25.
[6] Wankiewicz, B. (2009). Zasoby finansowe a rozwój samorządności lokalne. Warszawa: CeDeWu, p20.
[7] More about development of transport infrastructure: Nowicka-Skoworn M., & Mesjasz-Lech A. (2013). Globalization and the Development of Logistics Infrastructure of the Freight Transport by Road. *Regional Integration: Europe, the Mediterranean and the World Economy*. (19 p.). Palermo, Italy: 53rd ERSA Congress.
[8] More about the management of transport services: Skowron-Grabowska, B. (2014). Business Models in Transport Services. *Przegląd Organizacji.* 1(888), 35-39; Skowron-Grabowska, B. (2014). Problems of Managing Transportation Systems in Urban Areas. *Logistyka.* 5, 25-27; Brzozowska, A. (2013). Zarządzanie w globalnych sieciach transportowych. *Gospodarka Materiałowa i Logistyka.* 10 (1226), 10-17.

- What was the share of revenues and expenditures connected with transportation and communication in individual types of local government entities in the percentage structure of this type of revenues and expenditures in total in such entities?
- What was the dynamic of changes in budgetary revenues and expenditures connected with transportation and communication over the years 2008-2013?
- What was the scope of investments in the area of transportation and communication in local government entities?
- Was stagnation or a revival observed in Poland in 2008-2013 in investment activity of local government entities in the area of transportation and communication?

In order to deal with the above questions, the paper attempts to analyse and evaluate budgetary revenues and expenditures in local government entities based on the data obtained from the Central Statistical Office of Poland collected in Local Data Bank and Regional Accounting Chambers and the Ministry of Finance in Poland. The historical data collected in the study allowed for ex-post analysis, particularly in terms of calculation of the indices of percentage structure and dynamics of changes in the values studied in 2008-2013.

2 EVALUATION OF BUDGETARY REVENUES AND EXPENDITURES IN LOCAL GOVERNMENT ENTITIES IN THE DIVISION OF BUDGETARY CLASSIFICATION OF "TRANSPORTATION AND COMMUNICATION" IN 2008-2013

In 2008-2013, budgetary revenues in local government entities in total generated in the area of "Transportation and Communication" were characterized by a progress, from 5.75 billion in 2008 to 11.54 billion zlotys in 2013, which is illustrated by the data presented in Fig. 1. The greatest revenues in these terms were recorded in the period studied in gminas (increasing from 3 to over 8 billion zlotys). Powiats showed an upward tendency for budgetary revenues until 2010 (with the increase from 0.73 to 2.49 billion zlotys), whereas this value declines to the level of 1.17 billion zlotys in 2013. Furthermore, revenues in voivodeships ranged in 2008-2011 from 1.03 to 1.38 billion zlotys, whereas a dynamic increase was observed in 2012-2013 (to 67 billion zlotys in 2012 and 2.26 billion zlotys in 2013).

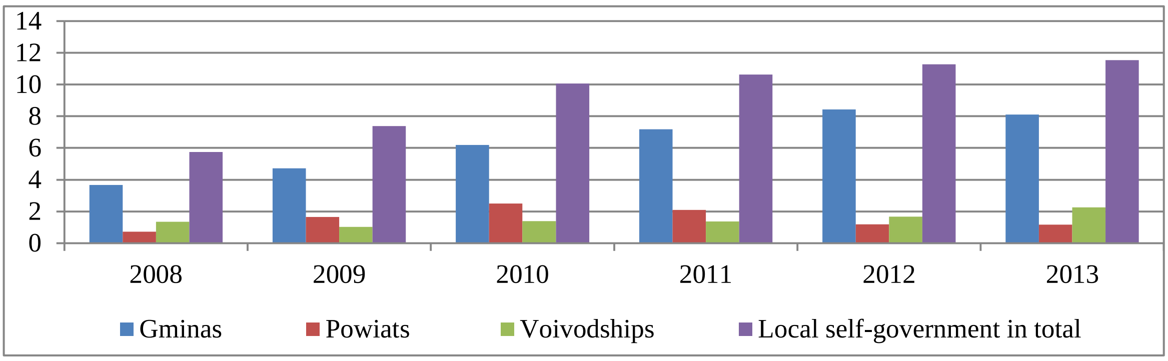


Figure1: Budgetary revenues in local government entities in the area of "Transportation and Communication" in 2008-2013 (in billion zlotys)

Source: own calculations based on Central Statistical Office of Poland, Local Data Bank.

In conclusion, it can be indicated that the greatest revenues on tasks in the area of transportation and communication were generated in the period studied by gminas, which is demonstrated by the data illustrated in Diagram 2. The more in-depth analysis leads to the conclusion that the highest (rising from 63.8 to 74.75%) share of revenues in individual types of local government entities was observed in gminas. Share of revenues in powiats in revenues in total in local government entities generated for tasks in the area of transportation and communication was increasing until 2010 (reaching 24.7%), whereas in the next years this value was gradually decreasing, reaching 10.17% in 2013. Furthermore, voivodeships recorded the highest share in this type of revenues in 2008 (23.48%). In 2009-2012, this measure ranged from 12.78% to 14.8% and reached 19.58% in 2013.

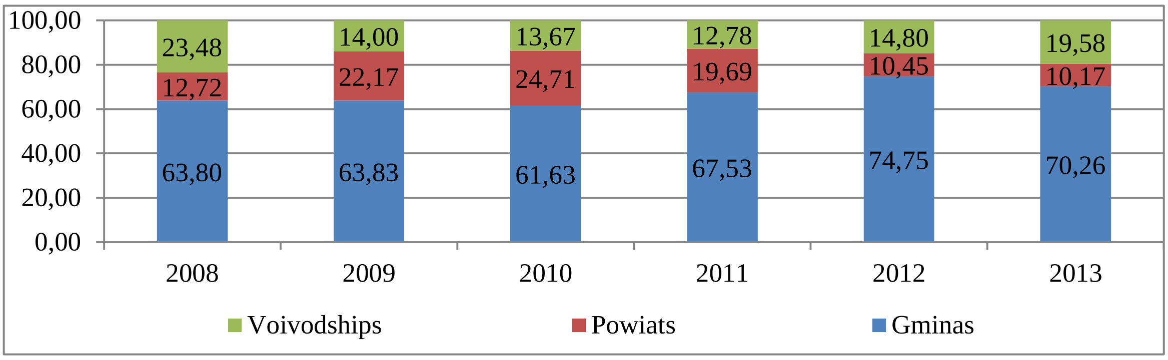


Figure 2: Structure of budgetary revenues in individual types of local government entities in the area of "Transportation and Communication" in 2008-2013 (in %)

Source: own calculations based on Central Statistical Office of Poland, Local Data Bank.

Table 1 presents dynamics of changes in terms of budgetary revenues in local government entities generated in the area of "Transportation and Communication". Analysis of fixed-base indices, with the reference base being the year 2008, reveals that budgetary revenues in local government entities in total nearly doubled in 2009-2013. Similar tendency was observed in gminas. Powiats and voivodeships in 2013 showed the increase in this type of revenues at the level of over 60%. With regard for chain indices, it can be concluded that, compared to the previous year, dynamics of changes in budgetary revenues in local government entities in total was characterized by slight increases, with this measure ranging from 2 to 6%. From 2010, gminas recorded a slowdown in growth dynamics, from 31.65% to 17.33%, whereas in 2013, a decline in the revenues was observed compared to the previous year (by 3.77%). In 2011, powiats showed a decline in revenues on transportation and communication by 15.78%, with even more substantial decline in 2012 (43.76%), whereas in 2013, this downward tendency was reduced (only 0.38%). Furthermore, voivodeships, except for 2009 and 2011, where a decline in the value studied was observed (by 23.47% and 1.23%, respectively), showed in the following years a dynamics of increase at the level of between 22 and 33%.

Table 1: Dynamics of changes in budgetary revenues in local government entities in the area of "Transportation and Communication" in 2008-2013 (in %)

		2009	2010	2011	2012	2013
Gminas	A	128,46	131,65	115,78	117,33	96,23
	B	128,46	169,12	195,81	229,74	221,07
Powiats	A	223,72	151,96	84,22	56,24	99,62
	B	223,72	339,95	286,29	161,01	160,39
Voivodshi	A	76,53	133,16	98,77	122,82	135,41
	B	76,53	101,90	100,65	123,62	167,39
Local self-governments in total	A	128,39	136,36	105,66	106,00	102,38
	B	128,39	175,07	184,98	196,08	200,75

A – *previous year* = 100%; B – 2008=100%

Source: own calculations based on Central Statistical Office of Poland, Local Data Bank.

Budgetary revenues generated in individual local government entities were used partially for expenditures on transportation and communication. As demonstrated by detailed data illustrated in Diagram 3, the expenditures in this areas incurred by local government entities in total were increasing gradually until 2011 from 23.26 billion zlotys to 32.61 billion zlotys. In 2012, this value was 29.43 billion zlotys, whereas in 2013, it reached 30.17 billion zlotys. Similar (to local government entities in total) tendencies in spending public resources on tasks connected with transportation and communication were observed for gminas: until 2011, expenditures rose from 15.76 billion zlotys to 21.64 billion zlotys, whereas in 2012-2013, they were characterized by a regression from 20.62% to 20.38%. Expenditures of voivodeships were at the level of 5.23 to 6.87 billion zlotys, whereas the lowest expenditures were incurred by powiats (2.27 to 5.16 billion zlotys.

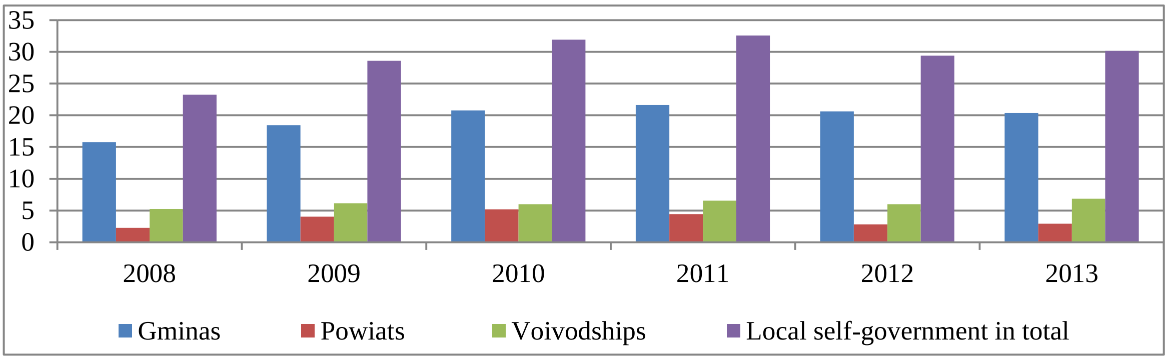


Figure 3: Budgetary expenditures in local government entities in the area of "Transportation and Communication" in 2008-2013 (in billion zlotys)

Source: own calculations based on Central Statistical Office of Poland, Local Data Bank.

Similarly to revenues, expenditures in gminas represented the highest share in the expenditures on transportation and communication in local government entities since they ranged from 64.5 to 70%, which is demonstrated by the data illustrated in Diagram 4. Share of expenditures of voivodeships in the percentage structure accounted for from 18.9% to 22.76% in 2008-2013 (with 9.6% to 16.17% in powiats).

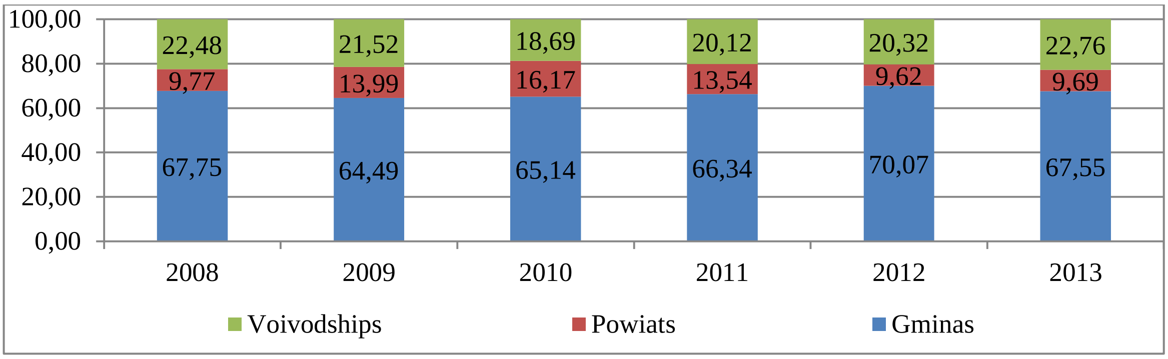


Figure 4: Structure of budgetary expenditures in individual types of local government entities in the area of "Transportation and Communication" in 2008-2013 (in %)

Source: own calculations based on Central Statistical Office of Poland, Local Data Bank.

Budgetary expenditures in local government entities on transportation and communication were characterized by poorer growth, contrary to the revenues generated. In the case of fixed-base indices, progression of expenditures was observed until 2011, from 23 to 40% and a slowdown to 26.5% was observed, with a slight increase observed in 2013 (to the level of 29.67%). Similar growth rate was recorded in gminas, expenditures for transportation and communication increased from 17% in 2009 to 37.28% in 2011 and in 212-2013, this index was at the level of ca. 30%. Escalation in the case of voivodeships was recorded in 2013 (31.3%). Furthermore, expenditures in powiats in 2009-2011 nearly doubled, whereas in 2012-2013, dynamics of the increase in expenditures for transportation and communication was at the level of 24-28%.

Table 2: Dynamics of changes in budgetary expenditures in local government entities in the area of "Transportation and Communication" in 2008-2013 (in %)

		2009	**2010**	**2011**	**2012**	**2013**
Gminas	A	117,05	112,76	104,01	95,30	98,82
	B	117,05	131,98	137,28	130,83	129,29
Powiats	A	175,97	129,00	85,53	64,10	103,34
	B	175,97	227,01	194,16	124,46	128,61
Voivodshi	A	117,71	96,96	109,98	91,09	114,84
	B	117,71	114,13	125,52	114,33	131,30
Local self-governments in total	A	122,96	111,63	102,14	90,23	102,51
	B	122,96	137,26	140,20	126,50	129,67

A – *previous year* = 100%; B – 2008=100%

Source: own calculations based on Central Statistical Office of Poland, Local Data Bank.

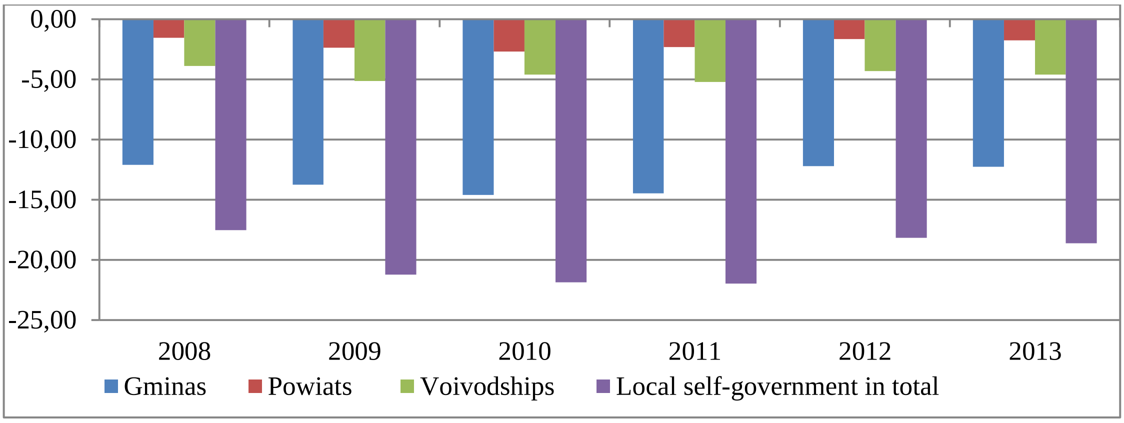


Figure 5: Budgetary deficit in individual types of local government entities in terms of tasks connected with transportation and communication in 2008-2013 (in billion zlotys)

Source: own calculations based on Central Statistical Office of Poland, Local Data Bank.

In conclusion, the investigations point that local government entities in Poland generated in 2008-2013 much less budgetary revenues, whereas they incurred much higher expenditures on transportation and communication. This led to budgetary deficit and the need for finding additional sources of finance, increasing debt in the entities studied. The highest deficit (over 21 billion zlotys) was generated by local government entities in total in 2009-2011, and the deficit decreased to over 18 billion zlotys due to a slowdown in dynamics of expenditures in total on transportation and communication. Deficit in the period studied accounted for 64-69% in gminas, 8-12% in powiats and 21-24% in local government entities in total.

3 EVALUATION OF INVESTMENT ACTIVITY IN TERMS OF TASKS CONNECTED WITH TRANSPORTATION AND COMMUNICATION IN 2008-2013

High demand on investments in terms of road infrastructure determined budgetary expenditures in the area of Transportation and Communication in 2008-2013 incurred by local government entities, which is illustrated by the data presented in Fig. 6. Revival of investment activity was observed in 2008-2011, with investment expenditures rising from 11.71 billion zlotys to 18.87 billion zlotys. This was caused mainly by the opportunities of using EU Funds available in the period of programming 2007-2013 and the increase in internal budgetary resources.

The thesis of opportunities of financing investments from foreign sources is supported by the data presented by the Regional Accounting Chambers in annual report on budget in local government entities. For example, in 2013, local government entities spent in total on programs and projects that used foreign resources 8.47 billion zlotys, which accounted for 40.6% of all the budgetary expenditures, with the expenditures financed with foreign resources at the level of 5.68 billion zlotys (67%). It can also be indicated that the greatest expenditures on programs and projects that used foreign funds in the area of "Transportation and Communication" were incurred in the Masovian Voivodeship (16.1%), Silesian Voivodeship (13.4%), Lower Silesian Voivodeship (8.7%) and Pomeranian Voivodeship (7.2%). Regional Accounting Chamber also reported that, compared to the year 2012, expenditures on programs and projects that used foreign funds reduced in 2013 by 2.6%[9]. The slowdown in investment activities in 2012-2013 was caused, among other things, by economic tendencies in the country, which resulted in poorer dynamics of the increase in budgetary revenues and completion of the programs and projects financed from EU funds within the perspective of 2007-2013. No additional sources of finance had an effect on a reduction in investment expenditures in terms of transportation and communication for all types of local government entities in Poland.

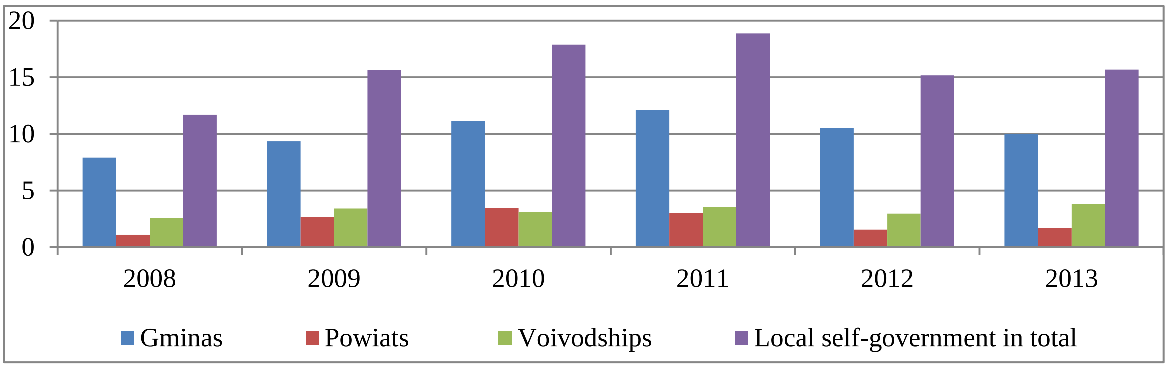


Figure 6: Investment expenditures in local government entities in the area of "Transportation and Communication" in 2008-2013 (in billion zlotys)

Source: own calculations based on Central Statistical Office of Poland, Local Data Bank.

The highest expenditures on investments were incurred by gminas in 2008-2011. It should be emphasized that until 2011, investment level increased from 7.91 billion zlotys to 12.13 billion zlotys, whereas in 2012-2013, this value was over 10 billion zlotys. Analysis of the data presented in Fig. 7 also shows that investments in gminas were predominant in the structure of investment expenditures in total in terms of transportation and communication, accounting for 59-69%. This results in particular from the greatest infrastructure in terms of transportation and communication, thus the necessity of incurring the highest expenditures to support, modernize, build and rebuild this infrastructure.

The highest share in the structure of investment expenditures in individual types of local government entities on transportation and communication was found in powiats in 2010 (19.52%) and this value reduced gradually from 2011, first to 16.06% and than to over 10% in 2012-2013. Furthermore, voivodeships in 2008-2009 were characterized by 22% share of investment expenditures in the expenditures in local government entities in total. In 2010, this share reduced to 17.34% and increased in 2011-2013 from 18.76% to 24.36%.

[9] Sprawozdania z działalności RIO i wykonania budżetu przez jednostki samorządu terytorialnego w 2013 r., s. 201 http://www.rio.gov.pl/html/sprawozdania_rio/2013/sprawozdanie_za_2013_r_www.pdf

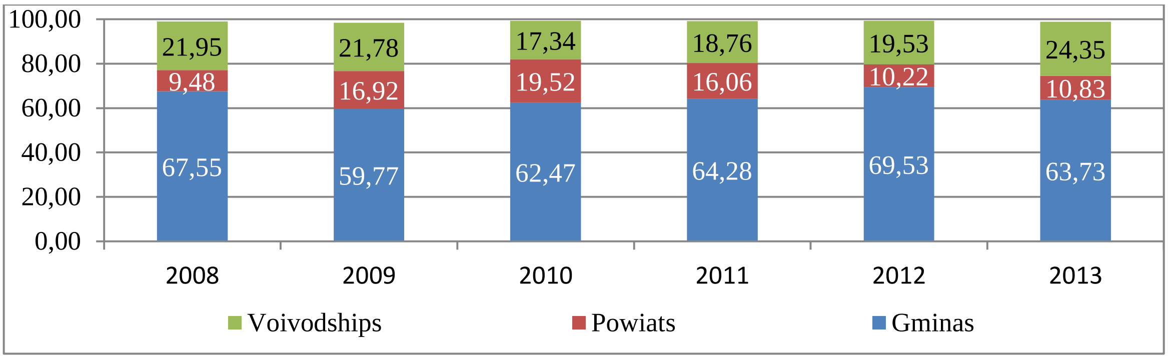


Figure 7: Structure of investment expenditures in individual types of local government entities in the area of "Transportation and Communication" in 2008-2013 (in %)

Source: own calculations based on Central Statistical Office of Poland, Local Data Bank.

The highest share in the structure of investment expenditures in individual types of local government entities on transportation and communication was found in powiats in 2010 (19.52%) and this value reduced gradually from 2011, first to 16.06% and than to over 10% in 2012-2013. Furthermore, voivodeships in 2008-2009 were characterized by 22% share of investment expenditures in the expenditures in local government entities in total. In 2010, this share reduced to 17.34% and increased in 2011-2013 from 18.76% to 24.36%.

Table 3: Dynamics of changes in investment expenditures in local government entities in the area of "Transportation and Communication" in 2008-2013

		2009	2010	2011	2012	2013
Gminas	A	118,33	119,34	108,59	86,89	94,87
	B	118,33	141,21	153,35	133,25	126,41
Powiats	A	238,74	131,70	86,82	51,16	109,59
	B	238,74	314,41	272,97	139,64	152,86
Voivodoship	A	132,68	90,91	114,19	83,62	129,19
	B	132,68	120,62	137,74	115,18	148,80
Local self-governments in total	A	133,05	115,18	105,29	80,48	103,12
	B	133,05	153,24	161,35	129,85	133,91

A – *previous year* = 100%; B – 2008=100%

Source: own calculations based on Central Statistical Office of Poland, Local Data Bank.

The thesis of the slowdown in investment activity in terms of tasks connected with transportation and communication is supported by the indices of dynamics of changes in the economic values analysed in the study, presented in Table 3. However, it should be emphasized that individual types of local government entities were characterized by different tendencies for changes. Gminas showed a dynamic increase in investment expenditures compared to the year 2008 as the reference base, with progression from 18.33% to 53.35% in the years 2009-2011. In 2012-2013, a slowdown in dynamics of increase in investment expenditures was observed, from 33.25% to 26.41%. Evaluation of chain indices leads to the conclusion that the negative rate of changes was observed in 2012-2013 since the investment expenditures decreased by 13.11% in 2012 and 5.13% in 2013.

Furthermore, powiats in 2009-2011 were characterized by over doubled and tripled investments compared to 2008, followed by the slowdown in the growth dynamics to ca. 40% in 2012 and 53% in 2013. In the case of chain indices, the greatest regression was recorded in 2012, with the investment expenditures reduced by nearly half. Furthermore, a declining tendency in investment expenditures on transportation and communication was observed in voivodeships in 2011-2012. In 2013, fixed-base indices and chain indices rose dynamically.

Table 4: Share of investment expenditures on transportation and communication in budgetary expenditures in total in individual types of local government entities in 2008-2013 (in %)

	2008	2009	2010	2011	2012	2013
Gminas	50,19	50,74	53,70	56,07	51,12	49,07
Powiats	48,81	66,23	67,61	68,63	54,77	58,08
Voivodoship	49,15	55,40	51,95	53,94	49,51	55,70
Local self-governments in total	50,34	54,75	56,00	57,86	51,52	52,02

Source: own calculations based on Central Statistical Office of Poland, Local Data Bank.

The last question analysed in this study is analysis and evaluation of the share of investment expenditures in budgetary expenditures in terms of public tasks concerning transportation and communication. To achieve this goal, the detailed indices were calculated (presented in Table 4), with division into individual types of local government entities. Undoubtedly, it can be concluded that the tasks in terms of transportation and communication were characterized by a very high share in budgetary expenditures in total: for local government entities in total in Poland, this index accounted for 50-57.9%, with 49-56% in gminas, 48.8-68% in powiats and 49-55.7% in voivodeships. Therefore, on the average (53.95% for local government entities in total, 52.5% for gminas, 58.4% for powiats and 52.35% for voivodeships), over half of the expenditures generated in the division of the budgetary classification "Transportation and Communication" are investment expenditures.

4 CONCLUSIONS

The analysis and evaluation of revenues and expenditures in local government entities in Poland connected with performance of public tasks in the area of transportation and communication carried out in this study revealed the greatest share of this type of revenues and expenditures in individual types of local government units in gminas. As indicated in the study, this results primarily from the greatest number of entities of this type and the biggest communal infrastructure that needs substantial investment expenditures.

Two periods can be distinguished in the years analysed in the study. The first period, from 2008 to 2011, was characterized by a dynamic increase in budgetary revenues, finding additional sources of financing of infrastructural initiatives, particularly EU funds, which directly translated into a revival of investment activity in terms of activities connected with transportation and communication. The second period, i.e. the years 2012-2013, was connected with a slowdown in investment activities. This results, among other things, from completion of financing tasks from EU funds in 2007-2008 and the economic tendency in the country, lower dynamics of growth of budget revenues, limitation of the budget deficit in local government entities, generated particularly in previous years.

REFERENCES

[1] Brzozowska, A. (2013). Zarządzanie w globalnych sieciach transportowych. *Gospodarka Materiałowa i Logistyka.* 10 (1226), 10-17

[2] Dylewski, M. (2007). Planowanie budżetowe w podsektorze samorządowym. Uwarunkowania, procedury, modele. Warsaw: Difin.

[3] Dylewski, M., Filipiak, B., & Gorzałczyńska-Koczkodaj M. (2006). *Finanse samorządowe, Narzędzia, Decyzje, Procesy.* Warsaw: PWN.

[4] Famulska, T. (2009) Gospodarka finansowa jednostek samorządu terytorialnego w warunkach integracji europejskiej. Katowice: Difin.

[5] Nowacka, E. J. (2005). *Polski Samorząd terytorialny*. Warsaw: Wydawnictwo Prawnicze LexisNexis.

[6] Nowicka-Skoworn M., & Mesjasz-Lech A. (2013). Globalization and the Development of Logistics Infrastructure of the Freight Transport by Road. *Regional Integration: Europe, the Mediterranean and the World Economy*. (19 p.). Palermo, Italy: 53rd ERSA Congress.

[7] Tarno, J., Sieniuć, M., Sulimierski, J., & Wyporska, J. (2004). *Samorząd terytorialny w Polsce.* Warszawa: LexisNexis.

[8] Skowron-Grabowska, B. (2014). Business Models in Transport Services. *Przegląd Organizacji.* 1(888), 35-39

[9] Skowron-Grabowska, B. (2014). Problems of Managing Transportation Systems in Urban Areas. *Logistyka.* 5, 25-27.

[10] Wankiewicz, B. (2009). Zasoby finansowe a rozwój samorządności lokalnej. Warsaw: CeDeWu.

A COMPARISON OF DEEP SEA CONTAINER ROUTES IN THE YEARS 2011 – 2014

Marino Lupi, Prof.
Alessandro Farina, PhD
Fabio Severi, BSc
University of Pisa
Logistics System Centre of Leghorn
Via dei Pensieri 60, Livorno, Italy
marino.lupi@unipi.it, alessandro.farina@for.unipi.it, fabio.seve90@hotmail.it

ABSTRACT

In this study, a comparison between deep sea shipping container services, offered from the main Italian ports, in the years 2011 and 2014, is carried out. The study sample is formed by the departures registered during the months of January 2011 and August 2014. We have made reference, in particular, to ports belonging to the following clusters, which, altogether, form the 95% of the Italian overall deep sea container traffic: the Ligurian Sea - Northern Tyrrhenian Sea multi-port gateway system (Genoa, La Spezia, Savona, Livorno), the Center-North Adriatic multi-port gateway system (Ancona, Ravenna, Venezia, Trieste), the Campania gateway multi-port system (Napoli, Salerno), the Italian multi-port hub system (Gioia Tauro, Cagliari and Taranto). The world areas are grouped in: North America, South America, Central America, West/Pacific America, West Africa, East/South Africa, Red Sea, Arabic / Persian Gulf, Southeast Asia / Far East. A comparison regarding route structure and vessel capacity is also carried out. The comparison has shown that, while the number of deep sea shipping departures, from Italian ports, slightly increased between 2011 and 2014, the dimensions of the ships, which call in Italian ports, increased relevantly, and this is in line with the current trend in container ship gigantism. At present the most important Italian port system, with regard to deep sea shipping direct routes, is the Ligurian – Northern Tyrrhenian port system, while the least important is the Adriatic port system: in fact Adriatic ports mainly offer short sea shipping services. On the other hand, the development of European Adriatic-Baltic Corridor will bring, in years to come, to a reduction of the current gap between deep sea shipping container direct services in Ligurian- Northern Tyrrhenian ports compared to that of the Adriatic ports. The world area mostly connected with Italian ports is the Southeast Asia – Far East, where the most important container ports of the world are located; also North America and Red Sea are well connected with Italian ports. The least number of connections occurs with Africa (West and East/South Africa) and with Australia.

Key words: Deep sea shipping, container routes, container traffic, Italian ports, maritime traffic comparison.

1 INTRODUCTION

Containerized traffic is the most important cargo type transported by sea; moreover, the trend in Italian GDP is highly connected with the trend of this cathegory of freight [4].

In this paper, at first, a review of deep-sea container shipping services to/from Italian ports in 2014 is performed. A full analysis, regarding the services registered in year 2011, has been performed in Lupi et al. [3]. Then, a comparison between the services registered in 2011 and 2014 is carried out.

Italian ports have been classified in the following clusters:

- Ligurian Sea - Northern Tyrrhenian Sea multi-port gateway system: Genoa, La Spezia, Savona, Livorno;
- Northern Adriatic multi-port gateway system: Ancona, Ravenna, Venezia, Trieste;
- Campanian multi-port gateway system: Napoli, Salerno;
- Multi-port hub system: Gioia Tauro, Cagliari and Taranto.

The paper is organized as follows. Section 2 focuses on the analysis of statistical data regarding Italian port container traffic. In section 3 details on container deep sea shipping routes, at major Italian ports, in the year 2014, are provided. In section 4 a comparison between data in the year 2011 and 2014 is carried out. Conclusions follow.

2 THE TREND OF CONTAINER TRAFFIC IN ITALIAN PORTS

In Table 1, the development of containerized traffic in Italian ports is reported. In general, the overall Italian throughput shows a constant increase until the years 2007-2008, when the maximum throughput, of 10.5 – 10.6 million TEUs, is reached. After 2008, a long period of crisis has followed which resulted: in a severe decrease of traffic in 2009, a slight increase in 2010, a slight decrease in 2011-2012, and a slight increase in 2013. In any case the pre-crisis traffic, of 2007, hasn't yet been reached.

The most important port in the Ligurian-Northern Tyrrhenian system is the port of Genoa, which has registered an almost constant increase in the container throughput in the last years. The port of La Spezia, instead, has closely followed the development of the economic crisis, with a slight decrease in 2009 and in 2012, but in 2013 it has overcome the pre-crisis traffic level. The port of Savona - Vado Ligure has experienced an impressive growth until 2008, but after, until 2013, a strong decrease of traffic can be observed. The port of Livorno is located in the Northern-Thyrrenian Sea and can be considered to belong to the same cluster including Ligurian ports. Container throughput at Livorno has not changed relevantly until 2003, then it has increased, significantly until 2008, then decreased in 2009; in 2013 the pre-crisis traffic hasn't yet been reached.

The North-Adriatic multiport gateway system is formed by the following ports: the Italian ports of Venezia, Trieste and Ravenna; the Slovenian port of Koper; the Croatian port of Rijeka. With reference to the Italian ports, traffic in Ravenna has remained quite constant between 2000 – 2010, with values between 160.000 and 200.000 TEUs, but it registered a small increase to 230.000 TEUs from 2010 to 2013. Containerised traffic in Venice has registered a slight, but constant, increase and it has been only slightly affected by the global economic crisis. The port of Trieste has been characterised by a severe decrease in container throughput during the years 2002 – 2003 and by an increase in the subsequent years, with only a slight reduction of traffic in 2009. After 2009, Trieste has doubled its traffic reaching a throughput of over 400.000 TEUs. As far as the ports of Koper and Rijeka is concerned, they have both experienced a very impressive increase in the last years: in particular, the port of Koper has become the first container port of the North Adriatic port system with a container throughput of 600 000 TEUs in 2013.

In the matter of the Italian transhipment hub ports, i.e. Gioia Tauro, Taranto and Cagliari, it can be noted that Gioia Tauro is characterised by the highest container throughput in Italy, with a maximum throughput of about 3.5 million TEUs in 2008 and 3.1 million TEUs in 2013; however, this port has registered a serious decrease in the years 2009-2011, in particular, in 2011, it reached the minimum throughput of 2.300 TEUs. Cagliari has strongly increased its throughput from 73.600 to 314.000 TEUs between 2002 and 2003. After, it has further increased its throughput to 600.000 – 700.000 TEUs (702.000 TEUs were registered in 2013). Taranto instead, after a consistent increase in the throughput from 190.000 to 700.000 TEUs from 2001 to 2004, has registered a severe decrease in traffic, in the last three years, reaching in 2013 the 190.000 TEUs: that is the traffic registered in 2001.

Table 1: Container throughput at Italian ports, in number of TEUs, in the period 2000 – 2013

PORTS	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
ITALY (total)	7272001	8228781	8911152	9482593	9702708	9864375	10609108	10549886	9513014	9777962	9526808	9618700	10082380
Gioia T.	2488332	3008698	3148662	3261034	3208859	2938176	3445337	3467824	2857440	2852264	2304987	2721108	3094254
Genova	1526526	1531254	1605946	1628594	1624964	1657113	1855026	1766605	1533627	1758858	1847102	2064806	1988013
La Spezia	974646	975005	1006641	1040438	1024455	1136664	1187040	1246139	1046063	1285155	1307274	1247218	1300432
Livorno	501912	519751	540642	638586	658506	657592	745557	778864	592050	628489	637798	549047	559180
Taranto	197755	471570	658426	763318	716856	892303	755934	786655	741428	581936	604404	263461	197317
Cagliari	25908	73657	313938	501194	639049	687657	547336	307527	736984	629340	603236	627609	702143
Napoli	430097	446162	433303	347537	373626	444982	460812	481521	515868	534694	526768	546818	477020
Venezia	246196	262337	283667	290898	289860	316641	329512	379072	369474	393913	458363	429893	446591
Trieste	200623	185301	120438	174729	198319	220310	265863	335943	276957	281643	393186	408023	458597
Salerno	321304	374868	417477	411615	418205	359707	385306	330373	269300	234809	235209	208591	263405
Savona	50092	54796	53543	83891	219876	227197	242720	252837	196317	196434	170427	75282	77859
Ravenna	158353	160613	160360	169432	168588	162052	206786	214324	185022	183577	215336	208152	226879
Ancona	90030	94315	75841	65077	64209	76458	87193	119104	105503	110395	120674	142213	152394
Koper	93187	114863	126237	153347	179745	218970	305648	353880	343165	476731	589314	570744	600441
Rijeka	12711	15215	28298	60864	76258	94390	145040	168761	130740	137048	150677	152016	169943

Source: Assoporti [7]. The North-Western gateway system is formed by the ports of Genova, Savona, La Spezia and Livorno, the North-Eastern Adriatic gateway system by the ports of Venezia, Trieste, Ravenna, Ancona; the Campanian gateway system is formed by Napoli and Salerno; the Italian hub port system by the ports of Gioia Tauro, Taranto and Cagliari. The others are minor ports.

3 DEEP–SEA SERVICES IN THE ITALIAN PORT SYSTEMS IN 2014

This research has been accomplished through a collection of data from: l' Avvisatore Marittimo [6] and Informare [5], where the list of ship departures for each Italian ports is provided; and from several websites: Marinetraffic [8], which provides day by day the exact position of the ship; Oceanschedules [9], which reports for each vessel the ports called in the last days; and the major global shipping companies' websites. We made reference to ship departures registered at Italian ports in the month of August 2014.

Table 2 depicts deep sea shipping container departures from Italian ports, separate in the four clusters mentioned above.

With regard to Tyrrhenian ports, Genoa is the largest deep-sea shipping port in the Northern Italy, both taking into account the number of direct connections and the DWT of the containerships calling at this port. La Spezia port is the second in rank and Livorno is the third.

Regarding Adriatic ports, the only port registering a deep sea shipping service is Trieste. It can be noticed the huge gap to be filled by North-Eastern Adriatic Italian ports to reach the North-Western Tyrrhenian Italian ports respect to direct deep sea services. Actually North Adriatic Italian ports operate their deep-sea container traffic volumes mainly being connected, through feeder services, to Gioia Tauro and Malta hubs [1, 3, 6].

The Campanian ports of Napoli and Salerno have also a considerable container deep sea shipping traffic; moreover their deep sea shipping traffic is greater than that of the Adriatic ports.

With reference to hub ports, the port with the highest number of departures is Gioia Tauro, followed by Cagliari: moreover the dimensions of the ships calling at Gioia Tauro are the largest among the ships calling at Italian ports.

The deep sea shipping destinations of the Italian ports have been grouped according to the geographical classification proposed by the "Avvisatore Marittimo": West Africa, East Africa, North America, Central America, South America, America / Pacific coast, Red Sea, Arabic / Persian Gulf, Southeast Asia / Far East. The area with the highest number of connections is Southeast Asia / Far East, with a total of 66 ship departures from all Italian ports, in particular: 43 ship departures from the North-Western Tyrrhenian Italian gateway port system, 11 from Northern Adriatic Italian gateway port system, 27 from the Campania gateway system and 19 from the hub port system. West Africa and East Africa are the least connected world regions to Italy.

In Far East, mainly Chinese and Japanese ports are served, but also Indian ports, such as Mumbai and Chennai, and Port Kelang (Malaysia) are major destinations connected to Italy. Other shipping routes connect directly (i.e. without transhipment) Italy to ports located in the Arabic Sea and in Central America.

Also North America is highly served by deep sea shipping container routes: 38 departures in the month of August 2014 have been registered considering all Italian ports, while 37 departures have been registered from the Northern Tyrrhenian gateway ports. North America regards, in particular, the U.S. ports of New York, Norfolk and Savannah. Instead, Central America comprises all the major ports of the Mexican Gulf, in particular the U.S. ports of Houston and Miami.

Other important world areas are Red Sea and Persian Gulf. These areas are on the way to Far East. Moreover, because the route to Far East crosses the Suez Channel, several ships call at the ports of Port Said and Suez, respectively on the north and the south of the channel: however we considered both ports as part of the Mediterranean region. Therefore, if a vessel stops at Suez but not at any other port of the Red Sea, the connection to Suez is not considered a connection to the Red Sea. The most important port in the Red Sea is Jeddah in Saudi Arabia, and the most important port in the Persian Gulf is Port Qasim in Pakistan. However, not all the ships directed to Southeast Asia / Far East call at the ports belonging to these two world areas, and this explains the reason because they register less ship calls than Far East.

Table 2: A synthesis on the deep sea container services to/from Italian ports, distinct by destination region, in terms: of number of services by month, of total and average DWT, of average draught. Data refer to August 2014.

2014	West Africa	Red Sea	East Africa / South Africa	North America	Central America	South America	America / Pacific	Arabic / Persian Gulf	South-east Asia / Far East	Australasia / Pacific	TOTAL	Total DWT (tons)	Average DWT (tons)	Average draught (m)
GENOA	7	17	1	22	11	9	12	10	38	5	**80**	5408645	67608	11.2
LA SPEZIA	3	5	2	18	7	0	12	7	21	2	**48**	3663203	76317	10.9
SAVONA	0	0	0	0	1	2	3	0	0	0	**3**	68937	22979	9.3
LIVORNO	7	1	0	10	11	13	8	1	3	1	**40**	2089657	52241	10.4
ANCONA	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0
RAVENNA	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0
VENICE	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0
TRIESTE	0	6	0	0	0	0	3	0	11	0	**11**	693576	63052	10.5
NAPLES	2	2	4	3	4	1	0	2	4	4	**16**	1101488	68843	11.0
SALERNO	1	1	1	2	7	1	2	1	0	0	**12**	519923	43327	9.3
GIOIA TAURO	0	2	2	10	6	10	3	6	9	3	**37**	3325122	89868	11.0
CAGLIARI	0	8	0	1	0	3	5	9	5	0	**15**	1022107	68140	11.2
TARANTO	0	0	0	0	0	0	3	0	5	0	**5**	328495	65699	11.4
TOTAL NORTH WEST GATEWAY	9	18	3	37	25	13	20	14	43	8	**122**	8131420	66651	10.9
TOTAL NORTH EAST GATEWAY	0	6	0	0	0	0	3	0	11	0	**11**	618574	56234	10.5
TOTAL CAMPANIA GATEWAY	2	3	5	5	11	2	2	3	4	4	**27**	1583502	58648	10.3
TOTAL HUB PORTS	0	10	2	11	6	13	11	15	19	3	**57**	4675724	82030	11.1
TOTAL	**10**	**34**	**5**	**38**	**26**	**19**	**23**	**26**	**66**	**10**	**158**	**11281739**	**71403**	**11.6**

Source: Informare [5], Marinetraffic [8], Oceanschedules [9], and shipping companies websites [10].

As to northern Tyrrhenian ports, the world area mostly connected is the Southeast Asia / Far East, with 43 departures per month; this is also the area connected by the biggest ships: the average DWT is nearly 90000 tons. The second important world area, for departures per month, is North America, with 37 departures, followed by Central America (i.e. Mexican Gulf), with 25 departures; but the average DWT is quite low, and equal to around 50000 tons for both areas. America / Pacific registers 20 departures per month and an average DWT of 70000 tons. The Red Sea registers 18 departures per month and an average DWT of 76000 tons. Actually the number of connections to Red Sea is not so high because Suez was considered as part of the Mediterranean in the 2014 analysis. The Arabic Sea / Persian Gulf world area registers 14 departures by month and an average DWT of 86000 tons. The least connected world area is East Africa / South Africa, with only 3 departures per month.

With reference to Adriatic ports, the number of ship departures is very low: only 3 ships per month call at America/Pacific ports, 6 call at Red Sea ports and 11 call at Southeast Asia / Far East ports. The average DWT is around 65000 tons for ships directed to Red Sea and Far East, and 45000 tons for ships directed to America.

In regard to Campanian ports, the most important connected area is Central America (Mexican Gulf), with 11 ship departures per month, followed by North America and by East Africa / South Africa, with 5 ship departures per month. The maximum average DWT, instead, is registered for ships direct to Red Sea (93000 tons) and Southeast Asia / Far East (86500 tons).

Regarding hub ports, again the best connected world area is Southeast Asia / Far East, with 19 departures per month and an average DWT of over 100000 tons. Follows Arabic / Persian Gulf with 15 departures and over 100000 tons of DWT. South America registers 13 departures per month, North America and America / Pacific 11, while Red Sea registers 10 departures per month . Ships direct to America/Pacific registers the lowest average DWT for hub ports, equal to 59000 tons; Ships direct to North America registers an average DWT of around 68000 tons, and ships direct to Red Sea of 82000 tons. The least connected world area is West Africa, because there are no departures from hub ports having West Africa as destination; there are only 2 departures to East Africa / South Africa.

All these information refer to the year 2014. The same information regarding the year 2011 are reported in Lupi et al. [3].

4 COMPARISON WITH DATA RECORDED IN THE YEAR 2011

The data collected in August 2014 have been compared with the analogous data collected between 23 December 2010 and 25 January 2011 reported in tab.3. The comparison between the data collected show that the overall deep sea shipping traffic from Italian ports has increased since 2011: both regarding the total number of deep sea shipping services, by month, which call at least in an Italian port (this number increased from 150 in 2011 to 158 in 2013) and the total DWT (this number increased from 8 in 2011 to 11 million tons in 2013). In particular, the increase has been registered rather in the ships dimensions than in the number of services: actually the increase in the total DWT has been is by 40%, while the increase in the number of departures has been by 5%.

As far as the traffic in each port is concerned, some observations can be done. A comparison between data in 2011 and 2014 is reported in table 4. The table shows the variation in the number of departures by month and in total DWT for each port and port clusters.

Genoa kept the same number of deep sea departures by month, equal to 80, but increased the total deep sea DWT by 35%, from around 4 million tons in 2011 to over 5 million tons in 2014. La Spezia increased both the number of departures (from 43 to 48, +12%) and the total DWT (+42%); Savona instead saw a relevant reduction in the deep sea shipping traffic, as it decreased the departures from 10 to 3 (-70%), and the total DWT from 277000 tons to 69000 tons (-75%). Livorno increased the DWT from 1.5 to 2.1 million tons (+42%), while the monthly deep sea departures remained the same.

Ravenna and Venezia completely lost all their deep sea shipping departures (which actually were only 2 and 6 respectively); actually the container throughput in these two ports did not decrease from year 2011 values, and it is also not negligible: therefore this traffic is now generated only by feeder short sea shipping container routes. Trieste's number of departures nearly doubled (i.e. +83%), from 6 in 2011 to 11 in 2014, and also the total DWT increased relevantly (+88%).

Table 3: A synthesis on the deep sea container services to/from Italian ports, distinct by destination region, in terms: of number of services by month, of total and average DWT, of average draught. Data refer to January 2011.

2011	West Africa	Red Sea	East Africa / South Africa	North America	Central America	South America	America / Pacific	Arabic / Persian Gulf	South-east Asia / Far East	Australasia / Pacific	TOTAL	Total DWT (tons)	Average DWT (tons)	Average draught (m)
GENOA	8	27	2	18	17	7	13	17	38	0	**80**	4005659	50071	10.2
LA SPEZIA	0	18	3	8	8	0	4	11	23	11	**43**	2572361	59822	10.7
SAVONA	0	1	0	0	6	3	2	1	1	0	**10**	277410	27741	8.86
LIVORNO	3	2	0	14	21	6	13	0	6	0	**40**	1468481	36712	9.41
ANCONA	0	0	0	0	0	0	0	0	0	0	**0**	0	0	0
RAVENNA	0	1	0	0	0	0	0	1	0	0	**2**	23820	11910	6.9
VENICE	0	5	0	0	0	0	0	2	4	0	**6**	270245	45041	9.07
TRIESTE	0	6	0	0	0	0	0	2	6	0	**6**	369606	61601	10.4
NAPLES	7	15	4	5	8	0	4	7	11	3	**35**	1949034	55687	10.7
SALERNO	0	0	0	4	5	0	2	0	0	0	**8**	220875	27609	9.15
GIOIA TAURO	0	11	2	8	11	4	6	10	10	3	**32**	2242587	70081	11.2
CAGLIARI	0	12	0	15	8	0	3	4	10	0	**24**	1130892	47121	10.3
TARANTO	0	3	0	0	0	0	0	0	3	0	**3**	235093	78364	13.2
TOTAL NORTH WEST GATEWAY	**8**	**47**	**3**	**24**	**32**	**7**	**19**	**24**	**54**	**11**	**120**	**6117959**	**50983**	**10.2**
TOTAL NORTH EAST GATEWAY	**0**	**8**	**0**	**0**	**0**	**0**	**0**	**1**	**8**	**0**	**9**	**458086**	**50898**	**9.82**
TOTAL CAMPANIA GATEWAY	**7**	**15**	**4**	**9**	**13**	**0**	**6**	**7**	**11**	**3**	**43**	**2169909**	**50463**	**10**
TOTAL HUB PORTS	**0**	**26**	**2**	**22**	**18**	**4**	**8**	**14**	**23**	**3**	**59**	**3608572**	**61162**	**11**
TOTAL	**8**	**68**	**5**	**32**	**33**	**7**	**20**	**35**	**77**	**11**	**150**	**8072955**	**53397**	**10.4**

Source: L'Avvisatore Marittimo [6], and shipping companies websites [10].

With reference to Campanian port system, the gap between Napoli and Salerno reduced, because Napoli decreased its departures by month from 35 to 16 (-54%), while Salerno increased them from 8 to 12 (+50%). The total DWT of Napoli decreased from about 2 million tons to 1.1 million tons (-43%); the total DWT of Salerno increased from 220000 tons to 520000 tons (+135%).

In regard to hub ports, Gioia Tauro increased the deep sea departures by month, from 32 to 37 (+16%), and the DWT from 2.2 to 3.3 million tons (+48%). It must be noted that, in 2011, traffic data refer to the early beginning of the year, when Gioia Tauro did not experience yet the massive reduction in container traffic that occurred at the end of the summer, when two of the most important shipping companies abandoned this port. Cagliari decreased the departures, by month, from 24 to 15 (-38%) and the DWT from 1.1 to 1.0 million tons (-10%). Taranto increased the departures, by month, from 3 to 5 (+67%) and the DWT from 235000 to 328000 tons (+40%)

Table 4: Comparison between deep sea shipping container services in 2011 and 2014. The table shows the number of departures per month and the total DWT, as well as the variation in percentage of these two quantities between 2011 and 2014.

	2011		2014		Variation 2011 - 2014	
	n°departures per month	Total DWT (tons)	n°departures per month	Total DWT (tons)	n°departures per month	Total DWT
GENOVA	80	4005659	80	5408645	0%	35%
LA SPEZIA	43	2572361	48	3663203	12%	42%
SAVONA	10	277410	3	68937	-70%	-75%
LIVORNO	40	1468481	40	2089657	0%	42%
ANCONA	0	0	0	0	0%	0%
RAVENNA	2	23820	0	0	-100%	-100%
VENEZIA	6	270245	0	0	-100%	-100%
TRIESTE	6	369606	11	693576	83%	88%
NAPOLI	35	1949034	16	1101488	-54%	-43%
SALERNO	8	220875	12	519923	50%	135%
GIOIA TAURO	32	2242587	37	3325122	16%	48%
CAGLIARI	24	1130892	15	1022107	-38%	-10%
TARANTO	3	235093	5	328495	67%	40%
TOTAL NORTH WEST GATEWAY	120	6117959	122	8131420	2%	33%
TOTAL NORTH EAST GATEWAY	9	458086	11	618574	22%	35%
TOTAL CAMPANIA GATEWAY	43	2169909	27	1583502	-37%	-27%
TOTAL HUB PORTS	59	3608572	57	4675724	-3%	30%
TOTAL	150	8072955	158	11281739	5%	40%

On the whole, the Northern Tyrrhenian ports increased the departures by month from 120 to 122 (+2%) and the total DWT from 6.1 to 8.1 million tons (+33%). The average DWT increased from 51000 to 66700 tons (+31%) and the average draught from 10.2 to 10.9 metres (+7%). The northern Adriatic ports increased the departures by month from 9 to 11 (+22%) and the total DWT from 458000 to 618600 tons (+35%). The average DWT increased from 51000 to 56000 tons (+10%) and the average draught from 9.82 to 10.5 metres (+7%). Campanian ports decreased the departures by month from 43 to 27 (-37%), and decreased the total DWT from 2.2 to 1.6 million tons (-27%). The average DWT increased from 50500 to 59000 tons (+17%) and the average draught from 10 to 10.3 metres (+3%). Hub ports decreased the departures by month from 59 to 57 (-3%), and increased the total DWT from 3.6 to 4.7 million tons (+30%). The average DWT increased from 61000 to 82000 tons (+34%) and the average draught from 11 to 11.1 metres.

Fundamentally it can be observed that:

- from 2011 to 2014, the average DWT almost always have increased, that is the overall ships dimension have increased, instead the total number of departures by month did not change relevantly, because in some ports the number of departures increased, while in others it decreased;
- the port grouping mainly crossed by deep sea shipping routes is the North-Western Tyrrhenian port cluster; however, the biggest vessels cross the hub ports.

Generally container ships, crossing Italian ports, show a tendency to increase their dimensions: therefore Italian ports must adequate their depths in order to continue being crossed by deep-sea shipping container routes.

As to the world areas mostly connected to Italian ports, the most important world area is the Southeast Asia / Far East; however, the number of departures by month decreased from 77 in 2011 to 66 in 2014 (-14%). The second important area in 2011 was the Red Sea, with 68 departures by week; in 2014 the departures by week is considerably less, i.e. 34 (decrease by 50%), but this is a result of an incongruence in data collection, because in 2011 Suez was considered a Red Sea port, while in 2014 it was considered as a Mediterranean port. The second important area, in 2014, is in fact the North America, with 38 departures by week; in 2011 this area registered only 32 departures (increase by 19%). Other important areas are: Arabic-Persian Gulf, with 35 departures by month in 2011 and 26 in 2014 (decrease by 26%); and Central America, with 33 departures by month in 2011 and 26 in 2014 (decrease by 21%)

The least connected area in 2014 is the East / South Africa, with only 5 departures by month, in 2011 they were the same number. Other not well-connected regions, in 2014, are West Africa and Australasia / Pacific, with 10 departures by month each: in 2011 West Africa had 8 departures by month (increase by 20%) and Australasia 11 (decrease by 10%). In 2011, East /South Africa registered the same number of departures.

5 CONCLUSIONS

In this paper, an analysis, with reference to data collected in August 2014, of deep–sea shipping departures from Italian multiport systems is presented; a comparison with an analogous set of data collected in 2011 has been carried out.

The performed survey shows, clearly, that the main deep sea shipping routes are those connecting Italian ports to Southeast Asia / Far East, crossing Red Sea and Arabic ports, as well as those to North and Central America ports. Other routes which connect Italian ports to South America, to Africa and to Oceania are only minor routes. Moreover, North-western ports have several deep-sea shipping departures, followed by hub ports and by Campanian ports. Actually, while the higher number of routes cross Tyrrhenian ports, the biggest ships cross hub ports, particularly Gioia Tauro.

Adriatic Italian ports play only a minor role in direct (that is without transhipment) deep sea shipping services. Feeder services to transhipment hubs are not considered in the present study, but the analysis clearly indicates that the deep-sea shipping connectivity gap, that separates the North-Eastern Italian multi-port gateway system from the North-Western Italian multi-port gateway system, is far to be filled. Indeed, despite the container throughput at North Adriatic ports has progressively increased and its value does not appear to be negligible compared to North Tyrrhenian Ligurian ports, the majority of the containerships calling at the Adriatic Sea ports refer to the Short Sea Shipping services.

Nevertheless, the new giant ships, once put in operation along the trunk routes, will free smaller, but still very large, ships which will accommodate the demand growth in other routes with direct services. Among these routes, the direct links from the Far East to both the North Western and the North Eastern Italian deep-sea port gateway systems could benefit of some reinforcement in terms of service frequency and overall capacity. Finally, both the economic development of Central and Eastern EU countries and the extension of the Trans-European Transport Network towards the East Europe could contribute to add and/or shift towards the North Adriatic Sea some important deep-sea services.

REFERENCES

[1] Danesi, A., Farina, A., Lupi, M. (2010). A comparative analysis of Lo-Lo and Ro-Ro Short Sea Shipping networks in Italy, International Conference of Transport Science 2010, Portoroz, Slovenia: Faculty of Maritime Studies and Transport, University of Lubiana.

[2] Gouvernal, E., Debrie, J., Slack, B. (2005). Dynamics of change in the port system of the western Mediterranean. Maritime Policy and Management, 32(2), 107-121.

[3] Lupi, M., Danesi, A., Farina, A., & Pratelli, A. (2012). Il trasporto marittimo di container in Italia. Studio sulle rotte Deep e Short Sea Shipping in partenza dai principali porti Italiani e sulle quote modali ferroviarie. Ingegneria Ferroviaria, 67(5), 409-444.

[4] Lupi, M., Farina, A., Pratelli, A., Gazzarri, A. (2014). Application of classification rules to Italian ports. Promet – Traffic & Transportation 26(4), 345-354.

[5] Informare, all the editions of August 2014

[6] L'Avvisatore Marittimo, 91 (50), 28 December 2010.

[7] Assoporti website: www.assoporti.it

[8] Marinetraffic website: www.marinetraffic.com

[9] Oceanschedules website: www.oceanschedules.com

[10] Main shipping companies websites:

- http://www.zim.com/services/schedules/pages/schedulebyvessel.aspx
- http://www.hmm21.com/cms/company/engn/index.jsp#
- http://www.yangming.com/english/ASP/e-service/vessel_tracking/search_by_vessel.asp
- http://www.evergreen-marine.com/
- http://ebusiness.coscon.com/wps/portal/!ut/p/b1/04_Sj9CPykssy0xPLMnMz0vMAfGjzOL9ffx9fJ19fS2cAkMNDDw9TIycvLx8jQ2CTPULsh0VAdsZqHs!/
- https://www.hanjin.com/hanjin/CUP_HOM_3005.do?sessLocale=en
- https://www2.nykline.com/
- http://www.oocl.com/eng/ourservices/serviceroutes/tpt/Pages/default.aspx

ENVIRONMENTAL ASPECTS OF PUBLIC PROCUREMENT IN TRANSPORT SECTOR

Axel Luttenberger, PhD
University of Rijeka
Faculty of Maritime Studies
Studentska 2, Rijeka, Croatia
axel@pfri.hr

Lidija Runko Luttenberger, PhD
Komunalac d.o.o.
Jurdani 50, Jurdani, Croatia
lidija.luttenberger@komunalac-opatija.hr

ABSTRACT

Each year European public authorities spend a significant amount of the EU gross domestic product in public procurement of goods, services and works related to transport. Public procurement, being a policy strategy instrument, must integrate environmental considerations in the contract award procedures. The paper analyses environmental impacts of transport, the environmental aspects of 2014 EU Procurement Directives and their capacity to contribute to the reduction of adverse environmental effects in the sector of transport. The new legislation should pursue various efficient alternatives competing to provide the most environmentally friendly solutions. The authors put forward the proposal for implementation and future development of procurement legislation and present barriers and recommendation in its implementation.

Key words: Public procurement, transport sector, environmental aspects, legislation.

1 INTRODUCTION

Public procurement is the purchase by governments and state-owned enterprises of goods, services and works. In 2011, on average, general government procurement spending represented 29% of total general government expenditures (or 13% of GDP) [1].

It was due to solid foundation of jurisprudence built up by the ECJ over the last 15 years that all levels of government in all the EU Member States could be brought to commit to čEuropean procurement law, despite heavy political resistance and its encroachment of the old status quo [2].

The paper analyses the concept of sustainable procurement, public procurement of innovation, the provisions of EU 2014 Procurement Directives related to the environment, the real costs of procurement, its role in reducing the environmental effects of transport sector, considers the barriers and puts forward the recommendations for implementation and future development of procurement policy.

2 SUSTAINABLE PROCURMENT WITH PARTICULAR REFERENCES TO ENVIRONMENTAL PROTECTION

Sustainable public procurement (SPP) means making sure that the products and services that the organisation buys achieve value for money on a life cycle cost basis and generate benefits not only for said organisation, but also for the environment, society and the economy. SPP is used by both public and private sector organisations to ensure that their purchasing reflects broader goals linked to resource efficiency, climate change, social responsibility and economic resilience. These aspects are often interlinked, see Figure 1. At its most basic, SPP can mean buying energy efficient computers or fair trade coffee. At its most comprehensive it means systematically integrating sustainability considerations into all procurement activities, whether purchasing goods, services or works and regardless of the form which procurement takes (e.g. service contracts, centralised framework agreements or other 'non-traditional procurement approaches). Some examples would be a rainwater harvesting system providing water for the fire engine, the use of blended fuel for vehicles made from used cooking oil, the criteria for reducing packaging, etc. [3].

Therefore, sustainable public procurement can have a role in indirectly stimulating social and environmental benefits through exerting pressure on suppliers to reduce their own impacts [4].

The principles of sustainable public procurement, primarily in the interest of fostering local employment and local business, could also be enforced by a document such as Code of Practice, like the one in Lewisham, UK [5] stating that the contractors, suppliers and service providers engaged to work for the Council must show a commitment to the borough, its residents and businesses.

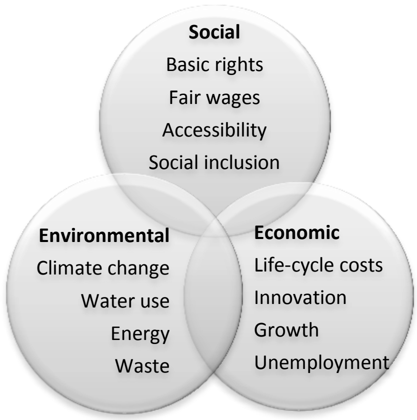


Figure 1: SPP goals [3]

3 PUBLIC PROCURMENT OF INNOVATION

Public procurement can be a major source of innovation. Public procurement might allow to improve the service delivered to the local community and to increase the technological competitiveness of the local industrial and research system. In this context, regional foresight might help identify both long-term societal needs and the patterns of evolution of emerging technologies that can match these needs [6].

However, while public procurement is increasingly seen as an important potential instrument of innovation policy, according to Georghiu et al. [7] the evidence of its effectiveness is largely anecdotal. The main barriers (to innovation) reported by suppliers refer to the lack of interaction with procuring organisations, the use of over-specified tenders as opposed to outcome based specifications, low competences of procurers and a poor management of risk during the procurement process [8].

Innovative ideas are not – not yet – implemented due to an insufficient consideration of the impact, a lack of resources, regulations, policy and existing procurement frameworks, but also due to the uncertainty that comes with innovation. As a result, an organization could make a distinction between two types of innovation: small-scale innovations that can be obtained through regular procurement (requesting functional specifications and awarding based on most economically advantageous tender criteria) and larger, radical innovations that require a special procedure [9].

4 ENVIRONMENTAL ASPECTS OF EU 2014 PROCURMENT DIRECTIVE

EU 2014 Procurement Directives[1] provide for some new options for implementing environmental protection put forward hereinbelow.

4.1 Principles

Article 18(2) of Directive 2014/24/EU [10] sets out that „Member States shall take appropriate measures to ensure that in the performance of public contracts economic operators comply with applicable obligations in the fields of environmental, social and labour law established by Union law, national law, collective agreements or by the international environmental, social and labour law provisions listed in Annex X. "

Recital 37 clarifies the scope of Article 18(2) stating that „it is of particular importance that Member States and contracting authorities take relevant measures to ensure compliance with obligations in the fields of environmental, social and labour law that apply at the place where the works are executed or the services provided and result from laws, regulations, decrees and decisions, at both national and Union level, as well as from collective agreements, provided that such rules, and their application, comply with Union law".

4.2 Technical specifications

Technical specifications[2] define the characteristics required of a works, service or supply. They can include requirements relating to a specific production process, such as taking account of environmental or social aspects.

If, for example, a contracting authority wants to favour local products over 'exotic' products, it can include costs of transport in the costs, while ensuring that it does not discriminate between operators. It can stipulate in the technical specifications that purchased products should not contain toxic chemicals or that they should be produced using environmentally efficient machinery creating minimum waste. However, the technical specifications cannot stipulate that the product must be fair trade or that a minimum price must be paid to the producer. In other words, ethical dimensions cannot be defined at this stage [11].

---

[1] 2014/23/EU (the Concessions Directive), 2014/24/EU (the Public Sector Directive) and 2014/25/EU (the Utilities Sector Directive) – hereafter simply referred to as the 2014 Directives.

[2] 2014/24/EU - Article 42

For works contracts, specifications can relate to, for example the performance of the constructed works (e.g. energy performance of a building, accessibility for disabled people, indoor climate), the way in which the works are carried out (e.g. minimising of waste and noise from construction sites, optimising material delivery schedules to lessen traffic disruption, energy/water efficiency of machinery), and the materials used in construction (e.g. use of renewable and/or recycled materials, restriction of harmful or unrecyclable materials, efficient use of material) [3].

Labels[3] may be used as part of procurement to define the technical specifications, and also award criteria or contract performance clauses and to verify compliance with those.

4.3 Choice of participants

The Directive in Article 56 provides that contracting authorities may decide not to award a contract to the tenderer submitting the most economically advantageous tender (MEAT) where they have established that the latter has not complied with the obligations laid down by Union legislation on social and labour law or environmental law or with the international provisions on social and environmental law listed in Annex X to Directive 2014/24/EU.

However, „Contracting authorities may decide not to award a contract to the tenderer submitting the most economically advantageous tender where they have established that the tender does not comply with the applicable obligations referred to in Article 18(2).“ Therefore the disparity between an ambitious principle and its optional application reduces the scope of the provision”[11].

4.4 Contract award criteria

With regard to Article 67, the contracting authorities must base the award of public contracts on the most economically advantageous tender, identified on the basis of the price or cost, using a cost-effectiveness approach, such as life-cycle costing, and may include the best price-quality ratio, which shall be assessed on the basis of criteria, including qualitative, environmental and/or social aspects, linked to the subject-matter of the public contract in question. Such criteria may comprise, for instance: quality, accessibility, and social, environmental and innovative characteristics; organisation, qualification and experience of staff, where the quality of staff can have a significant impact on the level of performance of the contract; and after-sales service, technical assistance and delivery conditions. Consequently, the ‘lowest cost’ concept has been preferred to the ‘lowest price’ concept in order to expand the options available to contracting authorities, by allowing them to base their decision on a more comprehensive assessment than just price [11].

However, the Directive also states that „Member States may provide that contracting authorities may not use price only or cost only as the sole award criterion...“

As with specifications, award criteria can relate to production processes or any other stage of the life cycle – for example the way in which raw materials are sourced, energy or water consumption during use, and the end-of-life recyclability or biodegradability of a product [3].

---

[3] 2014/24/EU - Article 43

4.5 Life-cycle costing

Article 68 of Directive 2014/24/EU enshrines a concept which did not exist in Directive 2004/18/EC, namely life-cycle costing (LCC) in works and services. The aim is to send a political signal to public purchasers. The life-cycle concept covers all internal costs borne during the life-cycle of works, supplies or services, such as costs imputed to environmental externalities, which include pollution caused by the extraction of raw materials or collection and recycling costs. This measure is aimed to improve environmental protection and aid the fight against climate change. Accordingly, the LCC will cover, insofar as these are relevant, the 'cost of emissions of greenhouse gases and of other pollutant emissions and other climate change mitigation costs' (Article 68(1)(b)). This is clearly a powerful lever to change the production and consumption habits of public authorities [1].

Article 68(2) reads further: „Where contracting authorities assess the costs using a life-cycle costing approach, they shall indicate in the procurement documents the data to be provided by the tenderers and the method which the contracting authority will use to determine the life-cycle costs on the basis of those data. "The method used for the assessment of costs imputed to environmental externalities must fulfil certain conditions.

Finally, it is stated that „whenever a common method for the calculation of life-cycle costs has been made mandatory by a legislative act of the Union, that common method shall be applied for the assessment of life-cycle costs. A list of such legislative acts, and where necessary the delegated acts supplementing them, is set out in Annex XIII. The Commission shall be empowered to adopt delegated acts in accordance with Article 87 concerning the update of that list, when an update of the list is necessary due to the adoption of new legislation making a common method mandatory or the repeal or modification of existing legal acts."

It should be noted that social protection and employment promotion have not been included in the calculation of the life-cycle cost [11].

4.6 Abnormally low tenders

Article 69 lays down that it will be compulsory to reject an abnormally low tender in cases where the contracting authority finds that the abnormally low price or costs are due to failures to comply with obligations arising from Union law or national law compatible with Union legislation in the field of social and labour law or environmental law, or international labour law provisions.

4.7 Procurement procedures

Four procedures allowed under the 2014 Directives offer enhanced flexibility [3]:

- When procuring research and development (R&D) services, it is possible to make use of an exemption to the Directives and apply pre-commercial procurement (Recital 47).

- The innovation partnership[4] procedure is specifically designed to cover the full innovation cycle from R&D through to piloting and purchase on a commercial scale of new products or services.
- The competitive dialogue[5] procedure allows meeting with bidders to progressively refine the requirements, especially where it is not possible to write a specification in advance. Norwegian Directorate of Public Roads opted to use a competitive dialogue in order to explore innovative solutions for the design, construction and operation of a low environmental impact vessel [12]. Uttam et al. [13] applied it to an infrastructure project that includes the construction of a bridge, tunnel, underpass as well as pedestrian and bike path.
- The competitive procedure with negotiation[6] gives public sector more freedom to negotiate with bidders where contracts involve elements of design or innovation or in other defined circumstances.

4.8 Encouraging SMEs to bid

Article 46 sets out that „contracting authorities shall, except in respect of contracts whose division has been made mandatory pursuant to paragraph 4 of this Article, provide an indication of the main reasons for their decision not to subdivide into lots, which shall be included in the procurement documents or the individual report referred to in Article 84.“

Dividing contracts into smaller lots may make contract requirements more achievable to small and medium-size companies (and less attractive to bigger companies). Under the 2014 Directives it is required to explain why a contract has not been divided into lots [3].

4.9 Variants

Allowing some flexibility around specifications can be a good way of encouraging the market to propose innovative and sustainable solutions. One means of doing this is to allow variants7: solutions which meet your minimum requirements but in a different way to that envisioned in the detailed technical specifications. This method also helps to minimise the risk of a low number of compliant bids or unfeasibly high prices. For example, if the purchaser of vehicles is uncertain whether electric, hybrid or alternative-fuelled options may be suitable, it may be allowed to propose those as variants. The minimum requirements in terms of safety, ergonomics, features and warranties would be specified in tender documents. Variant bids would then be assessed against the same award criteria as applied to non-variant bids, allowing to compare costs, quality and environmental performance and make a decision about which fuel/propulsion technology is best see [3].

4.10 Trials and demonstrations

If new products or methods are being proposed as part of the contract, it may make sense to have a trial period or request samples prior to making a decision on awarding the contract.

---

[4] 2014/24/EU - Article 31
[5] 2014/24/EU - Article 30
[6] 2014/24/EU - Article 29
[7] 2014/24/EU - Article 45

4.11 Exclusion criteria based on compliance with fundamental labour and environmental law

The 2014 Directives have clarified that technical specifications can relate to sustainability impacts at any stage of the life cycle of a product and it is not necessary for them to define qualities of the finished product only[8].

4.12 Public-public cooperation

The Directives provide for the first time explicit legislative rules determining which contracts can be concluded between public sector entities without applying public procurement procedures. These rules are based on European Court of Justice case-law, but also take into account the need, often expressed by procurement practitioners, for improved legal certainty and they involve in-house relationships, cooperation between contracting authorities and transfer of a public task [14].

5 THE REAL COST OF PROCURMENT

Assessing the real costs of procurement means calculating the total cost of an asset, from the point of purchase right through to the use phase and including the end-of-life costs, see Figure 2. Unfortunately, most public sector organisations are still faced with budgets which prioritise upfront purchase price over longer-term costs, and which may ignore social or environmental costs altogether. These problems can be exacerbated if one organisation purchases a product, service or work but another is responsible for its operation, maintenance and disposal. Such a scenario presents the so called 'split incentive' problem [3].

As explained in item 4.5 hereof, the 2014 Directives[9] specify that following costs may be taken into account, whether they are borne by the contracting authority or other users [3]:

(I) Costs relating to acquisition;
(II) Costs of use, such as consumption of energy and other resources;
(III) Maintenance costs;
(IV) End of life costs, such as collection and recycling costs;
(V) Costs imputed to environmental externalities linked to the product, service or work during its life cycle (e.g. greenhouse gases and other pollutant emissions, or other climate change mitigation costs) if their monetary value can be determined and verified, see Figure 3.

[8] 2014/24/EU - Articles 18, 57 and Annex X
[9] 2014/24/EU - Article 68

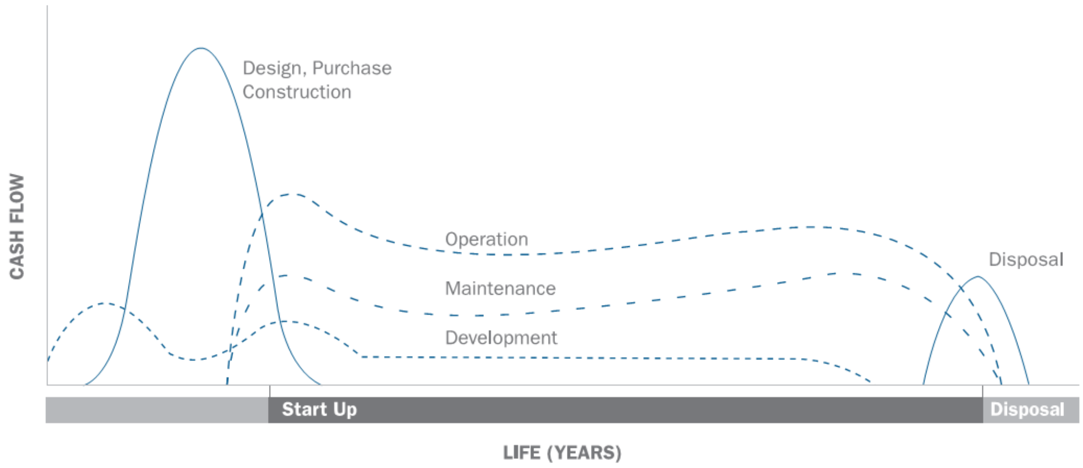


Figure 2: The process of life-cycle costing (LCC) involves assessing costs arising from an asset over its life cycle and evaluating alternatives that have an impact on this cost of ownership [15].

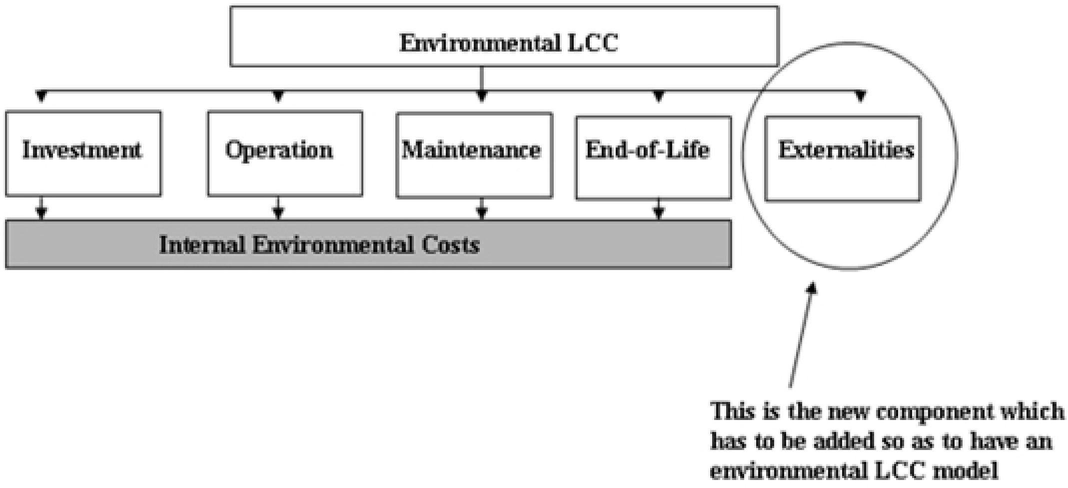


Figure 3: Environmental LCC structure [16].

The aim is to strongly encourage procurers to „think outside the (price) box" in the context of sustainable public procurement. It is quite evident that buying green can save money, particularly when an LCC approach is taken during the procurement process. In a quote attributed to Einstein, we are warned that „not everything that can be counted counts and not everything that counts can be counted". In advocating the use of LCC, it is however important to acknowledge that the science of LCC is far from perfect. The success of LCC is dependent on its scope (meaning the inclusion of environmental externalities or/and other externalities) and the methodology used (which in many cases is incomplete and based on experts' perceptions, not on hard scientific evidence) [4].

Life cycle costing (LCC) is sometimes confused with life cycle assessment (LCA) – however they are very different. Where LCC calculates the costs of a product throughout its life cycle (which can include giving a monetary value to environmental externalities), LCA assesses the environmental impacts, such as greenhouse gas emissions, over the life cycle [3, 17].

Therefore, LCA and LCC ae two different sciences and are governed by considerably different considerations [18].

An environmental LCC methodology takes into account four main cost categories plus external environmental costs, as shown in Figure 3. The latter may come from LCA analyses on environmental impacts, which measure for example the external costs of global warming contribution associated with emissions of different greenhouse gases. Environmental costs can be calculated also in respect of acidification (grams of SO_2, NO_X and NH_3), eutrophication (grams of NO_X and NH_3), land use (m^2*year) or other measurable impacts [16].

6 TRANSPORT SECTOR

Transport sector must take part in the collective effort to limit the rise in average global temperature by suggesting improvements in the design of the materials used but also the organisation of transport itself [19].

European legislation requires the tailpipe emissions of CO_2 to be measured during the type approval procedures for new vehicles. This approach, known as tank to wheel (TTW) only counts the CO_2 emissions produced when fuel is burned by the vehicle engine. This however is a poor indicator of climate impact as much of that impact actually occurs during the production of the fuel – especially for alternative vehicle fuels [20].

The impact of transport on the environment was, until recently, viewed mainly in terms of atmospheric pollution and noise emissions. Transport has a wide-ranging impact on the environment ranging from operational pollution, land-use, congestion and the risks inherent to the transport of dangerous goods. The measures should pursue the reduction of transport intensity and emission, reduction of land use, and the choice of carrier under considerations of sustainable aspects [21]. The development of urban transport should give priority to collective and "soft" transport [19] and to adequate link-up between the different stages of urban journeys as well as to easy access to and from inter-urban transport [22].

Therefore, in transport sector, environmental aspects of public procurement should be considered in three major areas: transport means (vehicles, ships, etc.), construction of infrastructure (with particular reference to land use) and also logistics services provided in supplying the goods, services and executing the works.

Vehicles are purchased or used by many public authorities, and will play a role in the delivery of other contracts such as for construction, landscaping, waste management, social care, facilities management and highways maintenance. Savings on fuel and, in many cases, vehicle tax, can be substantial when cleaner and more efficient vehicles are chosen. Further savings can be realised by rationalising fleet requirements and making the most of eco-driving and innovative technologies such as telematics and satellite navigation to reduce wear and tear and unnecessary mileage [3].

An example of how environmental externalities may be included in LCC is given by the Clean Vehicles Directive (2009/33/EC) [23]. Under this Directive, contracting authorities and entities are obliged to take energy consumption and emissions into account in their purchases of road transport vehicles [16].

The Republic of Croatia transposed into its legal system the Clean Vehicles Directive by way of the Act Promoting Clean and Energy Efficient Road Traffic Vehicles [24] on the basis of which were adopted the Ordinance on methodology for calculating operative costs throughout a period of exploitation of road transport vehicle [25] and the Ordinance on standards used in procedures of public procurement of road transport vehicles [26] laying down that upon purchase of vehicles the contracting authorities shall consider energy effects and environmental effects throughout the period of exploitation of a vehicle with regard to energy consumption, CO_2 emissions, NO_x emissions, emissions of non-methane hydrocarbons and particles emissions.

Ship life cycle management is elaborated in [27]. Gratsos et al. [28] indicate that ships built with corrosion allowances, which are truly adequate for the ship's design life, when all factors have been taken into account, have a lower life cycle cost per annum for the maintenance of the integrity of their structure. This despite the fact that they would carry a slightly smaller quantity of cargo and therefore their income over time would be marginally less. Furthermore these ships are more reliable performers having a lower average annual downtime.

An important benefit with ship transportation is the limited need for land areas. Methods to calculate the land use requirements for ship transportation and the pollution contribution from ports should be established. Furthermore, methods have to be developed to allocate the environmental impact of port activities to ship transportation. The scrapping phase has to be addressed. These problems are important to address to enable consistent comparison of alternative transportation modes [29]. The advantages of short sea shipping compared to road transport and integral environmental effect of shipping are analysed in [30].

Public sector has a lot of power to influence practices in the construction industry and obtain better environmental, social and economic outcomes [3]. An example of construction of a low-carbon motorway exit is presented in [31].

Available research on sustainable procurement intensively focuses on international product suppliers and less on service suppliers such as logistics services providers. However, in addition to their well-known economic role, logistics processes have a strong impact on the environment (e.g. transportation-induced greenhouse gas emissions, noise and land consumption) and social issues (e.g. transport safety and physically draining occupations) [32].

7 BARRIERS AND RECOMMENDATION

Just as spatial planning refers to the methods used by public sector to influence the future distribution of activities in space [33] and which may determine transport modes available in the future and whether public transport will be preferred or not, so can the policy enshrined in public procurement laws and implementation thereof significantly affect the transport sector.

As regards EU procurement directives, it may be regretted, for example, that several provisions are optional and have been left to the discretion of the Member State or contracting authority. It may also be regretted that the level playing field has not been kept watertight and that a form of competition between the least stringent legislation has been made possible. The result of the Directive’s transposition must be assessed at the end of the next legislative period, in 2019, on the basis of a robust ex post impact analysis, which takes account of the reality on the ground and which allows the results effectively achieved to be measured [11].

As the procurement Directives are principally concerned with how to buy, rather than what to buy, contracting authorities have a considerable amount of scope in determining the subject matter or title of their tender and should benefit therefrom. The examples of subject matter could be provision of sustainable catering services for schools, supply of low emission vehicles, construction of low energy office building, etc. [3].

Borg et al. [34] hold that there is the lack of investment culture in the sense that mission statement of public administration is directed by service provision, while investments aimed at yielding direct future economic returns are not a natural part of this culture. This is reflected at the decision-making level, where priority is directed to improving service levels, and within administrations which often lack the skills to undertake simple cost benefit analyses.

Sustainable public procurement needs to be made simple. Public procurement is full of procedures and red tape as it is, so we must not add more [18]. Apart from lack of understanding of the sustainability issue by policy makers and those responsible in the contracting authorities, existing LCC tools are either very complex for ordinary user, not user-friendly, or are sometimes not available online because there is a problem in its financing, meaning that the knowhow is available only at a fee.

Also, the question is how feasible is to expect procurers to have advanced multi-disciplinary skills? Currently, a large majority of procurement professionals across the world tend to hail from academic backgrounds that lean towards business administration, international relations, political sciences, social sciences, history and the arts [18].

Many procurement officers confuse „green procurement" with energy efficient procurement. One may question whether it is allowed for a school to purchase locally produced food on legal grounds (to minimise the energy needed for transportation). But it is, in legal terms, easy to specify energy efficient equipment since such equipment can be compared and evaluated on their technical and economic performance. The problem is that of defining the correct and relevant evaluation criteria, hence the need for purchasing guidelines [34].

The criteria for EU green public procurement are provided as voluntary instrument elaborated for several goods/services/works, such as passenger cars directly purchased or contracted under leasing/renting systems, public transport vehicles and services, and waste collection trucks and services, while for sectors associated with transport, such as construction, road construction those are currently under revision [35].

The „buy national", especially „buy local" programs certainly constitute sustainable public procurement initiatives as they support less international transport, less packaging, and support the creation and expansion of „green jobs" and „green industries".

Mitigation strategies that effectively incorporate LCA into transportation planning should involve the following [36]: changing analytical and decision criteria for project selection, improving the capability to compare different transportation modes to one another in planning and project financing processes, improving the capability to conduct analysis of complex environmental impacts into transportation planning before project selection occurs (i.e. not only in post-decisional environmental impact assessments, improving analytical integration across different spatial and temporal scales, and creating purchasing strategies that emphasize the use of products and materials with higher recycled content and establish relationships with suppliers that have instituted efficiency measures

Finally, accounting for social costs and benefits is particularly challenging. For example, costs such as unemployment benefits that would have been necessary without the procurement of a given asset, or health care costs that would have been necessary if environmentally preferable alternatives would not be been procured, are particularly challenging to forecast [18].

8 CONCLUSION

Transport is the sector that in many ways exerts an impact on the environment – through production and operation of vehicles, construction and maintenance of infrastructure, and the transport component integrated in the delivery of goods, provision of services and performance of works. Although there are now various instruments available for pursuing the procurement that will affect the environment less, there are still many complex obstacles in the way.

The first one is that in preparation stage seldom there occurs any analysis of various possible alternatives in transport projects, particularly with regard to their integral impact on the environment. Besides pollution and greenhouse gas production, particular attention should be paid to materials consumption, land use, and the consumption of water and energy.

The application of available LCC calculation models still requires multiskilled professionals of multidisciplinary background. Also, not always very clear and unambiguous wording of procurement legislation requires much skills to apply just procedure for achieving the desired environmental and sustainability goals.

Sustainability aspects should support public-public partnerships and „buy local“ programmes, and certainly less the public-private partnerships involving design, build, operate and maintain contracts. The costs of environmental protection and environmentally-friendly operations will hardly be borne by private sector.

LITERATURE

[1] Government at a Glance 2013, OECDiLibrary, 14.11.2013

[2] Cox, R.H.J., Revolution Justified, Planet Prosperity Foundation, Maastricht, 2012

[3] The Procura+ Manual – A Guide to Implementing Sustainable Public Procurement, 3rd Edition, ICLEI-Local Governments for Sustainability, 2014

[4] Dragos, D., Neamtu, B., Sustainable Public Procurement: Life Cycle Costing (LCC) in the New EU Directive Proposal, EPPPL - European Procurement & Public Private Partnership Law Review, 1, 2013, 19-30

[5] Sustainable Procurement Code of Practice for all organizations who wish to contract with the Council, Lewisham, October 2012, http://www.lewisham.gov.uk

[6] Vecchiato, R., Roveda, Cl, Foresight for public procurement and regional innovation policy: The case of Lombardy, Research Policy 43 (2014) 438-450

[7] Georghious, L. et al., Policy instruments for public procurement of innovation: Choice, design and assessment, Technological Forecasting & Social Change, 86 (2014) 1-12

[8] Uyarra, E., et al., Barriers to innovation through public procurement: A supplier perspective, Technovation 34 (2014) 631-645

[9] Public Procurement of Innovation Policy Framework, Rijkswaterstaat – Ministry of Infrastructure and the Environment, November 2014

[10] Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC, OJ L 94, 28.3.2014, p. 65.

[11] Van den Abeele, É., Integrating social and environmental dimensions in public procurement: one small step for the internal market, one giant leap for the EU?, European trade union institute (etui), Working Paper 2014.08, Brussels, 2014

[12] European Commission, GPP In practice, Issue no. 42, June 2014

[13] Uttam, K., Le Lann Ross, C., Competitive dialogue procedure for sustainable public procurement, Journal of Cleaner Production 86 (2015) 403-416

[14] Public procurement reform, Factsheet No. 5: Public-public cooperation, European Commission, http://ec.europa.eu/growth/single-market/public-procurement/modernising-rules/reform-proposals/index_en.htm, 27.2.2015

[15] Life-cycle costing, Australian National Audit Office, Canberra, December 2001

[16] Life-cycle costing, European Commission, http://ec.europa.eu/environment/gpp/lcc.htm, 3.3.2015

[17] Runko Luttenberger, L., Life cycle assessment (LCA) – a System tool in industrial ecology, Engineering Review 20 (2000) 53-60

[18] Life Cycle Costing – A Question of Value, International Institute for Sustainable Development (IISD), http://ec.europa.eu/environment/gpp/pdf/WP-LifeCycleCosting.qx.pdf, 3.3.2015.

[19] Bulletin of the Obsevatory on Transport Policies and Strategies in Europe, Issue 27 – May 2011, Ministère de l'Écologie, du Développement durable et de l'Énergie http://www.developpement-durable.gouv.fr/

[20] Clean fleets – purchasing clean public vehicles, June 2014, www.clean-fleets.eu

[21] Large, R.O., Procurement of logistics services and sustainable development in Europe: Fields of activity and empirical results, Journal of Purchasing & supply Management 19 (2013) 122-133

[22] Green Impact of Transport on the Environment, COM (92) 46 final, Commission of the European Communities, 20.2.1992

[23] Directive 2009/33/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of clean and energy-efficient road transport vehicles, OJ L120, 15.5.2009, p.5

[24] Zakon o promicanju čistih i energetski učinkovitih vozila u cestovnom prijevozu, NN 127/13.

[25] Pravilnik o metodologiji za izračun operativnih troškova tijekom razdoblja eksploatacije vozila za cestovni prijevoz, NN 136/13.

[26] Pravilnik o mjerilima koja se koriste u postupcima javne nabave vozila za cestovni prijevoz, NN 11/14.

[27] Ship life cycle assessment and management, Gesellschaft für angewandten Umweltschutz und Sicherheit im Seeverkehr mbH, Bremen, October 2011

[28] Gratsos G.A., et al., Life cycle cost of maintaining the effectiveness of a ship's structure and environmental impact of ship design parameters: an update, RINA Conference on the Design and Operation of Bulk Carriers, Athens, Greece, October 26-27, 2009

[29] Life Cycle Evaluation of Ship Transportation – Development of Methodology and Testing, Research report, Det Norske Veritas (DNV), 1998

[30] Runko Luttenberger et al., The Viability of Short-Sea Shipping in Croatia, Brodogradnja 64 (4), 472-481

[31] Construction of a low-carbon motorway exit – Rijkswaterstaat, the Netherlands, GPP2020, www.gpp2020.eu, 3.3.2015

[32] Kudla, N.L., Klass-Wissing, T., Sustainability in shipper-logistics service provider relationships: A tentative taxonomy based on agency theory and stimulus-response analysis, Journal of Purchasing & Supply Management, 18 (2012) 281-231

[33] Runko Luttenberger, L., Luttenberger, A. Challenges of Marine Spatial Planning in Eastern Adriatic, Book of Proceedings 6th International Maritime Scientific Conference, Solin, Croatia, Faculty of Maritime Studies Split, 2014, pp 33-40

[34] Borg, N. et al. Release the power of the public purse, Energy Policy 34 (2006) 238-250

[35] EU GPP criteria, European Commission, http://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm, 19.2.2015

[36] Chester, M. et al., Infrastructure and automobile shifts: positioning transit to reduce life-cycle environmental impacts for urban sustainability goals, Environmental Research Letters 8 (2013) 015041

CHALLENGES OF LOGISTIC RESEARCH

Ana Macura, PhD Student
CEMEX Hrvatska d.d.,
F. Tuđmana 45, 21212 - Kaštel Sućurac, Croatia
ana.macura@cemex.com, a-macura@hotmail.com

ABSTRACT

Logistic and supply chain have been ever developing business functions over the past decades. Following the major logistic and supply chain trends globally, it has become very important to investigate logistic and supply chain systems in Croatia as well as the changes in the logistic and supply chain systems and the level of the improvements. The paper is based on one research that has been principally aimed in detecting the current status of logistic and supply chain functions in Croatian companies and organizations. The results of the research gave guidelines for other researches of logistic systems, organizations and logistic experts in Croatia. The paper elaborates the results of the concluded research while questioning the research and providing possible guidelines for other future logistic researches.

Key words: Logistic, logistic research, supply chain, logistic in Croatia.

1 INTRODUCTION

Logistics and supply chain are positioned as one of the most important business functions. In the past few decades the optimization of logistic and supply chain as well as implementation of latest technology systems resulted in more sophisticated and improved supply chains. The benefits became self-evident and tangible – the logistic costs have been optimized and supply chain systems became an added value to the finished product and service. Following the global trends of logistics and supply chain, it has become very important to investigate the current status of logistic and supply chain in Croatia.

The base of the paper is the logistic research that was carried out during October of 2013. The main motive of the research was to determine the level of competencies of logistic employees in Croatian companies. It is evident that there has been a development in logistic educational programs over the past few years; traffic subsector in professional education in Croatia includes 12 four year educational programs and 4 three year educational programs while logistic subsector includes 1 four year educational program [16]. Also, university level logistic education has been introduced few years ago and has gained much popularity with the students. There is more than 22.000 employees in the logistics sector in Croatia; major part of the logistic related jobs are mid level office jobs and the major part of the logistic employees in Croatia have high school level degree [16]. Logistic and supply chain functions require vast range of knowledge of logistic and supply chain processes and functions as well as adequate expert response to operational daily changes. Logistic experts have to be able to have the special competencies and skills to adequately respond to day to day logistic management and operative challenges [10]. One of the most important logistic and supply chain key elements is the human element; depending on the level of expertise of the human resources within the logistic organization, there are more options in having the possibility to control and overview processes in the entire logistic network [12]. Therefore the need for expert logistic employees has been recognized by market and business requirements – the question is how did the organizations in Croatia respond to the logistic needs. Croatian retail companies are destined to build modern logistic systems based on modern information technologies since logistic costs in Croatia represent a high impact due to the lack of development in domestic production [9]. According to the available researches and papers, the author did not find any knowledge of the detailed scientific research related to the logistic competencies and skills of the employees working in Croatian companies regardless of the company function primarily logistic or not.

Survey has been planned to be an initial part of the more detail research referring to the logistic experts' current level of competencies and actual need for logistic experts in Croatia. Initial survey was supposed to give results on initial logistic overview providing details and directions for future more detailed research. However, the responses received as well as the number of the responses received did not provide information that could be representative on initial logistic overview in Croatia but it opened new questions and gave guidelines and possible directions for other researches.

What defines logistic scientific research as unsuccessful? Is the research unsuccessful if the results do not support the hypothesis? Can the results of the logistic research carried through survey be useful even with the low response? Should the researcher share the mistakes that have been recognized when the research has been concluded, with the peers? Should the conclusions reached upon recognizing the mistakes and investigating the faults of the research be published? Author's conclusion is that, even though the research did not result in desired way and there were some obvious faults in the research, there were some results that could be used as a base and guidelines for future researches. Therefore the final verdict was to put the ego aside, recognize the mistakes and faults, and publish the results.

One of the main results of this research could be the guidelines for other researches as well as the determination of challenges of logistic research in Croatia. The paper elaborates the results of the research in detail while pointing out the main challenges of the research. The author also questions the research method and possible mistakes so that other junior researches can use and learn from the paper. The conclusions give the synthesis of the research.

2 RESEARCH CONTEXT AND SAMPLING

The research has been conducted through a survey. Survey has been sent to the participants in October of 2013 and responses received until October 30th 2013 have been analysed. Survey participants have been companies from the data base specially created for this research. Data base has been compiled from 4 (four) different databases from which participants were randomly chosen:

- Croatian Chamber of Commerce online database (logistic companies in Croatia)
- Online database of various companies in Croatia on www.tvrtke.com
- Contact database of supply chain conference participants (2013 Supply Chain Arena)
- Personal contacts from online social network Linkedin

The research intention was to include various companies regardless of their size and the number of employees, therefore companies in the database were not only logistic companies. One of the published researches elaborates the results of the low level of consciousness of Croatian companies related to the modern technology impact to exposing and hiring human resources [13] therefore one of the motives for the research was also to give focus to the companies which primary function is not logistics and that could provide some answers on the logistic employees and logistic departments within those companies.

The survey has been sent by email to 430 companies while 60 or 13,95% usable questionnaires were received back. It is evident that there has been a low response to the survey. Some of the reasons for such low response have been investigated in detail and even discussed with the participants. Four possible reasons for low response were detected (apart from the addressees that just disregarded the survey and chose not to participate):

- Retail companies replied in general that it is their company policy not to participate in this kind of academic researches (this affected the low response since more than 20% of the database for the survey contained major retail companies in Croatia)
- No responses received from state owned companies and organisations as well as communal companies. Published research related to logistic of managing municipal owned real estate stated that half of the participants do apply elements of logistic approach to managing municipal owned real estate while the other half either does not or did not answer - which shows the level of logistic approach implementation [5]. The lack of received answers could reflect to the perception of logistics and logistics services as well as logistic approach implementation in state owned companies and organisations.
- There were many responses that logistic in general does not apply to their company (even though the company does use logistic services). This reflects to the perception of logistics and logistics services among non-logistic professionals in Croatia which could be a main motive for some new researches
- Conducting a survey through email can result in low response since some recipients of the survey disregard it automatically considering it similar to spam mail; using personal interviews and sending the survey through post could result in higher response rate

This low response did question the success of the research but the conclusion is that, even though there has not been a high response rate which would give a representative results on current logistics in Croatia, the responses received and the results gained do represent a good indication and could make a good basis for other researchers and researches.

The survey contained questions related to the organisation and the survey participant and the section of questions referred to the actual logistic employees and logistic managers as well as the level of their competencies.

3 SURVEY RESPONSES

3.1 Survey participant

Logistic experts within the organisations are responsible for managing complete processes considering operative functions of managing logistics, warehouse management, transport management, internal logistics, supply chain management, procurement management etc while logistic managers have to be able to plan, manage and change the complete added value chain [4].

Majority of the participants that have taken the survey belong to the managerial levels: 40 responses of 60 total responses (67% of total responses) are employed at manager level (board members, divisional directors, department managers).

Possible conclusion why majority of the responses came from the managerial level could also be linked to the perception of logistics in Croatia. Lower levels of employees are not connected with logistic functions and divisions therefore do not have a clear picture of logistic functions. This hypothesis could be a very interesting guideline for some future research.

Majority of responses came from the people who have 5-20 years of experience working in supply chain and/or logistics: 33,3% have been working in supply chain and/or logistics between 5,1 and 10 years and 31,6% have been working in supply chain and/or logistics between 10,1 and 20 years.

Among the responses that came from the supply chain and logistic divisions 81,48% had experience in logistic and/or supply chain between 5,1 and 20 years while 11,11% have less than 5 years of experience in logistic and/or supply chain. One response came from participant with more than 20,1 years of experience in logistic and/or supply chain while also one response came from participant with no experience in logistic and/or supply chain.

The majority of the responses came from the active logistic employees therefore this response could also be linked to the perception of logistics among non-logistic employees.

3.2 Logistic department and organisation

The participants were asked about the department division in which they are currently positioned within the organisation. Almost half of the responses came from the participants currently employed in the logistic and supply chain; 45% of responses came from the supply chain and logistic divisions. This can be also viewed in respect to the perception of logistics within the non-logistic companies and non-logistic employees since majority of them chose not to participate in the survey. These responses that came from the supply chain and logistic divisions came from following company industrial divisions: Sales 37 %, Production 19 %, Services 44 %. These responses resulted in another question: do other organisations that do not belong to industrial divisions of sales, production and services recognise the roles, responsibilities and importance of supply chain and logistics and what is their perception of supply chain and logistics.

One also very interesting result is that various responses received were such as Procurement, Warehouse and Logistics at blank box (participant had to input the department division themselves) even though there was an option of choosing Procurement and Logistics. This indecisiveness could be also linked to the perception of supply chain and logistic functions.

Majority of the responses received from the supply chain and logistic divisions are employed at companies with over 50 employees (as shown in Figure 1).That could lead to conclusion on perception on logistics within Croatian companies which we already mentioned that it could be a motive for new researches: bigger companies usually have employees divided in divisions and departments according to their functions. Therefore, there is a high chance that they do have logistic employees and do recognise the logistic and supply chain functions.

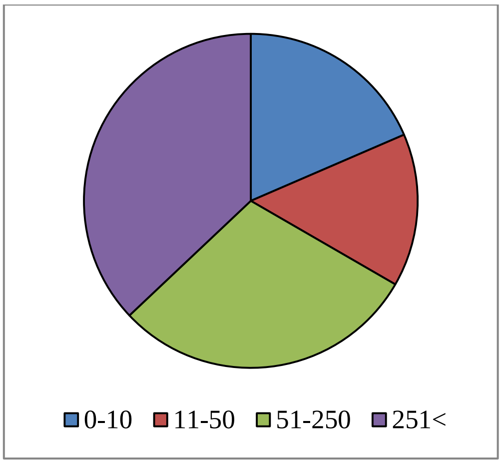


Figure 1: Company size – number of employees (responses received from supply chain and logistic divisions)

Source: author

All participants that responded that are employed at the supply chain and logistic divisions are employed at privately owned companies. That opened a new question: how do the state owned companies and organisations operate with their logistic functions, do they have logistic departments and what is their perception of logistic and supply chain functions (unfortunately, survey has been sent to several public and communal organizations and companies but no response came from those organisations).

Logistics as a business function pervades all of the other functions within organisations: research and development, procurement, production, sales [2].The result is a common premise that majority of the employees are connected somehow with logistic function, either working within logistic division or department or working on positions that use logistic functions. Authors of one research conducted in Slovenia concluded that there are opportunities for further development since 21,4% responses of their survey fully agreed that logistic in their companies is organised as an independent function [3].

One of the main intentions at the start of the research was to establish the existence of separate logistic and/or supply chain divisions in the Croatian companies. While companies with larger number of employees usually do have separate logistic departments, the question is how logistic functions are organised with smaller size companies. Research conducted on a smaller sized company Vitis d.o.o showed the company organisation which included logistic operator divided from warehouse and distribution function that included only warehouse-distribution operator [8].A very good review of customer satisfaction with Vitis d.o.o. is a result of constant investments in logistics and human resources [8].

Responses received to the question of existence of logistic department for organisations that do not have logistics as a primer function are following: (21,67% responses from the companies whose primer function is logistics), 45% of responses came from companies that do have logistic and/or supply chain division, 33,33% of responses came from companies that don't have logistic and/or supply chain division.

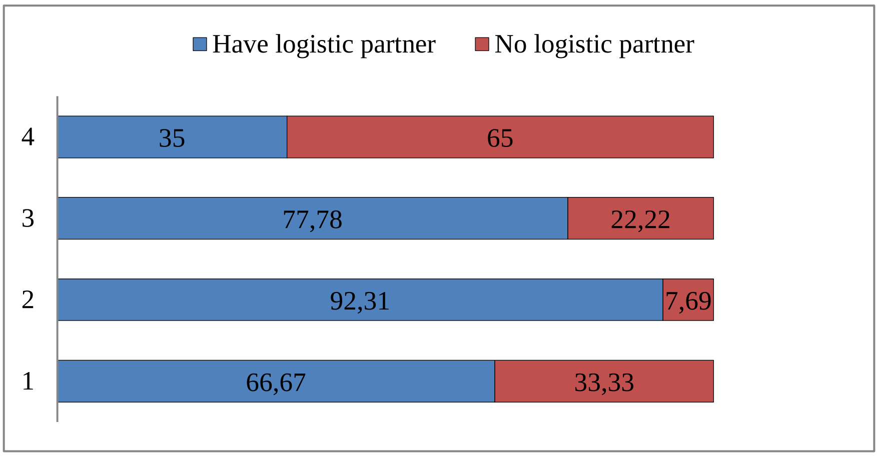
The principal goal of the research was to determine the actual status of existing logistic and/or supply chain employees. We have received 73,33% of the answers from the companies that stated that they do have employees that are working exclusively on logistic related positions while 26,67% of the responses came from the companies that do not have employees that are working exclusively on logistic related positions.

Logically, all of the responses (21,67%) that came from the companies whose primer function is logistics stated that they do have employees that are working exclusively on logistic related positions. Among responses that came from companies that do have logistic and/or supply chain division majority (96,30%) of them stated that they do have employees that are working exclusively on logistic related positions while 3,70 % stated that they do not. Among 33,33% responses that came from companies that don't have logistic and/or supply chain division responses received are: 25% of the responses stated that they do have employees that are working exclusively on logistic related positions while 75 % stated that they do not.

3.3 Logistic partners

One of the questions in the survey questionnaire was related to logistic partners. The intention was to investigate if Croatian companies rely on reliable logistic partners regardless of the company industrial divisions. More detailed research referred to relationship between Slovenian companies and logistic partners has shown that over half of 3PL respondents have very high level of collaboration and half of them have very good communication with their client [1].

Results related to logistic partners are shown in percentages in Figure 2.

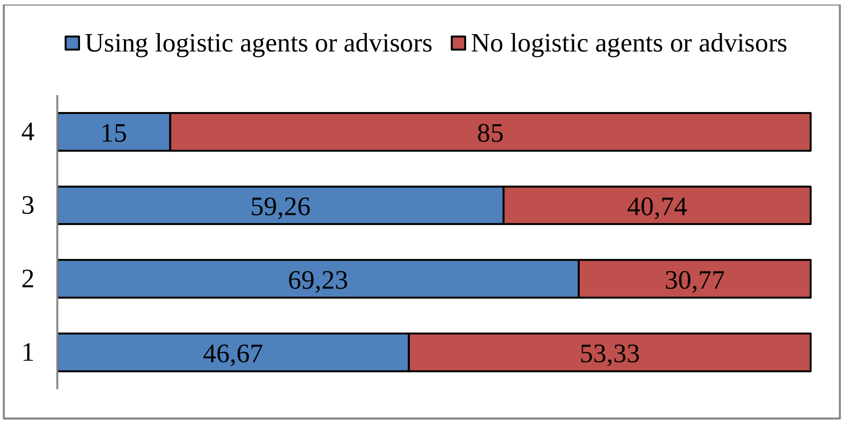


4 Companies that do not have logistic and/or supply chain division
3 Companies that do have logistic and/or supply chain division
2 Companies whose primer function is logistics
1 Total

Figure 2: Logistic partners

Source: author

There was also a question of using the logistic agents or advisors in order to establish new logistic and supply chain infrastructure. Results are shown in percentages in Figure 3.



4 Companies that do not have logistic and/or supply chain division
3 Companies that do have logistic and/or supply chain division
2 Companies whose primer function is logistics
1 Total

Figure 3: Logistic agents and advisors

Source: author

The results received related to logistic partners and logistic agents were not studied in detail. In order to elaborate the results and have some conclusions, future researches are needed.

3.4 Logistic employees and managers

The Chief Supply Chain Officer Report for 2012 emphasizes the gap between the amount and type needed to operate today's supply chain and what is available in the market [20]. Part of the research referred to supply chain talent challenges highlighted the differences in knowledge workers; knowledge workers in China are not seen as equal of those in United States or Germany [20].

The statement that logistic and supply chain management organizations have a real and growing people problem was the main result of 19th Annual Third-Party Logistics Study – almost half of the participants stated that there are problems with finding and retaining qualified employees [21].

The important factor in implementation of logistics is intellectual capital referring to support to logistic functions in knowledge perspective of: human resources, technology, production and traffic processes, services [7]. The critical resource of modern business is intellectual capital instead of physical and financial capital [14]. Human factor is ranked very high and is a very important factor that contributes to effective implementation of logistic [3]. There is a strong connection between companies related to reverse logistics since majority of companies does not have educated employees and optimisation strategies [9]. Logistic experts performing the logistic task need to ensure that the entire process runs smoothly, without interruptions and obstacles; and if some problems do occur, logistic expert needs to have the right competencies and skills as well as the right tools to resolute the problem in the fastest and easiest way [10]. Logistic expert as a vital part of the supply chain is a very important figure and can be considered as an added value to the entire chain; logistic expert represents a company resource which links the management and operational level [11].

Various authors higlighted the role and importance of human element in logistic and supply chain systems while some globally executed researches higlihted the trouble of hiring and keeping qualified employees. Therefore the intention of the research was to determine the actual status of human resources within Croatian organisations.

Following the question regarding the level of institutional competencies of logistic employees In Croatia, responses received are; 21,67% responses came from the organisations with no logistic employees, 23,33% responses stated that the logistic employees in general have high school degree, 50% of the responses stated that logistic employees in general have college or university degree while 5 % of the responses stated that the logistic employees in general have Master or PhD degree. Responses to the question whether logistic employees do have logistic or similar high school and/or university degree were questionable therefore those responses have been disregarded. The question in the survey has not been clear enough for the participants, therefore the responses were not useful. This could be used as a guideline for the author of this research as well as other researchers.

Also, these 5 % of the responses that stated that the logistic employees in general have Master or PhD degree could be questionable when compared to the other responses; therefore we can disregard this result following the possible conclusion that either the question was not expressed well and/or the participants did not understand it.

The intention of the research was to establish whether the companies do have logistic employees and what is their level of competencies. The question was much generalised and therefore the responses could not be detailed, question was possibly not understood by the participants so the responses received are not representative.

Logistics covers great number of various functions which might and might not be closely linked to primer logistic function; logistic experts and managers need to have a great range of knowledge, competencies and skills in order to respond to operative logistic challenges at managerial and operative function level [10]. Logistic management is responsible for eficiency of warehouse management, eficiency of busines assets usage, eficiency of transport and optimisation of all expenses within logistic sector [6]. Research related to inventory management in reverse logistics higlighted the concern from the logistic aspects, the lacking of planning shows a general management lacking [15]. New logistic approach is needed which also includes education of employees since there is a lack of logistic approach in management of recovered spare parts which is left to inertia and it happenes spontaneously [15].

Therefore, the importance of investigation of current level of managers' competencies becomes evident. The research intention was to establish whether the companies do have logistic managers and what is their level of competencies. The survey did not go into the depth of this issue.

Responses received were following: 23,33% responses came from the organisations with no logistic department therefore no logistic manager, 11,67% responses stated that the logistic manager has high school degree, 53,33% of the responses stated that logistic managers have college or university degree while 11,67% of the responses stated that the logistic manager has Master or PhD degree.

Next question was intended to establish do the logistic managers have institutional competencies (logistic degree) and responses received have been unusable which leads to conclusion that either the question was not expressed well and/or the participants did not understand it. Anyhow, the responses to that question are: 26,67% responses that there is no logistic manager, 43,33% responses that logistic manager has institutional competencies (logistic degree) while 30% responded that logistic manager has no institutional competencies (logistic degree). Of course, if these results are compared to the previous question, we can see the discrepancies; therefore these results have to be disregarded.

4 DISCUSSION AND CONCLUSIONS

The concluded research primarily was not successful due to various reasons, some of them attributed to the author of the survey:

- Methodology of the research was not correct
- Some of the questions were not detailed, they were too generalised and therefore not clear to the participants; the responses received were not representative
- Combination of questions was incorrectly formulated and therefore not clear to the participants; the responses could not result in the needed logistic overview
- Survey has been sent to the participants only by email which affected the low response; that should be changed and use more of personal interview form in order to have higher response and usable results

Results of the unsuccessful research are primarily questions that are opening debates and give guidelines for future researches. Although the results of the survey cannot be representative they do give some indications of the perception on logistics and logistics functions in Croatia.

Majority of the responses came from the managerial level so we can presume that they do understand the function of logistics – the question that follows is: What is the perception of logistics among employees on operational, administrative and other levels?

Majority of the responses came from the employees linked to logistic functions in some form - the question that follows is: What is the perception of logistics among employees working on non-logistic functions?

The survey has been disregarded by state owned companies and organisations as well as communal companies - the question that follows is: How do state owned companies and organisations organise their logistic services and functions?

Major retail companies disregarded the survey by responding that they do not participate in this kind of researches. Major retail companies usually do have logistic departments therefore the research that would include them needs to be executed by another method (probably use the interview form).

The research and the survey executed did not result in providing the info as per the main goal of the research. However, the research did gave result which can be used as an indication and a base for possible other researches. Therefore, there is no unsuccessful research. Even though the results of the research might not prove or disprove the hypothesis, the results of the research can always be used, even as a base for other researches or even as a guideline of how not to organize another research. Final result of this research is a lesson for the author as well as for other junior researches.

In order to be able to give some final results related to the conducted survey, it would be necessary to compare much more surveys or, in lack of existing published researches, conduct a new research.

REFERENCES

[1] Bajec P., Zanne M.; Trusted relationship: A key factor to successful future 3PL, International Conference on Transport Science ICTS May 2011

[2] Buntak K., Šuljagić N.; Economics of logistic functions in a company, Technical journal 8,4(2014), 388-393

[3] Dobnikar M., Bajec P.; Analyzing the role and importance of logistics for Slovenian enterprises, International Conference on Transport Science ICTS May 2011

[4] Funda D.; Sustav upravljanja kvalitetom u logistici, Tehnički glasnik Vol.4 No.1-2, 2010, 94-98

[5] Guszak I., Model logističke podrške upravljanju nekretninama u vlsništvu jedinica lokalne samouprave, Ekonomski pregled, 59 (7-8) 469-493, 2008

[6] Horvat Đ., Nedović Čabarkapa M.; Management of logistics in modern economic corporation, Poslovna logistika u suvremenom menadžmentu IX/2009, Osijek, 21-29

[7] Ivić K.; Intellectual capital – support for improvement and development of business logistics, Poslovna logistika u suvremenom menadžmentu X/2010, Osijek, 113-121

[8] Kozina G., Darabuš M.; The role of logistics distribution in Vitis d.o.o. – Varazdin, Technical journal 7,1(2013), 72-79

[9] Krpan LJ., Furjan M., Maršanić R.; Resources recovery retail logistics, Technical journal 8,2(2014), 182-191

[10] Macura A., Čišić D., Logistic roles and responsibilities considering operative logistic challenges, th International Maritime Science Conference IMSC April 2014

[11] Macura A., Čišić D., Logistic coordinator as inevitable part of supply chain processes, Pomorstvo: Scientific Journal of Maritime Research, Vol26 No.2, December 2012, pp.315-326

[12] Macura A., Kos S., Brčić D., Forming of multimodal transport network as part of specific product supply chain, International Conference on Transport Science ICTS May 2011

[13] Oroz Štancl I.; Croatian logistic companies' websites: advantage or disadvantage, Holon 3(2), 2013, 158-178

[14] Poletan Jugović T., Jurčić J.; Logistic forwarder operator as perspective of the classic forwarder, Pomorski zbornik 43 (2005)1, 151-163

[15] Tomašić D., Đukić G., Šafran M.; Inventory management in reverse logistics – analysis of Croatian automotive industry postsale practices, Tehnički vjesnik 20,3 (2013), 541-547

[16] Promet i logistika, profil sektora, Agencija za strukovno obrazovanje i obrazovanje odraslih, Zagreb 2012

[17] www.hgk.hr (accessed September and October 2013)

[18] www.tvrtke.com (accessed September and October 2013)

[19] www.linkedin.com (accessed September and October 2013)

[20] www.scmworld.com

[21] www.supplychainquarterly.com/news

THE CONCEPT OF DEVELOPMENT OF PASSENGER FERRY SERVICES IN THE BALTIC SEA REGION IN TERMS OF THE GROWING INTERBRANCH COMPETITION

Marta Mańkowska, PhD
University of Szczecin
Faculty of Management and Economics of Services
Department of World Economy and Maritime Transport
Cukrowa Street 8, 71-004 Szczecin, Poland
marta.mankowska@wzieu.pl

ABSTRACT

For decades ferry services were the main and traditional type of transport which enabled the passengers in the Baltic Sea Region (BSR) to move. The late 90's of the twentieth century brought about substantial changes in relation to the ferry services operational circumstances and their competitive environment in the BSR. The annulment of duty-free sales reoriented the business profile of ferry operators and directed more attention to the cargo segment. What also limited the competitive position of the ferry services handling passenger traffic was the fixed links, such as the Great Belt Fixed Link and the Oresund Fixed Link, which were brought into operation. Finally, since the turn of the twentieth and twenty-first century a key factor determining operation of ferry passenger services in the BSR has been a dynamic growth of air transport.

The changes in the market environment of ferry services in the BSR have contributed to the reduction or reorganization of a significant number of ferry connections in the Baltic Sea. The existing fixed links and developing air connections have become a practically unbeatable form of travel for passengers for whom the most important factor determining their choice of transport modes is travel duration.

The aim of this article is to create a concept of development of passenger ferry services in the BSR in terms of the growing interbranch competition. In order to do so an analysis and evaluation of the extent of mutual substitutability and complementarity of passenger transport services provided by ferry and alternative fixed links or air connections in the BSR will be performed.

Key words: Passenger ferry services, interbranch competition, Baltic Sea Region.

1 INTRODUCTION

For decades ferry services have been a primary transport branch enabling passengers, vehicles and merchandise to move in the Baltic Sea Region (BSR) and, at the same time, they have been undergoing a series of transformations in connection with the types of ferries in operation, functions they serve, as well as the structure of the traffic they handle. As a result of the continued integration of the majority of the EC countries (European Community) the beginning of the 90's of the 20th century was marked with a change in the competitive environment and conditions under which the ferry operators functioned in the Baltic region.

One of the most important changes was annulment of the duty-free sales within the area of the then EC. The decision made by the EU Commission was of significant importance to the ferry operators who provided services for the passenger traffic in the Baltic Sea Region, because income derived from the duty-free sales accounted for 33% up to as much as 66% of total income earned by the shipowners and ferry operators, which was dependent on the ferry services (Rodzoch, 2003, pp.125-129). In accordance with the approximate data provided by Generation Research due to the annulment of duty-free sales the annual decrease in income earned by the Baltic ferry operators and shipowners in the period from 1998 to 2000 accounted for 1.1 billion USD (-38.5%). In 2004, with the EC expansion, which included another Baltic states such as Poland, Lithuania, Latvia and Estonia, this trend was also observed in the ferry services in the south and east Baltic.

One of the most essential issues which the ferry operators will have to face in the BSR in 2015 is the changes relating to the emissions of pollutants and greenhouse gases generated by the sea transport means. These changes result from the 2010 EC directive which reduces the sulphur content down to 0.1% in marine fuel used by ships at berth (from 2015) within the Emission Control Area (ECA) which contains the Baltic and North Sea basins and the English Channel. Another issue is intended incorporation of sea transport into the European Union Emissions Trading System (Kotowska, 2014, pp.73-77). Undoubtedly, these actions will contribute to an increase in operational expenses of the ferry operators, who, as a result, will increase competitiveness of the alternative forms of transport including air and land (rail and road) transport.

At the same time, the development of interbranch competition in communication transport is a key factor determining operations of the modern passenger ferry services in the BSR. Numerous aspects, especially the ones related to the speed of moving (Tłoczyński, 2009, pp.195-205), made air travel more appealing to the significant part of passengers who had previously used ferry services. The development of air traffic on the main international routes in the BSR area is primarily generated by the low-cost airlines.

The end of the 20th century was also marked with construction of the first fixed links within the BSR which are, in terms of time, a more competitive alternative to ferry links as well, (Grey, 2010):

- The bridge-tunnel crossing across the strait of Great Belt, which was put into use at the turn of 1997 and 1998, along the total length of roughly 20 km linking the Danish islands of Zealand and Funen;
- The fixed, international road and rail crossing across the strait of Sound (Oresund Bridge) which was put into use in 2000 and is known as the Bridge over the Sound with its length of approximately 16 km, linking the Danish island of Zealand, with Copenhagen situated on its territory, and the town of Malmö in the province of Skåne.

Construction of the Great Belt crossing resulted in termination of the ferry connections which had linked the two Danish regions for over 100 years. Similarly, when the fixed, international crossing across the Sound was put into use, the direction of the passenger traffic between Europe and Scandinavia was changed. Construction of the fixed link resulted in termination of the Copenhagen-Malmö ferry service which had been the most popular ferry line in the BSR. Other ferry lines in the immediate vicinity were terminated or rearranged as well (Brogren, 2009, pp.12-16).

Another investments of this kind are planned for the future. The most advanced project is construction of a rail and road tunnel under the Fehmarn Belt (length: 18 km; due for completion in 2020) linking Hamburg and Scandinavia, which will be an alternative to the existing Puttgarden-Rodby ferry line. The second project under consideration is construction of a bridge linking the Danish city of Elsinore with the Swedish city of Helsingborg. This will be an alternative to the existing ferry link.

In order to compete successfully with the airline operators and fixed links, the ferry operators should use their competitive advantages and adopt their current concept of the development of the passenger services sector to the varying market conditions.

The aim of this article is to create a concept of development of passenger ferry services in the BSR in terms of the growing interbranch competition. In order to do so an analysis and evaluation of the extent of mutual substitutability and complementarity of passenger transport services provided by ferry and alternative fixed links or air connections in the BSR will be performed.

2 THE BALTIC MARKET IN PASSENGER FERRY SERVICES IN THE FACE OF INTENSIFIED INTERBRANCH COMPETITION

2.1 Market description

Considered as an alternative for handling the passenger traffic in the Baltic relations, ferry services include regular connections, i.e. ferry services of various lengths. For this kind of activity special types of sea vessels operate (ferry), of at least 1,000 or more GT (gross tons). They include dual-mode ferries providing simultaneous transport of passengers, merchandise and means of transport on one voyage and hold a dominant position in terms of their importance.

According to the data provided by ShipPax Information (ShipPax Data), there are over 2 billion passengers who travel by ferry every year with over 250 million passenger cars transported. The Baltic Sea is one of the leading ferry markets in the world. On average, every year (in the Period 2004-2013) it is over 220 million passengers and less than 85 million passenger cars transported in the BSR. Taking into consideration the economic and geographical determinants in the BSR the following regional ferry services markets can be distinguished:

1. West market which includes the ferry lines between Denmark and Sweden, Denmark and Norway, Denmark and Germany, Germany and Sweden, Norway and Germany; its ferry operators include Stena Line, DFDS Seaways, Scandlines AG, TT-Line and Color Line.
2. East market which includes the lines between Sweden and Finland and Estonia, Estonia and Finland and Russia; its is provided services for by such shipowners as Finnlines, Viking Line and Tallink Silja Line.
3. Middle market with the connections between Poland and Sweden, Latvia and Lithuania together with the trans-Baltic lines linking Germany and Lithuania, Latvia and Finland; its is provided services for by Scandlines AG, Finnlines, Tallink Silja Line, Stena Line, Polferries and Unity Line.

In terms of voyage duration ferry services can be divided into (Kotowska, 2014, pp. 144-146):

- short duration voyages of up to 2 hours,
- mean duration voyages of 2 up to 11 hours,
- long duration voyages of over 11 hours.

In the east-west relations the most active region in which the Baltic ferry services are performed includes the Helsinki-Tallin-Stockholm triangle with its centre in Mariehamn on the Åland Islands, which is a result of keeping shopping on these lines on a "tax-free" basis.

In this area the most popular are short voyages including the Tallin-Helsinki (2 h.) as well as mean distance routes such as the Stockholm - Mariehamn (5.25 h.) and long distance routes such as Stockholm - Helsinki (16 h.). In the north - south orientation from Scandinavia to the European continent the busiest traffic is observed on the shortest routes: from the Swedish city of Helsingborg to the Danish city of Helsingør (0.2 h.) as well as from the Danish town of Rødby to the German town of Puttgarden (0.45 h.). The high volume of passenger services is also characteristic of the mean distance, westward ferry lines from Sweden through the Sound to Denmark and then farther on through the Great Belt westward, as well as longer distance ferry services from Norway to Danish Jutland and Copenhagen. The mean distance voyages from the places in the south of Sweden, such as Trelleborg, across the Baltic Sea to the German ports of Sassnitz (4.15 h.) or Rostock (6 h.) are also popular. Importance of the mean distance lines, linking the Polish seaports with the ports of Sweden, particularly the ferry services from Świnoujście to Ystad (7 h.) as well as from Gdynia to Karlskrona (10.30 h.), is also on the steady increase. The long distance routes from Germany to Norway (Kiel-Oslo, 20 h.) and Sweden (Göteborg - Kiel, 14.5 h.), are also popular, especially in the sector of tourist transport.

The fleet of ferries operating in the BSR consists of more than 200 vessels and is one of the youngest in the world with an average ship lifetime of 15 years. The quality of the public passenger area (including the catering, accommodation, commercial, entertainment and business areas) in the operational sea ferries is at the same time the most important factor shaping the product range of passenger ferry services (Mathisen, 2010; Rigas, 2008).

Luxurious passenger cruiseferries (adapted also for transporting passenger cars), which have a high quality and roomy public passenger area, operate on the routes, such as the Åland Islands, with a high volume of the passenger traffic (Sjöström, 2007, pp.18-20; Wold-Hansen, 2010, pp. 22-25). The vessels of this kind have also been put into operation on few touristic Baltic lines between Germany and Norway with a shipowner Color Line, Finland and Estonia and Sweden as well as Estonia and Latvia (shipowners: Viking Line, Tallink Silja Line). It is less often, but it is still the case, that on these relations new generation high-speed passenger ferries (HSC) operate. They are also adapted for transporting passenger cars and are primarily dedicated to handling the communication traffic on short routes with a high frequency of voyages.

However, it is most often the modern dual-mode (passenger and freight) ferries which operate within the vast majority of the ferry lines operating in the BSR where, aside from the passenger traffic, intense freight traffic is observed, or within the relations with freight traffic prevalent over passenger traffic (except ferries which are used exclusively for cargo transport). With regard to the passenger area in relation to stowage this group of ships includes more and more popular pax-ro (passenger-freight) ferries as well as ro-pax (freight-passenger) ferries with a larger stowage (Hader 2008, pp.99-112; Takolander 2009, pp. 154-169).

On the one hand, in compliance with the idea of "ro-cruise" or "cruise-trailer" the modern pax-ro and ro-pax ferries enable ferry operators to provide services for both cargo and passenger transport, but on the other hand they enhance the product range of traditional ferry services (communicational function) towards a touristic function, or, more often, communicational and touristic function.

The communicational and touristic function combines the communicational function (transport from point A to point B) with providing additional services by carriers for passengers travelling by ferry, including, in particular, accommodation, catering, commercial and entertainment services. However, the strictly touristic function expresses the development of the tourist product range provided by ferry services and is expressed by the comprehensive services provided for the passengers both on board and land together with pick-pup and delivery services. This function is expressed in sales of integrated tourist packages. In this perspective a ferry operator is a tour operator, because what they have on sale is a maritime tourism product.

The level of importance of the passenger ferry services functions is varied on different Baltic ferry lines, which depends on their lengths, sizes and structures of the passenger traffic they provide services for as well as on intensification of the competition from other branches of transport.

2.2 A comparative analysis of the dynamics of development and structure of the ferry, air and land passenger traffic

Communication ferry transport on the mean and long distance ferry lines in the BSR face competition from airline operators**.** To illustrate the level of competition between air transport and ferry services in the BSR, the author used the levels of traffic generated by both branches of transport on the selected international Baltic routes, characterized by a high volume of transport, and, at the same time, with the services provided by air transport, i.e. Denmark-Sweden, Finland-Sweden, Denmark-Germany, Estonia-Finland Denmark-Norway, Germany-Sweden, Norway-Sweden, Germany-Norway, Estonia-Sweden, Poland-Sweden.

While comparing the absolute volumes of the passenger services provided by ferry services and air transport within the selected groups of states in the BSR, a dominant position of ferry services is clearly visible. In the years 2004-2013 the average yearly volume of passenger services provided by ferry services on the analyzed routes was approximately 47 million passengers, whereas for air transport it was 13.5 million passengers. However, the decrease in importance of ferry services providing services for the passenger traffic on the selected relations is demonstrated by way of comparing the development of transport in both transport branches (Figure 1).

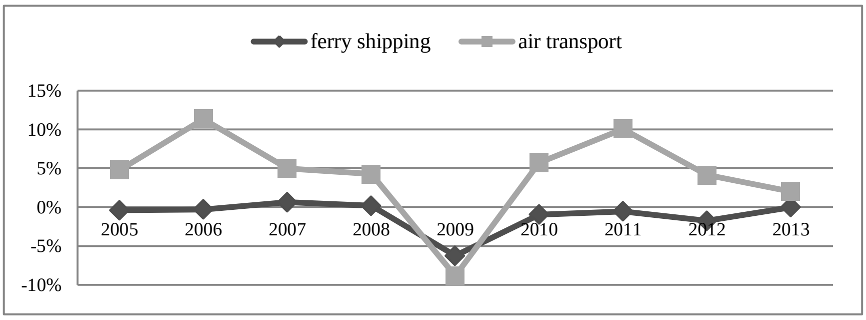


Figure 1: Progress of increase in the passenger traffic handled by the ferry services and air transport between selected BSR countries in the years 2004-2013

Source: Own work based on Eurostat and ShipPax (Eurostat Data and ShipPax Data).

In the analysed years 2004-2013, with sharp decreases in the years 2008 and 2009 taken into account, the annual average dynamics of increase in air transport was at a level of 4%, whereas ferry transport tended to decrease on average at a level of -0.3% per annum. However, what is worth pointing out is that in the worst period of time in terms of transport volume (2008/2009) a larger decrease in transport was reported in air transport (over 10%) than ferry services (over 6%).

In comparison to air transport, competition from land connections has a much smaller extent and is related to short distance links. From the two currently existing fixed links in the West Baltic region only the fixed land crossing in the south part of the Sound Strait, i.e. the Oresund Bridge, is of international nature. An alternative to this connection is the Elsinore-Helsingborg ferry service in the north part of the strait of Sound.

At the end of 2000 the Oresund Bridge land connection was used by almost 5 million people. However, in 2005 the number of passengers using the Oresund Bridge (11.7 million) exceeded the number of passengers travelling by ferry on the Elsinore-Helsingborg route (11.1 million). In the entire period of 2004-2013 the average annual volume of passenger services provided by ferry services on the analysed route was 9.7 million passengers, whereas the fixed land connection was used by 14 million passengers (60% - personal car travel, 40% - rail transport). This trend was carried on in the following years and the weakening competitive position of ferry services within these relations is also confirmed by a comparative analysis of the dynamics of growth in both transport sectors (Figure 2).

The nature and level of competition between ferry services and alternative land and air transport in the BSR is primarily dependant on the transport distances where transport services are performed and on the type of transport needs which the alternative branches of transport will meet. A passenger who has an alternative for picking their means of transport, based on the information they have on the primary and functional properties of a particular service specified by a transport operator, confronts this information with their expectations which, to a great extent, are related to their travel motivation.

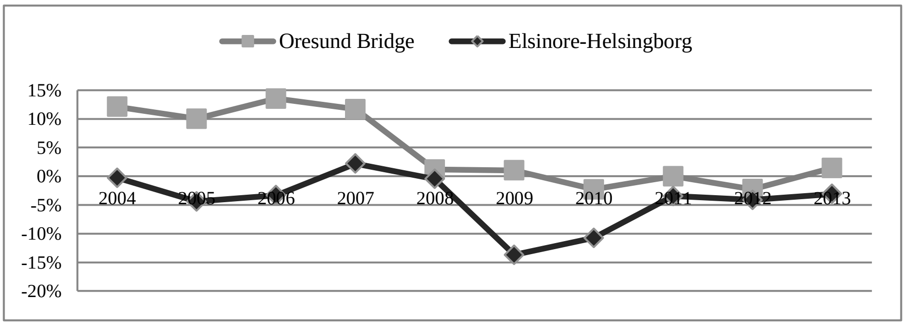


Figure 2: Progress of increase in the passenger traffic handled by the ferry services (Elsinore-Helsingborg route) and Oresud Bridge in the years 2004-2013

Source: Own work based on ShipPax (ShipPax Data).

In order to identify motivations for the trips taken by passengers who use the product range of ferry services as well as alternative air transport the selected results of a survey conducted by the author in the summer seasons of 2009 and 2010 on 650 passengers who travelled by ferry and plane between Poland and Sweden (Mańkowska, 2013A, pp. 133-146; Mańkowska, 2013B, pp. 89-98). In respect of their declared travel motivation three main groups (divisions) of passengers were distinguished in the survey:

- passengers who travel for touristic reasons (this group included passengers who travel to visit their friends, acquaintances and relatives);

- passengers who travel on business (this group included both passengers travelling on their own, as well as in company, who take part in business meetings aboard the ferry);
- passengers who travel to work, study (migrants/commuters).

Figure 3 illustrates the involvement of each passenger group in relation to the particular transport branch.

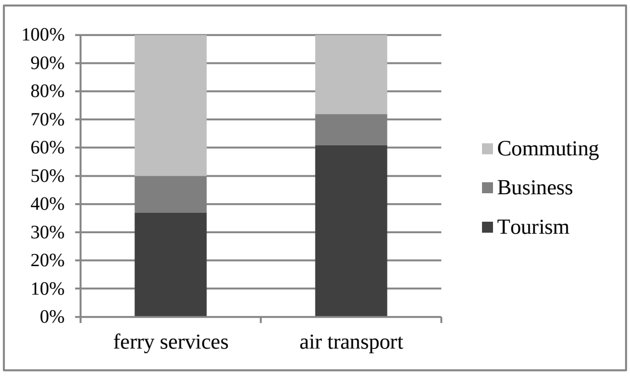


Figure 3: Declared travel motivations of the passengers who use ferry transport and air transport (percentage of indications)

Source: (Mańkowska, 2013A, pp. 133-146; Mańkowska, 2013B, pp. 89-98).

In the case of ferry services it was the passengers whose motivations for employment seeking and touristic reasons were prevalent in the analysed period of time. Furthermore, it is worth pointing out that over 80% of the passengers travelling by ferry for touristic reasons treat the ferry as a means of transport which enables them to reach a specific destination on land or utilize other forms of sea tourism. It was a mere 17% of people who use ferry tourism services. In the group of ferry services passengers, who took part in the survey, 93% were passengers who travel in their personal cars and only 7% were foot passengers. In the case of air transport passengers the prevalent group included people who travel for touristic reasons. In the group of surveyed passengers the main factor that influenced their choice of air transport over ferry was duration of the trip (71% of the surveyed respondents).

The surveyed ferry transport passengers were also asked to give their assessment relating to the importance of key transport demands in connection with the fulfilment of their journey by ferry including duration of the trip, cost, safety and comfort as well as punctuality and accessibility of the transport infrastructure and these demands which result from a specific nature of ferry transport. The biggest asset of ferry transport seems to be its dual-mode nature manifested in a simultaneous option for transporting passengers themselves and their accompanying means of transport (passenger cars), Figure 4.

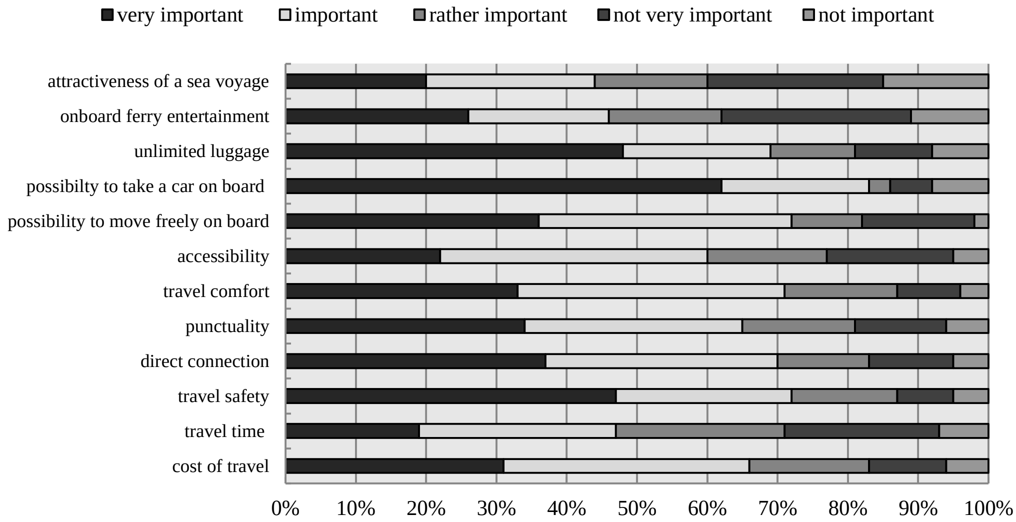


Figure 4: The passengers' assessment of particular components related to the fulfilment of their journey by ferry (percentage of indications)

Source: (Mańkowska, 2013A, pp. 133-146; Mańkowska, 2013B, pp. 89-98).

The biggest advantage of ferry services over competitive air transport is definitely its dual-mode nature manifested in a simultaneous option for transporting passengers themselves and their accompanying means of transport (passenger cars) on one voyage. However, this factor is less important in the face of competition from alternative, rail and road land transport which takes place on the short distance routes in the West Baltic region.

In order to illustrate the profile of passengers who travel across the strait of Sound aboard the ferries and who use the Oresund Bridge the results of research performed by the Oresund Bridge operator in the summer of 2009 were applied (Øresund Trends, 2012, p.91). The research emphasizes diversity of motivations for the trips taken in respect of additional means of transport (Figure 4).

Basically, in the case of passengers aboard ferries the touristic motivations are prevalent. In the case of passengers who use the Oresund Bridge the people who commute comprise the biggest percentage[1]. A total of 61% of those travelling by ferry were on leisure or holiday trips, while 32% were commuters. On the Oresund Bridge, 36% of car passengers and 49% of train passengers were commuters, whereas 35% of car passengers and 39% of train passengers were on a leisure or holiday trip. Business travellers preferred to cross the Øresund Bridge by car. And 28% of the car passengers traveled on business, while the figure for rail passengers was only 9%. For those crossing the Oresund by ferry, 16% were on business (Øresund Trends, 2012, p.91).

[1] For the most part, it results from the local nature of these connections which, for over 75% of them, are one-day trips. The citizens of Denmark account for over 50% of the passengers in this group, whereas the citizens of Sweden account for 20% and other nations comprise the remaining 30%.

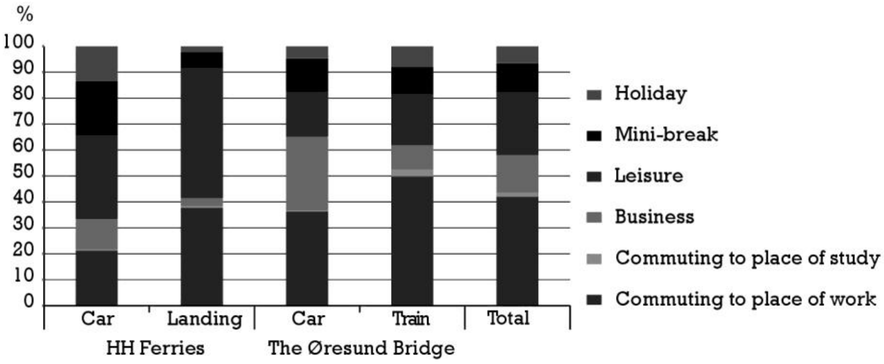


Figure 4: Declared travel motivations of the passengers who use ferry transport and the fixed link across the Øresund (percentage of indications)

Source: (Øresund Trends, 2012, p.91).

To sum up, overland transport and air transport in particular are unrivalled means of travel for passengers who consider duration of their trip all-important. The time factor is of the utmost importance, especially with regard to the mean and long distance connections for which there is a striking difference between the duration of the trip by ferry and air.[2] The main reason for constructing fixed links is also seeking to shorten the duration of the trip, although in this case the difference is smaller in comparison to air transport[3]. Therefore, the potential for development of ferry services should be found in each division of passengers who do not consider duration of their trip as a main deciding factor in relation to their choice of transport branch. Principally, the factors, which contribute to competitiveness of ferry services against alternative transport branches in handling communicational transport, can include:

- cost and comfort of travel on short routes with regard to overland transport as well as mean and long distance relations with regard to air transport;
- opportunity to move in one's own car on each relation, unlike in the case of alternative air transport;

A unique product of ferry services, which is not influenced by competition from air transport or fixed links, is also a tourist product range. In the circumstances of intensifying interbranch competition in handling the communicational traffic, it can be a basis for developing a long-term strategy of the development of passenger ferry services in the BSR.

This approach should be expressed by construction of a comprehensive transport product range which takes into account the needs and expectations of various user groups.

[2] For example, on one of the analysed Baltic routes between Poland and Sweden for which services are provided by the Gdańsk-Nynäshamn/Stockholm ferry line (19 h. long voyage) and the Gdańsk-Stockholm air connection (1 h. long flight) this difference is 18 hours.

[3]Currently, it is estimated it takes 30 minutes to cross the Oresund Bridge on the Copenhagen-Malmo route. The ferry crossing on the Elsinore-Helsingborg takes 20 minutes, but its length is shorter than 11 km. It is worth pointing out that the analysed ferry route is not a direct alternative to the bridge connection, because the distance between Copenhagen and Elsinore is 50 km. This can change if the investment to construct a fixed link on the Elsinore-Helsingborg route is accomplished.

3 THE CONCEPT OF A PRODUCT RANGE OF PASSENGER FERRY SERVICES IN THE BALTIC SEA REGION

With the structure of demand for passenger ferry services in the BSR and identified competitive advantages in the structure of a suggested product range provided by passenger ferry services, three autonomous, and at the same time integrated, partial ranges should be distinguished (Figure 5):

- communicational product range,
- tourist product range.
- commercial product range.

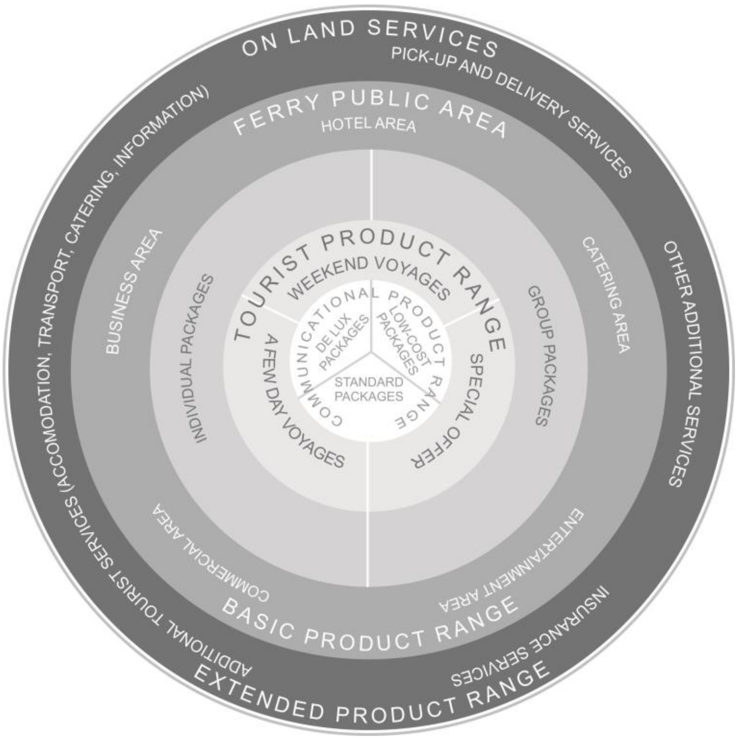


Figure 5: The concept of a product range of passenger ferry services

Source: Own work.

The specified partial product ranges should be made to the particular groups of passengers who use ferry services, and selected on the basis of the trips the passengers make as well as the function the ferry serves for providing this product range (Figure 6). Each of the specified, autonomous, partial services (communicational, tourist and commercial) should be performed at a basic and extended level, depending on the needs and expectations of the particular group of clients.

The basic product range includes all the types of specified partial product ranges which are fulfilled only aboard the ferry, that is within its unrestricted public area. Therefore, the general quality of services performed within one basic product range is determined by the quality and accessibility of particular components of the ferry public area together with the level of services provided for these components. The auxiliary product range contains an array of additional services provided for passengers outside the public area of the ferry, including pick-pup and delivery services from/to ferry terminals, additional tourist services and insurance services.

The core of the basic and extended product range is the communicational product range which is also a basic product range for the fulfilment of the touristic and commercial product range.

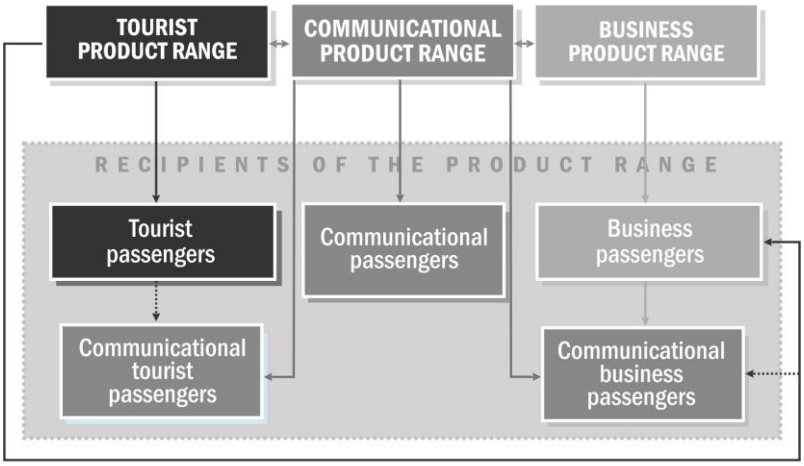


Figure 6: Recipients of the product range provided by passenger ferry services

Source: Own work.

The communicational product range which expresses a traditional ferry services function is aimed at a wide group of recipients, and in respect of the objective of the trip taken the recipients of this product range can include the following groups of passengers:

1. Communicational passengers who travel to study and work within the BSR states (commuters/migrants);
2. Communicational passenger groups which travel by ferry in order to use another tourist product range in their travel destination, or to visit their friends, family or acquaintances;
3. Communicational business passengers who travel to their destinations in order to participate in their business meetings.

Additionally, it would be reasonable to distinguish within this product range diverse price and quality travel packages dedicated to the specified groups of recipients who would be categorized, for example, according to their age and wealth.

The touristic product range is for the most part aimed at passengers who travel for touristic reasons and consider the ferry as a basic or one of the main attractions of their trip. Indirectly, communicational tourist passengers use this product range as well.

The trends observed on the tourist market in general indicate changes in passengers' preferences in relation to the duration of their leisure time. Instead of traditional two-week holidays, a few-day leisure periods are becoming more and more popular. From the vantage point of ferry services it is a perfect opportunity to develop this product range as an interesting form of spending several away days at sea (the so called "mini-cruises") with a possibility for visiting attractive places on land. Providing comprehensive tourist products of the ferry services market requires close, inside-branch cooperation with regard to the arrangement of tourist ferry voyages using the routes and ferries for which services are provided by other ferry operators as well as cooperation with the entities from other sections of services including tourism, transport and entertainment.

The current business product range of ferry services is for the most part aimed at organised groups and relates to the so called business tourism. It comprises arrangement of business meetings aboard the ferries, including conferences, trainings, workshops, together with packages of additional services provided on land. These products are very popular in the BSR, especially on the mean and long distance routes for which services are provided by cruiseferries. This product range, however, does not include attractive products dedicated to individual (communicational) business passengers who are one of the target groups of air transport passengers as well as clients who choose the product range of fixed links. The increase in traffic in this passenger division is influenced by trade between the BSR states, which generates demand for business trips.

Ferry services stand a chance in the development of services provided for this division of clients. It results from impediments in relation to passenger clearances at airports (congestion, security issues and natural factors such as weather conditions). As a result air travel time increases and its comfort and reliability decreases. It is also very often that airports are much farther away from the city centres, but ferry terminals are usually located in a closer vicinity to the centre. An additional advantage of ferry services over air transport in this division of passengers can be an opportunity to move in one's own car within a place/country of destination. In this context, however, the range of fixed links is limited spatially. Even taking into account new investments of this kind (Fehmarnbelt, Elsinore-Helsingborg), competition in this field will actually be concentrated in the West Baltic region.

4 SUMMARY AND CONCLUSIONS

Changes in the operational circumstances and competitive environment of ferry services in the BSR, particularly these changes which pertain to the introduction of a duty-free sale ban and development of the new areas of interbranch competition, have contributed to a decrease in its competitive position in handling the passenger traffic. Expansion of low-cost airlines which provide a faster, and very often, cheaper opportunity to move resulted in taking over part of the demand in the division of communicational transport which had been traditionally handled by ferry services. Analogously, construction of the fixed links in the West Baltic region have resulted in termination or rearrangement of the existing ferry services.

As a result, these factors have lead to the change in the operational profile of numerous ferry operators who directed more of their attention towards a more profitable division of cargo transport. The cruiseferries, which have been popular to date, are systematically replaced or restructured, at the expense of the passenger space, into pax-ro or ro-pax vessels with a larger truck capacity. The concept of development of ferry services based on operations of dual-mode ferries seems to be a prevalent direction of the development of this form of passenger maritime transport in the near future.

Intensification of interbranch competition between the ferry operators and air carriers as well as the range of fixed overland links results from a substitutable nature of these forms of transport. Whereby, complete substitution is out of the question. Transport services provided by the analysed, alternative transport branches are not homogeneous, but explicitly heterogeneous. Therefore, the ferry operators have an opportunity to gain advantage and build a competitive position by way of developing a comprehensive, transport product range which takes into account the needs, expectations and preferences of the particular types of its clients.

For this concept to be successful permanent monitoring of the structure of demand for transport should be its basis. An important, but currently unappreciated division of the ferry services passengers can be people at the age of 50 and over as well as 60 and over. According to some estimates in the years 1990-2020 participation of this population of clients of ferry services in the BSR will increase to as much as 75% of the passengers as a whole (Wollman 2010). People at this age tend to be very mobile and make demand for tourist services of high quality. On the other hand the ferry services range should, to a greater extent, meet the expectations of young people under 25, which basically requires changes in how this product range is perceived. Because now, passenger ferry services are often perceived as an outdated and uncomfortable means of travel.

What is also a very important issue is the improvement of standards of the public area on the ferries. This is accomplished by way of modernising the existing vessels or putting new vessels into use. The attractiveness of ferry services will also be determined by the development of the available ferry links network, which in comparison to, for example, the air market, is very costly. A solution can be internal and interbranch development of cooperation between the ferry operators, that is the development of range of combined sea and land voyages, in compliance with the idea of "thinking outside the box".

An important factor which has its impact on competitiveness of the ferry services range in the BSR is also improvement of the port infrastructure so that more and bigger ferries can be handled (modernization and/or construction of new berths) as well as the port suprastructure (passenger terminals which condition the improvement of handling) in connection with the improvement of their transport (road and rail) accessibility from land.

In the context of necessary fulfilment of investment actions, the biggest threat to the operations of the ferry operators in the BSR will be implementation of the new environmental regulations which can result in a decrease in competitiveness of the whole ferry sector, and thus weaken its tendency to invest. Consequently, it will, even more, shift the passenger demand from maritime transport to the alternative air and land routes, which will therefore result in termination of the operations performed by the small carriers, sale of the fleet and reduction in its value on the secondary market.

REFERENCES

[1] Brogren, K. (2009). Bridge over smooth water. Cruise&Ferry Info (NO. 1/2009). Halmstad, Sweden: ShipPax Information, pp. 12-16.

[2] Eurostat Data, http://epp.eurostat.ec.europa.eu, [downloaded on:7.07.2010 and 27.01.2015].

[3] Grey, M. (2010). Ferries still in contention. Interferry News. www.interferry.com [downloaded:10/05/2010].

[4] Hader, A. (2008). Car ferry, cruise ferry and ropax – ferry design between typology and individualization. In K. H. Breitzmann (Ed.), Cruise and ferry passenger shipping. Growth potential, ports, regional marketing and economic effects in the Baltic Sea Region (Heft 22, pp. 99-112). Rostock: Baltic Institute of Marketing, Transport and Tourism at the University of Rostock.

[5] Kotowska, I. (2014). Short Sea Shipping in the light of the idea of sustainable development of transport (pp.70-71, pp.135-137). Szczecin: Scientific Publishing House of the Maritime University in Szczecin [In Polish: Żegluga morska bliskiego zasięgu w świetle idei zrównoważonego rozwoju transportu].

[6] Mańkowska, M. (2013 A). Evaluation of the competitive potential of ferry service in relation to air transport to handle passenger traffic between the Polish and Sweden. In J. Dąbrowski, T. Nowosielski (Ed.), Współczesne problemy lądowo-morskich systemów transportowych, (pp. 133-146). Poland: The Institute of Maritime Transport and Seaborne Trade [In Polish: Ocena potencjału konkurencyjnego żeglugi promowej względem transportu lotniczego w obsłudze ruchu pasażerskiego między Polską a Szwecją].

[7] Mańkowska, M. (2013 B). The areas of competition and planes of cooperation in the Polish passenger transport market (sea, rail and air transport). Logistics and Transport (Vol. 20, No. 4, pp. 89-98). Poland: The International University of Logistics and Transport in Wrocław.

[8] Mathisen, T.A. (2010). Service Quality Aspects in Ferry Passenger Transport – Examples from Norway. European Journal of Transport and Infrastructure Research (Issue 10(2)/2010). www.ejtir.tbm.tudelft.nl [downloaded on 10/01/2015].

[9] Øresund Trends (2012). www.orestat.se [downloaded on: 5/02/2015], p.91.

[10] Rigas, K. (2008). Boat or airplane? Passengers perceptions of transport services to islands. The example of Greek domestic leisure market. Journal of Transport Geography. doi:10.1016/j.jtrangeo.2008/07/005, www.elsevier.com [downloaded on 10/12/2013].

[11] Rodzoch, K. (2003). Baltic ferry services market on the eve of the enlargement of the European Union. In H. Salmonowicz (Ed.), New conditions for the functioning and development of the Polish liner and ferry services (pp. 125-129). Szczecin: Foundation for the University of Szczecin [In Polish: Bałtycki rynek żeglugi promowej w przededniu rozszerzenia Unii Europejskiej].

[12] Sjöström, P. (2007). The Color Magic: A cruise vessel on a ferry route. Scandinavian Shipping Gazette (October 26/2007). Sweden: Göteborg, pp. 18-20.

[13] ShipPax Data. Statistical Yearbooks of ShipPax Information (2006-2014), Halmstad, Sweden: ShipPax Information.

[14] Sverre Wold-Hansen, P. (2010). Viking Line – cruise ferries from the centre of the Baltic Sea. Ferry update. News from DNV to the ferry Industry (NO. 1 2010). Norway: Det Norske Veritas, pp. 22-25.

[15] Takolander, K. (2009). The Ropax concept – a growing concept in the Baltic. In K. H. Breitzmann (Ed.), Cruise and ferry passenger shipping on the Baltic Sea Mass tourism and/or product differentiation? (Heft 27, p. 154-169). Rostock: Baltic Institute of Marketing, Transport and Tourism at the University of Rostock.

[16] Tłoczyński, D. (2009), Instruments to support the competitiveness of regional air transport. In M. Michałowska (Ed.), Efficient transport - Competitive economy (pp. 195-205). Poland: Publishing House of the University of Economics in Katowice [In Polish: Instrumenty konkurencyjności regionalnego transportu lotniczego].

[17] Wollman, B. (2010), A fast growing business opportunity. Cruise and Ferry Info. An eruption of thoughts (Special addendum Ferry Shipping Conference May 2010).

IMPROVEMENT OF CREW RESOURCE MANAGEMENT (CRM) REGARDING GERMANWINGS FLIGHT 9525 DISASTER

Željko Marušić, D.Sc.
Dajana Bartulović, M.Eng.
Ivan Forjan, B.Eng.
University of Zagreb
Faculty of Transport and Traffic Sciences
Vukelićeva 4, Zagreb, Croatia
zmarusic@fpz.hr

ABSTRACT

Crew Resource Management (CRM) represents a management system which deals with resources, equipment, procedures and people. CRM training includes knowledge, skills such as communications, problem solving, situational awareness, teamwork, and decision making. The continuous improvement of CRM techniques, training, and resources will increase safety and minimize risk as the aviation industry advances. Crew Resource Management can become a powerful tool to ensure safe aircraft operation. CRM training also represents a set of training procedures which can prepare flight crew for situations where human error can have enormous impact on overall aviation safety. Accident that occurred recently involving Germanwings Flight 9525, indicated how CRM training needs and requires improvements. This paper is focused on improvements in assessment of Crew Resource Management and evaluation of flight crew performance. Preposition is to include polygraph testing during flight crew training and testing.

Key words: Crew resource management, assessment, improvement, flight crew, polygraph testing.

1 INTRODUCTION

Crew Resource Management (CRM) optimizes use of resources, equipment, procedures and people. CRM training is focused on preparing flight crew to react and act correctly during situations where human error can have enormous impact on overall aviation safety.

Recent aircraft accident involving Germanwings Flight 9525, where pilot deliberately crashed the aircraft into the mountain, emphasized the shortcomings in CRM training.

There has been several similar aircraft accidents in the past.

In 2013, Mozambique Airlines Flight 470 pilot intentionally crashed the aircraft in Namibia, 33 people were killed, and the motives are still unknown.

In 1999, in New England, Egyptair Flight 990 crashed, 217 people were killed, because co-pilot intentionally crashed the airplane as the act of vengeance to previous suspension based on false sexual harassment allegation.

In 1997, Silkair Flight 185 crashed into the Indonesian river Palembang short after the take-off, where 104 people were killed. The black box was found intentionally turned off, and pilot made no attempts to save the airplane from falling.

In 1994, Royal Air Maroc ATR-42 serving the Flight 175 crashed ten minutes after take-off, in Morocco. Investigators came to the conclusion that the accident was caused by the pilot who decided to end his own life.

In 1982, Japan Airlines Flight 350 crashed during the take-off right after the fight occurred between pilot and co-pilot. 24 people were killed, and captain was banned to fly one year because of psychological problems.

The preposition is to include polygraph testing (lie detector testing) while conducting psychological tests of the flight crew, and also during CRM training.

2 GERMANWINGS FLIGHT 9525

As it was reported by press, Flight 9525 departed from Barcelona (El Prat Airport) at 09:01 UTC and headed to Düsseldorf Airport. Germanwings A320 aircraft, serving the Flight 9525, crashed in the French Alps on March 24th 2015, about 100 kilometers away from Nice, (within the Massif des Trois-Eveches).

Crash followed after rapid descent which started after the contacting ATC and aircraft reached cruising altitude. Everyone (150 people) on board were killed. It is believed that co-pilot intentionally crashed the aircraft.

Co-pilot received a sick note for the day of the crash, but he reported for duty anyway without informing anyone about his illness. Co-pilot was suffering from an undetermined illness and a note about his condition was found torn up in his apartment during investigation. Co-pilot was treated for depression in the past.

At one point pilot left the cockpit, and it is believed that this is when co-pilot locked the pilot in command out of the cockpit, before starting a descent that caused the aircraft to crash into the mountain. The pilot tried to enter the cockpit, he had a code to unlock the door, but the panel to unlock it was disabled. According to the black box, the pilot tried to enter using the intercom, he tried knocking and banging on the door, but with no success.

At 09:30 UTC, the aircraft left its assigned cruising altitude of 38,000 feet (11,580 m) and began a rapid descent without approval.

The descent time was about 10 minutes. The aircraft was descending at average descent rate of 3,400 ft. /min or 58 ft. /s (18 m /s). French ATC tried to contact the aircraft in descent, but without success. Radar contact was lost, when the aircraft was flying at an altitude of 6,175 ft. (1,882 m). [6]

Data from the transponder showed that the autopilot changed settings from the cruising altitude of 38,000 ft. (12,000 m) to the altitude of 100 ft. (30 m), which is the lowest setting of the autopilot.

Cockpit voice recorder recorded the contact from the ATC tower, pilot’s trying to enter the cockpit, and also calm breathing of the co-pilot during the descent. Cockpit voice recorder also recorded the screams of passengers before the crash.

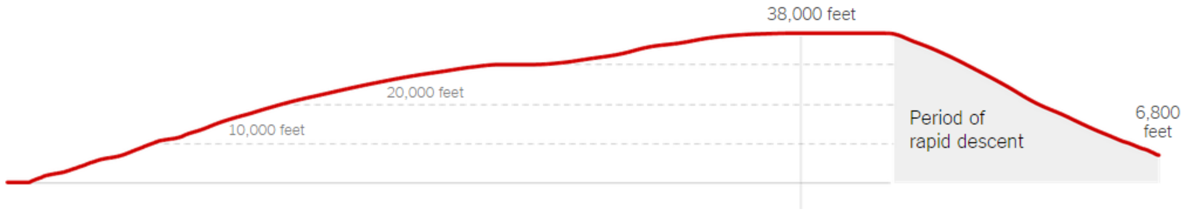


Figure 4: The descent of Germanwings Flight 9525

Source: New York Times: Todd Curtis, Airsafe.com; Glenn Harmon, Embry-Riddle Aeronautical University; flight path data from Flightradar24

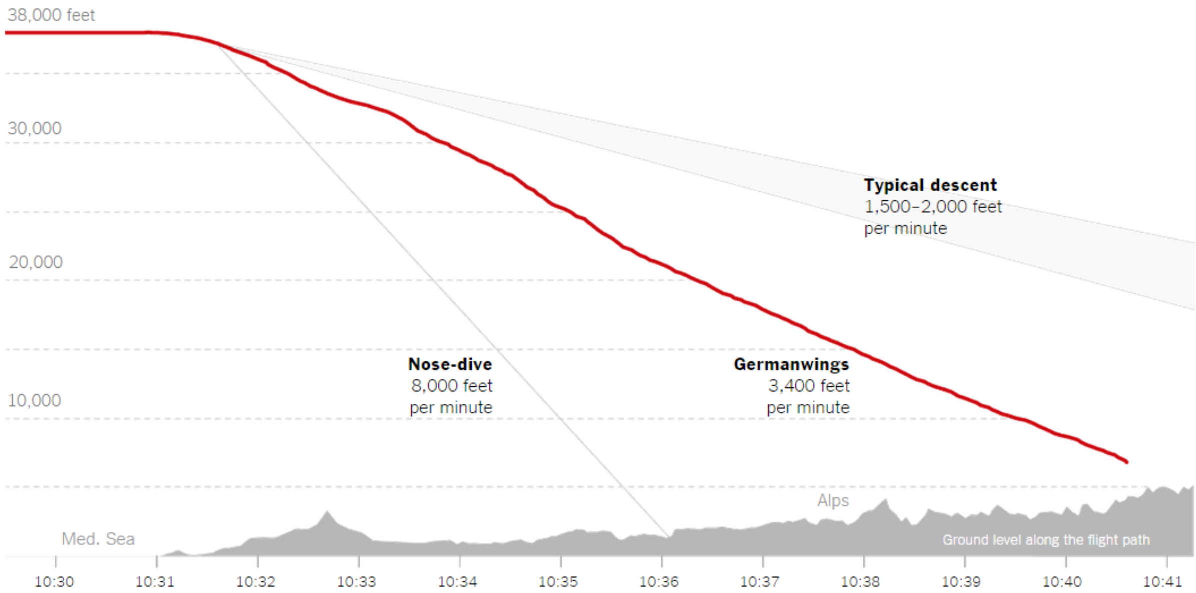


Figure 2: The descent of Germanwings Flight 9525

Source: New York Times: Todd Curtis, Airsafe.com; Glenn Harmon, Embry-Riddle Aeronautical University; flight path data from Flightradar24

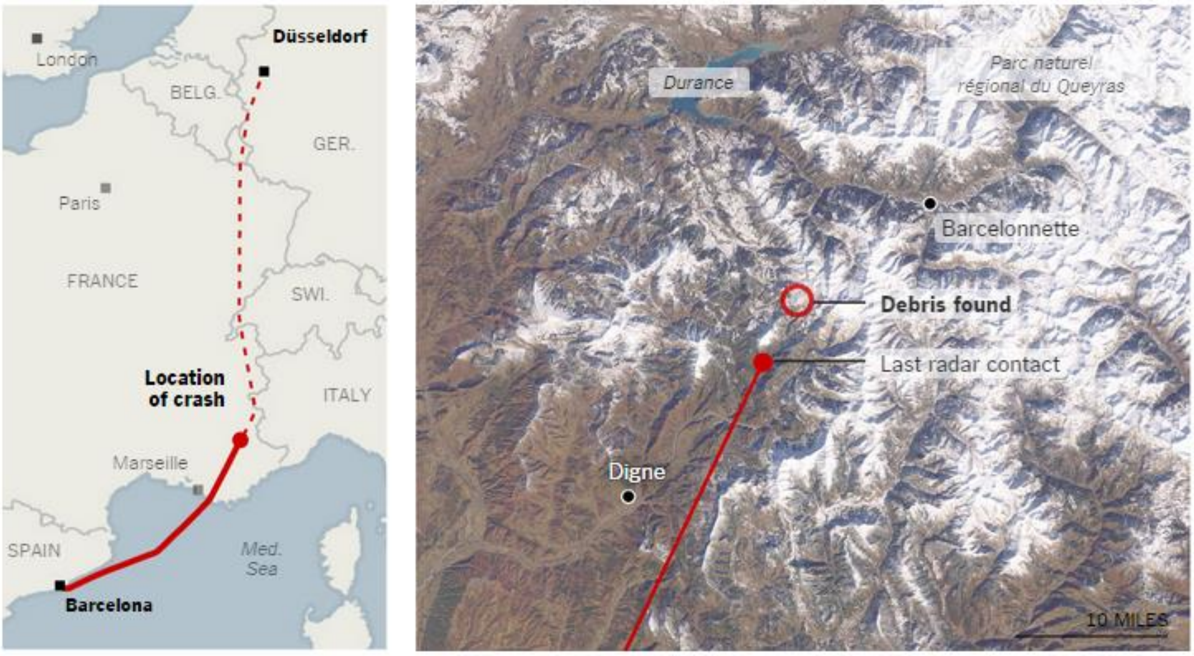


Figure 3: Flight path and crash site of Flight 9525

Source: New York Times: Flight path data from Flightradar24; satellite image by Earthstar Geographics via Bing Maps; debris location from French national police

3 CREW RESOURCE MANAGEMENT (CRM) TRAINING AND ASSESSMENT

Crew Resource Management (CRM) represents important management system for safety improvement by improving flight crew preparedness in various flight situations during flight operations. More attention and improvement of CRM can impact long-term improvement in aviation safety.

CRM is focused on flight operations and flight crew preparedness in various situations, i.e. CRM is developed especially for pilots and flight crew.

CRM training is performed on the following occasions: initial CRM training (for those who have not previously undergone such training); type-specific CRM training (for personnel who switch to a different aircraft type, as part of their conversion training); operator-specific CRM training (for personnel who switch to a different operator); and recurrent CRM training (for all flight crew and it regularly conducted and scheduled to cover the content of the initial course over a three-year period). [1, 10]

Important part of all training is evaluation. CRM training evaluation is considered more important than evaluations of other training courses because the impact of this is not easy to see in the short term. Valid CRM training must be used for follow-ups and further development of the CRM training.

It is all about closing the circle that begun by using information about operations to form the basis of CRM training, which was then subsequently performed and then evaluated to see if it has moved operations in the desired direction. [1]

Evaluation of CRM training should have course evaluation, and assessment of course content and course execution. CRM training should be developed and improved considering CRM evaluations.

4 IMPROVEMENT OF CREW RESOURCE MANAGEMENT (CRM) WITH POLYGRAPH TESTING

Conversations with pilots, separately or in groups, can contribute to obtaining the information which can point to key factors of CRM training improvement. However, evaluations and follow-ups of CRM training and flight crew CRM performance, are not enough in the way that there is a lack of information or the credibility of obtained information is questionable.

Well-functioning evaluations and follow-ups can, however, contribute to improving CRM training, which in turn can lead to crews demanding even better training, and improved training can then be initiated. [1]

In regard to evaluation and follow-up of CRM training, the following points can be worth consideration by operators: routines in conjunction with evaluation and follow-up of CRM training; use of course evaluations for CRM training; design of course evaluations; feedback to participants after completion of course evaluation; use of course evaluations for future CRM courses; examples of how changes to CRM training are based on course evaluations; examples of influence on operations based on evaluation and follow-up of CRM training. [1]

In addition to all above stated, in order to obtain more accurate information from pilots, co-pilot and flight crew, polygraph should be used during CRM assessments and evaluations. Most of the questionnaires are similar, maybe even easy to remember after several times of taking them, hence flight crew can learn how to answer questions.

Questionnaires should be frequently changed and polygraph test should be taken while flight crew answer the questions.

This could possibly reveal unstable or depressed individuals of flight crew who are about to operate the aircraft when they are not in acceptable health condition.

A polygraph (also known as a lie detector test) measures and records several physiological indices such as blood pressure, pulse, respiration, and skin conductivity while the subject is asked and answers a series of questions. [7] The use of the polygraph is in lie detecting; deceptive answers will produce physiological responses that can be differentiated from those associated with non-deceptive answers. [7] Use of polygraph while testing and questioning the flight crew could prevent disasters through revealing person's true condition.

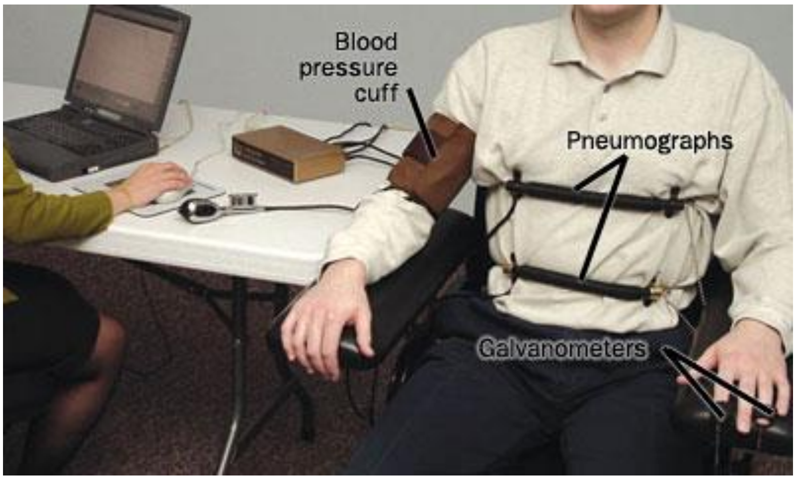


Figure 4: Polygraph testing device

Source: http://blog.lib.umn.edu/paldr001/myblog/polygraph3.bmp

5 CONCLUSION

Crew Resource Management is used to manage of all resources, procedures, rules, and people. Crew Resource Management is an important for aviation safety improvement. CRM focuses on flight operations, which means that CRM is designed and developed especially for pilots and the flight crew. CRM evaluation is important, especially because the results of CRM training are evident from such evaluations. Valid CRM evaluation must be used for further development of the CRM training. CRM training should have evaluation of the course itself, its content, and its execution. CRM training must improve while considering CRM training evaluations. In order to obtain more accurate information from pilots, co-pilot and flight crew, polygraph should be used during CRM assessments and evaluations. Most of the questionnaires are similar, maybe even easy to remember after several times of taking them, hence flight crew can learn how to answer questions. Questionnaires should be frequently changed and polygraph test should be taken while flight crew answer the questions. This could possibly reveal unstable or depressed individuals of flight crew who are about to operate the aircraft when they are not in acceptable health condition. Use of polygraph while testing and questioning the flight crew could prevent disasters through revealing person's true condition.

REFERENCES

[1] Dahlstrom, N., Laursen, J., Bergstrom, J. (2008). Crew Resource Management, Threat and Error Management, and Assessment of CRM Skills - Current situation and development of knowledge, methods and practices. Ljungbyhed, Sweden: Lund University School of Aviation. (http://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=1981926&fileOId=1981944; 29.03.2015)

[2] International Civil Aviation Organization (1998). *Human Factors Training Manual, Doc 9683.* Montreal, Canada: International Civil Aviation Organization.

[3] Marušić, Ž. (2014). *Ljudski potencijali u zrakoplovstvu, Autorizirana predavanja.* Zagreb, Croatia: Fakultet prometnih znanosti.

[4] Board on Behavioral, Cognitive, and Sensory Sciences and Education (BCSSE) and Committee on National Statistics (CNSTAT) (2003) *The Polygraph and Lie Detection*. USA: United States National Research Council.

[5] Internet sources: Germanwings Flight 9525 press sources: The New York Times, BEA, Fairfax New Zealand, The Sydney Morning Herald, CBC News, BFMTV, EASA, The Guardian, The Aviation Herald, The Independent, The Daily Telegraph, Friedlnews, International Business Times, CNN, etc. (29.03.2015)

[6] Internet source: Germanwings Flight 9525. http://en.wikipedia.org/wiki/Germanwings_Flight_9525 (29.03.2015)

[7] Internet source: Polygraph. http://en.wikipedia.org/wiki/Polygraph (29.03.2015)

[8] Internet source: New York Times: Todd Curtis, Airsafe.com; Glenn Harmon, Embry-Riddle Aeronautical University; flight path data from Flightradar24. http://www.flightradar24.com/ (29.03.2015)

[9] Internet source: New York Times: Flight path data from Flightradar24; satellite image by Earthstar Geographics via Bing Maps; debris location from French national police. http://www.flightradar24.com/ (29.03.2015)

[10] Internet source: Crew Resource Management. http://www.crew-resource-management.net/ (29.03.2015)

[11] Internet source: Germanwings crash: Who was Andreas Lubitz? http://www.telegraph.co.uk/news/worldnews/europe/france/11498314/Germanwings-crash-Who-was-Andreas-Lubitz.html (29.03.2015)

[12] Internet source: Polygraph testing device. http://blog.lib.umn.edu/paldr001/myblog/polygraph3.bmp (29.03.2015)

LOGISTIC DETERMINANTS OF THE FREIGHT TRANSPORT BY ROAD DEVELOPMENT IN POLAND

Agata Mesjasz-Lech, Ph.D.
Czestochowa University of Technology
Faculty of Management
Al. Armii Krajowej 19b, Czestochowa, Poland
agata.mesjasz@poczta.fm

ABSTRACT

Road transport is the main branch of Polish transport both in terms of the mass of freight and the revenues from the freight. Road transport is therefore the most commonly used mode of transport in Poland, also due to the transport time and ability to deliver cargo directly to the destination. This paper focuses on the logistic background of the freight transport by road in Poland as a system, which covers all activities consisting in the movement of material goods, in time and space, with appropriate technical equipment and thus supports the processes of delivery and distribution. The infrastructure of transport contributes to the economic growth through: increasing the demand for goods and services thanks to investments in the very infrastructure, attracting foreign investors and developing industrial agglomerations, increasing the efficiency of work through the concentration of business entities. This means that, in the socio-economic aspect, transport brings good effects on the competitiveness and activity of businesses and the economic growth. The purpose of this article is to identify the logistic determinants of the road transport. The author has analyzed the dynamic of road transport infrastructure development and the road network concentration in Poland in contrast to selected European countries in the period from 2002 to 2013. The performed analyses provide information on the changes in the road transport infrastructure and carriage of goods by road and show tendencies in the road network development. The following variable were analyzed in terms of the discussed problems: the total length of motorways (kilometres), annual road freight transport (thousands of tonnes), length of e-roads (kilometres), length of other roads (kilometres), number of goods road transport companies, carriage of goods by road (millions of tonne-kilometre).

Key words: Logistics, freight transport by road, transport logistics infrastructure, concentration analysis.

1 INTRODUCTION

Main goal of a transport system is moving people and goods which is how it influences other forms of business activities. Transport is a challenge in terms of energy security and climate change because this sector relies on petroleum products for which as for now there is no alternative [12]. The dependence of transport on oil fuels impacts the climate and air [4; 13; 21]. On the other hand, this sector is vital for the economy and society because investing into its development brings economic and social benefits [23]. An efficient and effective transport system not only contributes to better living conditions, but also supports entrepreneurship progress. Other key functions of transport in the economic sphere are connecting places and catering to the needs and expectations of the participants of economic life connected with the necessity for covering distances [3].

Transport is crucial to the concept of logistics. It directly contributes to the realization of logistics' primary goal which is delivering a particular product to a specified place at a certain time. Freight transport is a continuously growing part of transport in general and the effectiveness of logistic services connected with it is important for the economic development [10]. What is more, transport is increasingly seen as a service [6], which is why reference to logistics in connection with different aspects seems relevant here.

Road transport is the most commonly used type of transport in Poland. It realized 83,44% of all carriage in Poland in 2013. Similarly, in the same year, 86,54% of all revenue connected with transporting goods was generated by road transport. It is an example of a sociotechnical system which is a combination of social, technical and psychological elements indispensable in carrying people and goods from point A to point B [20]. This system vision of transport shapes its definition: transport is an arrangement of technical, organizational and human resources working together to enable the carriage of people and goods in time and space [7]. In the eyes of logistics, transport is a link between the producer and consumer. Its development is significant because it lengthens supply chains whose effectiveness depends on an efficient transport system. Logistic premises of transport include:

- Customer service improvement,
- Development of cross-border e-entrepreneurship,
- Striving for the reduction of raw materials and distribution stocks,
- Logistics infrastructure development.

Customer service level is viewed as the prime sphere of logistics [9], and belongs with processes which turn potential added value into economic added value. Basic customer service criteria in the case of freight transport are: cost, time, punctuality and risk of damages [14].

The development of cross-border e-entrepreneurship is brought by the transformation of the traditional market model into a market space, which is connected with the Internet capabilities in terms of information and offer access, communication and negotiation methods, ways of concluding transactions and payment methods [8]. Although the development of e-entrepreneurship results in the emergence of virtual electronic markets and electronic distribution of goods, still the bulk of purchased products must be delivered in a traditional way using basic modes of transport, including road transport.

Outlays reduction and increasing profits are key criteria of logistics. Outlays are usually measured through costs, and at least 10% of costs in a business are connected with logistics [5]. Costs in logistics, among others, include distribution costs, which along with manufacturing, administration, warehouse, capital and installation expenditures are an important ingredient of product price [18]. Distribution outlays also incorporate transport costs, which often vary according to the transport mode. Transport costs are mainly comprised of: freight cost, stock keeping cost, inland transportation cost, packing cost, interest cost, premium [22]. Operational cost reduction solutions are especially crucial in freight transport because it has low profitability [24]. An effective way to improve the results in terms of using logistic resources, including costs, is freight consolidation [17].

The increase of customer service level, the development of e-entrepreneurship and the reduction of transport costs cannot be achieved without proper infrastructure which „is built, maintained and expanded in order to enable the functioning of society” [19]. Infrastructure enables water and energy supply, communication, transportation, waste removal and treatment, thus ensuring the flow of goods and services which means it is the basis of many day-to-day activities [2]. Transportation infrastructure is necessary for the functioning of logistics on macro and micro levels. Road network characteristics include road length, road density, and the number of nodes [11]. Investments into transportation infrastructure contribute to the reduction of the costs of an enterprise run at a distance, and increase its global competitiveness [1]. There is a correlation between the road network length and the evolution of motorization, the growth of urban population and urban density, and the rise in the number of private vehicles [15]. Transportation infrastructure is one of the elements conditioning other logistic aspects of the functioning of road transportation, because it enables the transportation service. Coming from here, we carried out an in-depth analysis of the concentration and dynamics of selected elements of the road freight transportation infrastructure.

2 DATA AND METHODOLOGY

The analysis of road transportation infrastructure was based on statistical concentration measures: location quotient and Herfindahl-Hirschman index. The analyzed data come from the Eurostat database, especially: total length of motorways (kilometres), annual road freight transport (thousands of tonnes), length of e-roads (kilometres), length of other roads (kilometres), number of goods road transport companies, goods transported by roads (thousands of tonnes) and carriage of goods by road (millions of tonne-kilometre). The data cover the 2002-2013 period. When there were cases of a miniscule data insufficiency, it was dealt with using extrapolation and interpolation.

Herfindahl-Hirschman Index (HHI) is defined as the sum of squares of market shares, and is designated according to the following formula (1) [16]:

$$HH = \sum_{i=1}^{n} z_i^2 \qquad (1)$$

where:

z_i - a share of the value of the analysed feature for the *i*-th object in the total value of the analysed feature for all analysed *n* units.

The higher its value is, the greater the concentration is in the analyzed area. According to the recommendations of the FERC (Federal Energy Regulatory Commission) in the United States the value of the index indicates:

- a lack of concentration, when it is less than 0.10 indicates,
- a moderately high concentration, when it is between 0.10 and 0.18,
- a very high concentration, when it is above 0.18.

The Herfindahl-Hirschman Index determines an estimated concentration level in a given branch of industry and the competition level on a given market [25].

This location quotient determines the level of the analyzed variable compared to the so-called reference variable, according to the formula (2) [16]:

$$LQ = \frac{E_{ib}/E_b}{E_{ir}/E_r} \qquad (2)$$

where:

LQ – location quotient, E_{ib} – value of the variable in the i sector in the b area, E_b – value of the variable in all sectors in the b area, E_{ir} – value of the variable in the i sector in the r reference area, E_r – value of the variable in all sectors in the r reference area.

The location quotient permits one to study spatial concentration and can be therefore used in regional studies.

The location quotient value:

- greater than 1 means that the analysed area has a higher level of the variable in a given section than in the reference area,
- smaller than 1 indicates a potential shortage of certain activities in the analysed region,
- of 1 indicates a sufficient level of the feature in a given area.

3 RESULTS

The location quotient was used to measure the concentration in terms of road transport infrastructure in selected European countries. The areas measured were: motorways, e-roads and other roads, the sectors were individual European countries from the analyzed group, the reference area was all countries from the analyzed group. Applying the location quotient enables the determination of the level of individual road types concentration in the selected group of countries, and lets us single out the countries where the length of roads is higher than in others. The analyzed countries are: Bulgaria, the Czech Republic, Denmark, Estonia, Cyprus, Lithuania, Hungary, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, the United Kingdom, Iceland, Switzerland, Croatia. The selection of the countries was determined by data accessibility for the whole period of 2002-2012. The analysis yielded the following conclusions:

1. Length of motorways LQ reached the value above unity only for Portugal in all years and for Croatia in the years 2008-2012 which means that the length of motorways in these countries was bigger in the mentioned periods than the average for all analyzed countries. The value of the length of motorways in the other countries was smaller than unity throughout the whole analyzed period which lets us conclude that the length of motorways in these countries was shorter than the average value for the analyzed area of Europe.
2. As far as the length of e-roads is concerned, the LQ had a value higher than unity over the whole analyzed period for Bulgaria, Portugal, Romania, Slovakia, Finland, Sweden and Croatia. This leads to the conclusion that in these countries the length of e-roads is much longer than the average for the analyzed area of Europe. The values for the other countries were smaller than unity, which means that the length of e-roads in them was shorter than the average for the analyzed countries.
3. With the length of other roads, the LQ values in the analyzed period are smaller than unity for all countries which points out to the shortage of other roads in comparison to the average of the analyzed countries.

The location quotient should be analyzed also with respect to its change in time, which is why the relative chain increases were calculated for individual countries in the 2002-2012 period, and the countries were placed in four classes. Class I contains countries with a location quotient bigger than unity and with a positive change dynamics ($\Delta LQ>0$). Belonging to this class is most desirable because countries grouped here are seen as development-oriented when it comes to the analyzed feature. In class II there are countries with a low level of the LQ (LQ<1), but it increases in consecutive periods (ΔLQ>0). Countries from this group look promising in terms of the analyzed feature. Countries with a high level of the location quotient (LQ>1), and a negative change tendency (ΔLQ<0) belong to class III. We should analyze them for the decrease of this value and then propose tools and methods of support, especially for countries of major significance in terms of the analyzed feature. Class IV contains countries where the LQ level is low (LQ<1), and the direction of its change is negative (ΔLQ<0). Support for these countries in terms of the analyzed feature is usually ineffective considering the expenditure to benefit relation.

A detailed analysis was carried out for the groups with Poland classified for individual years. The results for the variables: length of motorways, length of e-roads, length of other roads are presented in tables 1, 2, 3.

In the studied period, Poland appears in class II (the years 2004, 2006, 2008, 2009, 2011, 2012), or in class IV (the years 2003, 2005, 2007, 2010), with reference to the length of motorways variable, which means that Poland is not among the leaders in the length of motorways. The LQ for most analyzed years, including the last two: 2011 and 2012 is low. And although this points out to a shortfall of motorways when we look at the average in the group of studied countries, there is a year to year increase tendency which paints a promising picture for the future length of motorways in Poland.

Table 1: Classes with Poland for variable length of motorways in each year of period 2003 to 2012

Year and class number	Countries
2003 Class IV	Bulgaria, Czech Republic, Denmark, Estonia, Greece, Cyprus, Latvia, Lithuania, Poland, Romania, United Kingdom, Iceland, Switzerland
2004 Class II	Czech Republic, Hungary, Poland, Romania, Sweden, Croatia
2005 Class IV	Bulgaria, Denmark, Estonia, Greece, Latvia, Lithuania, Austria, Poland, Romania, Slovakia, Sweden, United Kingdom, Iceland, Switzerland
2006 Class II	Bulgaria, Czech Republic, Denmark, Hungary, Poland, Sweden
2007 Class IV	Estonia, Greece, Cyprus, Latvia, Lithuania, Austria, Poland, Slovenia, Finland, United, Kingdom, Iceland, Switzerland
2008 Class II	Czech Republic, Denmark, Estonia, Hungary, Poland, Slovenia, Slovakia, Finland, Sweden
2009 Class II	Czech Republic, Poland, Romania, Slovenia, Slovakia, Finland, Switzerland
2010 Class IV	Denmark, Greece, Cyprus, Latvia, Lithuania, Hungary, Austria, Poland, Sweden, United Kingdom, Iceland, Switzerland
2011 Class II	Bulgaria, Poland, Romania, Switzerland
2012 Class II	Bulgaria, Estonia, Hungary, Poland, Romania

Source: Self-analysis

It is worth mentioning that in terms of the length of motorways, Poland got to a group where developing countries (the Czech Republic, Hungary) are mixed with the developed ones. In the years 2004, 2006, 2008, 2010 and 2012 Poland and Hungary were in one group. The comparison between these countries is connected with the fact that they were labelled as advanced developing markets by FTSE Group. Figure 1 shows LQ values for Poland and Hungary in the years 2002–2012 with respect to the length of motorways.

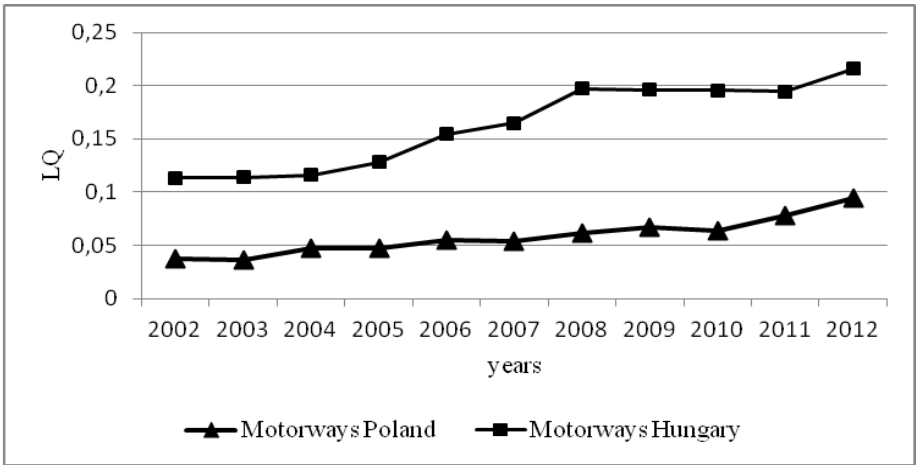


Figure 1: LQ values for Poland and Hungary in the years 2002–2012 with respect to the length of motorways

Source: Self-analysis

In the analyzed period, both countries display an increase of the LQ value, but its levels in Poland are higher. In both countries, over the whole period, there was an annual average increase of the location quotient which at the level of 9.8679% in Poland was slightly higher than in Hungary where it reached 6.6604%. In terms of the length of motorways during the period, Poland appeared in class IV four times and six times in class II, whereas Hungary belonged to class II seven times and three times it was in class IV.

Table 2: Classes with Poland for variable length of e-roads in each year of period 2003 to 2012

Year and class number	Countries
2003 Class IV	Czech Republic, Denmark, Estonia, Cyprus, Lithuania, Hungary, Austria, Poland, Slovenia, United Kingdom, Iceland, Switzerland
2004 Class IV	Czech Republic, Denmark, Estonia, Cyprus, Latvia, Austria, Poland, Slovenia, Iceland, Switzerland
2005 Class II	Czech Republic, Denmark, Latvia, Lithuania, Hungary, Austria, Poland, Slovenia, United Kingdom, Switzerland
2006 Class II	Denmark, Latvia, Hungary, Austria, Poland, Switzerland
2007 Class IV	Czech Republic, Denmark, Estonia, Cyprus, Latvia, Lithuania, Austria, Poland, Slovenia, United Kingdom, Iceland, Switzerland
2008 Class IV	Czech Republic, Denmark, Estonia, Cyprus, Latvia, Lithuania, Hungary, Austria, Poland, Slovenia, United Kingdom, Iceland, Switzerland
2009 Class IV	Czech Republic, Denmark, Estonia, Cyprus, Latvia, Lithuania, Hungary, Austria, Poland, Slovenia, United Kingdom, Iceland, Switzerland
2010 Class IV	Cyprus, Lithuania, Austria, Poland, ,Iceland,
2011 Class IV	Czech Republic, Denmark, Estonia, Cyprus, Latvia, Lithuania, Hungary, Austria, Poland, Slovenia, United Kingdom, Iceland, Switzerland
2012 Class IV	Czech Republic, Denmark, Estonia, Greece, Cyprus, Latvia, Lithuania, Hungary, Austria, Poland, Slovenia, United Kingdom, Iceland, Switzerland

Source: Self-analysis

When it comes to the length of e-roads, Poland appeared in class II only twice and in class IV eight times which is much more often than in the case of the length of motorways. This leads us to the conclusion that any support for Poland aiming at the development of e-roads building is ineffective. Countries appearing in one class with Poland in individual years were mostly Central European Countries, some Western European Countries and most of the Northern European Countries. Figure 2 presents LQ values for Poland and Hungary in the years 2002–2012 concerning the length of e-roads.

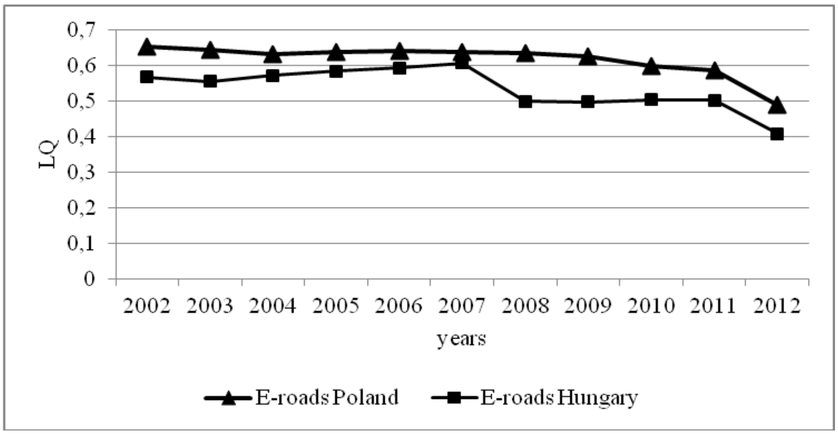


Figure 2: LQ values for Poland and Hungary in the years 2002–2012 concerning the length of e-roads

Source: Self-analysis

Polish and Hungarian LQ values concerning the length of e-roads are similar in the analyzed period. Also the average annual decrease of the values is comparable and reached 2.888% in Poland and 3.2406% in Hungary. Yet Hungary appeared only four times in class IV and six times in class II. And during the 2007–2012 period Poland always stayed in class IV, which means that the e-roads situation in Poland during the whole studied period was worse than in Hungary.

Table 3: Classes with Poland for variable length of other roads in each year of period 2003 to 2012

Year and class number	Countries
2003 Class II	Bulgaria, Czech Republic, Denmark, Estonia, Cyprus, Latvia, Lithuania, Hungary,
2004 Class IV	Bulgaria, Czech Republic, Denmark, Estonia, Greece, Cyprus, Latvia, Lithuania, Hungary
2005 Class IV	Bulgaria, Czech Republic, Denmark, Estonia, Greece, Cyprus, Latvia, Lithuania, Hungary
2006 Class IV	Bulgaria, Czech Republic, Denmark, Greece, Hungary
2007 Class IV	Bulgaria, Czech Republic, Denmark, Estonia, Greece, Cyprus, Latvia, Lithuania, Hungary
2008 Class II	Bulgaria, Czech Republic, Denmark, Estonia, Cyprus, Latvia, Lithuania, Hungary,
2009 Class IV	Bulgaria, Czech Republic, Denmark, Estonia, Greece, Cyprus, Latvia, Lithuania, Hungary
2010 Class II	Bulgaria, Czech Republic, Denmark, Cyprus, Latvia, Lithuania, Hungary,,
2011 Class II	Bulgaria, Czech Republic, Denmark, Estonia, Cyprus, Latvia, Lithuania, Hungary,
2012 Class IV	Bulgaria, Czech Republic, Denmark, Estonia, Greece, Cyprus, Latvia, Lithuania, Hungary

Source: Self-analysis

When it comes to the length of other roads, Poland appeared four times in class II and six times in class IV which means that also with respect to this category it belongs with countries where the development of other roads length is ineffective. However, Poland's presence in class III in the years 2003, 2008, 2010 and 2011indicated a feasibility of creating tools in this respect. In terms of the length of other roads, Poland was found in one class with the majority of Central Eastern European countries and some of the Southern and Northern European Countries. Figure 3 compares the length of other roads ratio values for Poland and Hungary in the years 2002–2012.

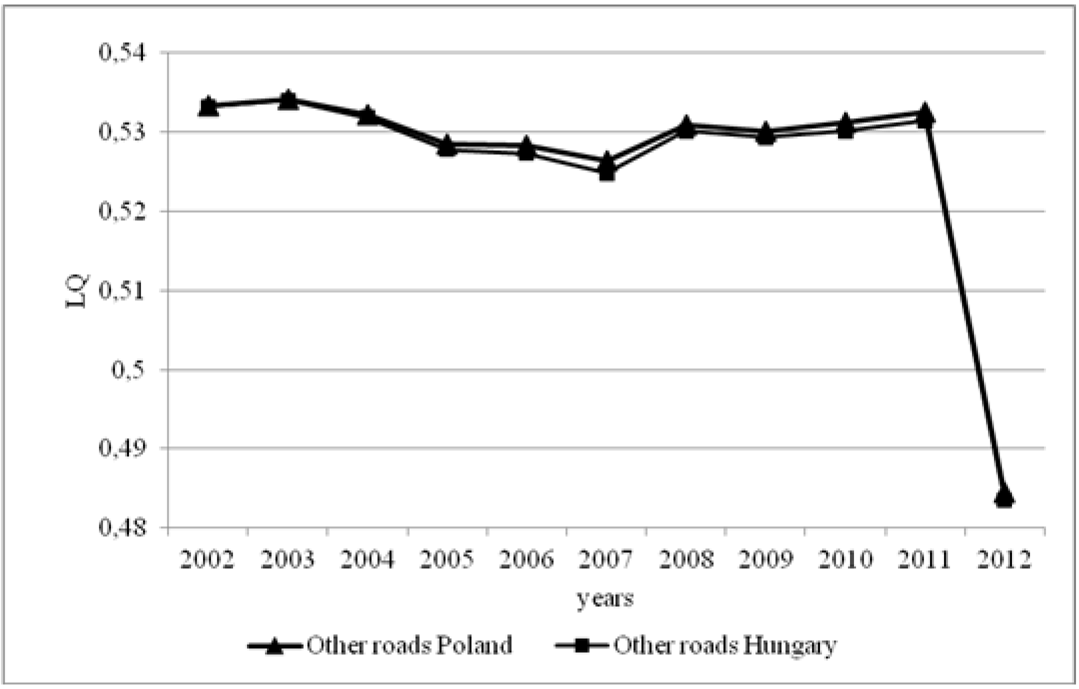


Figure 3: LQ values for Poland and Hungary in the years 2002–2012 concerning the length of other roads

Source: Self-analysis

The values of the location quotient for the length of other roads is almost identical for Poland and Hungary in the analyzed period. Both countries saw an annual average decrease of the length of other roads, in Poland by 0.96% and by 0.97% in Hungary, and the biggest LQ drop was observed in these countries in 2012 compared to 2011. The low quotient value and its negative chain increase put Poland and Hungary in the whole analyzed period in class IV.

The concentration in terms of freight transport by roads was measured with the Herfindahl-Hirschman index which was calculated for the selected region of Europe for the 2008-2013 period, and figure 4 presents the results.

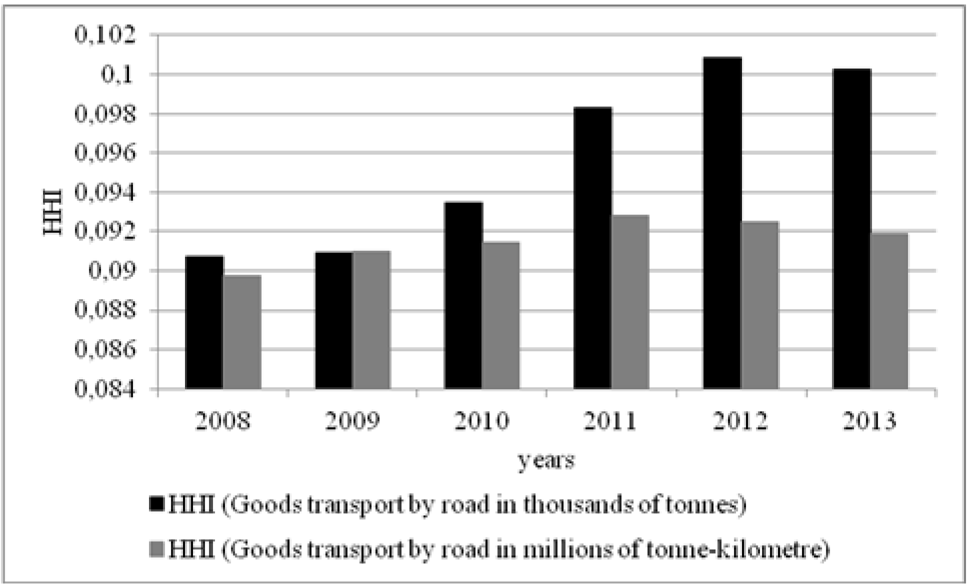


Figure 4: Herfindahl-Hirschman index for goods transported by road

Source: Self-analysis

Herfindahl-Hirschman index allowed us to measure the concentration in terms of freight transport by road. The HHI value for goods transport in thousands of tonnes was smaller than 0,1 during the whole analyzed period which means no concentration. The goods transport by road in millions of tonne-kilometre variable showed no concentration in the years 2008-2011 and some moderate concentration in the years 2012 and 2013. Although the index value differences for both variables are small, the annual average tempo of change expressed by HHI reached 2.03% for the goods transport by road in thousands of tonnes and 0.47% for the goods transport by road in millions of tonne-kilometre. We can clearly observe significant discrepancies in the annual average increase tempo of the index for the individual variables. The goods transport by road in thousands of tonnes index grew much faster than the goods transport by road in millions of tonne-kilometre index. The biggest increase of the index for both variables occurred in 2011 compared to 2010. Unfortunately 2013 brought the decrease of the index for both variables compared to the previos year.

In Poland in the 2004-2013 period there was an annual average increase of the volume of goods transport both in thousands of tonnes and in millions of tonne-kilometre by 6.59% and 10.26% respectively. The 2008-2013 period (whose HHI is presented in fig. 4) showes a much smaller annual average increase of the variables reaching 3.53% for goods transport by road in thousands of tonnes and 8.46% for goods transport by road in millions of tonne-kilometre.

Also the concentration in terms of goods road transport enterprises was measured. Again Herfindahl-Hirschman index was used and helped draw conclusions concerning the competitiveness on the goods road transport market. The following countries were analyzed: Bulgaria, the Czech Republic, Estonia, Spain, France, Italy, Cyprus, Latvia, Lithuania, Hungary, Malta, Austria, Poland, Romania, Slovenia, Slovakia, Finland, Sweden, Iceland, Liechtenstein, Norway. Figure 5 presents the results.

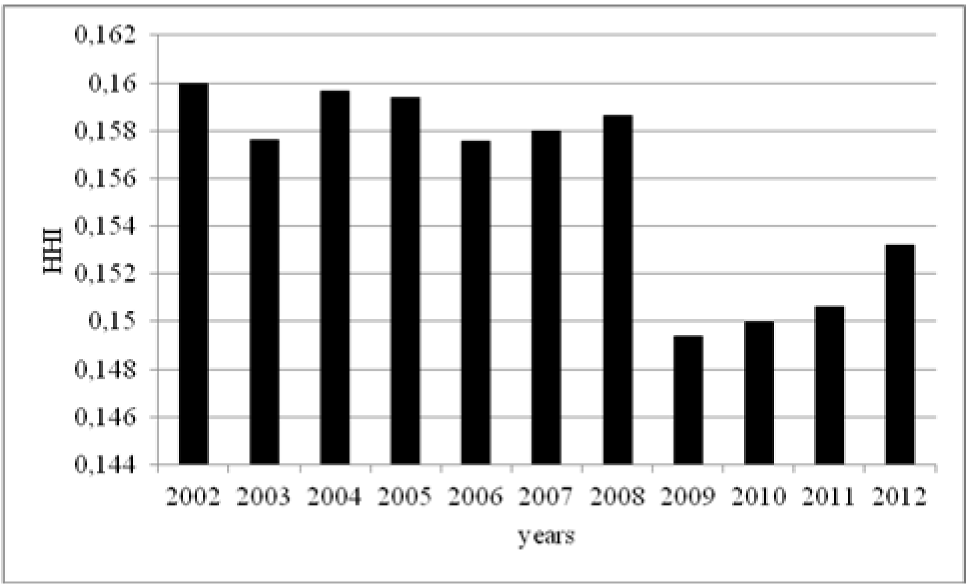


Figure 5: Herfindahl-Hirschman index for goods road transport enterprises

Source: Self-analysis

All analyzed years show moderate concentration in terms of the number of goods transport by road enterprises which lets us conclude that no country from the studied group dominates in this field. The lowest index value was observed in 2009, but from then on it grew continuously until 2012 on an annual average by 0.85%. The number of Polish road transport enterprises displays an annual average decrease in the years 2001-2012 by 0.41%. Although the drop was not considerable, the tendency can be called negative, however, in the 2008-2012 period the variable increased annually on average by 1.01%.

4 CONCLUSIONS

Transport is one of the key processes of logistics which are closely tied to the strategy of an enterprise, improve its competitiveness and create a potential value added. Effectively realized transport enhances customer service and boosts the customer's transaction satisfaction. We can say, therefore, that the level of customer service, which is also determined by costs, is one of the logistic determinants of transport. Additionally, the increase of the demand for goods transport services is connected with the growing popularity of Internet sales which is the result of e-entrepreneurship which can also be treated as a transport determinant. And without proper infrastructure, which is another factor in transport development, the realization of transport services would not be possible.

The concentration analysis showed that in most of the studied years Poland was classified among countries with good prospects concerning the length of motorways. Belonging to this group was the effect of an intense growth of the length of motorways in the years 2001-2012 (on annual average by 11,86%). Unfortunately, the situation with the length of e-roads and the length of other roads does not look as encouraging because with respect to these two variables, Poland was found in the group of countries characterized by ineffectiveness of the expenditure to benefits relation. The concentration values for Poland are close to those for Hungary where the market development is similar.

Moderate concentration in terms of the number of goods transport by road enterprises is caused by the fact that the analysis does not include such countries as Denmark, Germany, Netherlands, Portugal, the United Kingdom. In Poland, however, beginning in 2007, which was the start of the global economic crisis, until 2012 there was a slight annual average increase of the number of goods transport companies (by 0.15%). Yet a significant annual average growth in Poland occurred in the years 2004-2013 and was connected with the mass of goods carried by road expressed in both thousands of tonnes and millions of tonne-kilometers.

The development of transport, especially in the linear transport infrastructure is hard to be called satisfactory. The growing importance of logistics and logistic services surely has an influence on the features of road transport in Poland. Therefore, future research should be concerned with the analysis of logistics influence on transport, especially in terms of transport services.

REFERENCES

[1] Albarran, P., Carrasco, R., & Holl, A. (2013). Domestic transport infrastructure and firms' export market participation. *Small Business Economics*, *40*, 879–898.

[2] Chappin, E.J.L., & van der Lei, T. (2014). Adaptation of interconnected infrastructures to climate change: A socio-technical systems perspective. *Utilities Policy*, *31*, 10-17.

[3] Domańska, A. (2006). Wpływ infrastruktury transport drogowego na rozwój regionalny. Warszawa: Wydawnictwo Naukowe PWN.

[4] Elvik, R. (2013). A before–after study of the effects on safety of environmental speed limits in the city of Oslo, Norway. *Safety Science*, *55*, 10–16.

[5] Engblom, J., Solakivi, T., Töyli, J., & Ojala, L. (2012). Multiple-method analysis of logistics costs. *International Journal of Production Economics*, *137*, 29–35.

[6] Hyard, A. (2013). Non-technological innovations for sustainable transport. Technological *Forecasting & Social Change*, *80*, 1375–1386.

[7] Jacyna, M. (2009). *Modelowanie i ocean systemów transportowych*. Warszawa: Oficyna Wydawnicza Politechniki Warszawskiej.

[8] Jelonek, D. (2014). Uwarunkowania rozwoju e-przedsiebiorczości trans granicznej. In A. Nowicki, & D. Jelonek (Ed.), Technologie informacyjne w kreowaniu przedsiębiorczości, Częstochowa: Sekcja Wydawnictw Wydziału Zarządzania.

[9] Kadłubek, M. (2010). Obsługa klienta jako naczelne zadanie logistyki przedsiębiorstwa. *Logistyka*, *6*, 1283-1289.

[10] Liedtke, G., & Friedrich, H. (2012). Generation of logistics networks in freight transportation models. *Transportation*, *39*, 1335–1351.

[11] Li, H., Graham, D.J., & Majumdar, A. (2015). Effects of changes in road network characteristics on road casualties: An application of full Bayes models using panel data. *Safety Science*, *72*, 283–292.

[12] Li, H., Lu, Y., Zhang, J., & Wang, T. (2013). Trends in road freight transportation carbon dioxide emissions and policies in China. *Energy Policy*, *57*, 99–106.

[13] Liu, W., Lund, H., & Mathiesen, B.V. (2013). Modelling the transport system in China and evaluating the current strategies towards the sustainable transport development. *Energy Policy*, *58*, 347–357.

[14] Masiero, L., & Henshe, D.A. (2012). Freight transport distance and weight as utility conditioning effects on a stated choice experiment. *Journal of Choice Modelling*, *5(1)*, 64-76.

[15] Mraihi, R, Abdallah, K. & Abid, M. (2013). Road transport-related energy consumption: Analysis of driving factors in Tunisia. *Energy Policy*, *62*, 247–253.

[16] Nieszporska, S. (2009). *Analiza koncentracji w badaniach statystycznych*. In A. Mesjasz-Lech (Ed.), *Nowoczesne instrumenty zarządzania*. Częstochowa: Sekcja Wydawnictwa Wydziału Zarządzania Politechniki Częstochowskiej.

[17] Pan, S., Ballot, E., & Fontane, F. (2013). The reduction of greenhouse gas emissions from freight transport by pooling supply chains. *International Journal of Production Economics*, *143*, 86–94.

[18] Pettersson, A.I., & Segerstedt, A. (2013). Measuring supply chain cost. *International Journal of Production Economics*, *143*, 357–363.

[19] Roelich, K., Knoeri, C., Steinberger, J.K., Varga, L., Blythe, P.T., Butler, D., Gupta, R., Harrison, G.P., Martin, C., & Purnel, P. (2015). Towards resource-efficient and service-oriented integrated infrastructure operations. *Technological Forecasting & Social Change*, *92*, 40–52.

[20] Salmon, P.M., McClure, R., & Stanton, N.A. (2012). Road transport in drift? Applying contemporary systems thinking to road safety. *Safety Science*, *50*, 1829–1838.

[21] Silva-Send, N., Anders, S., & Narwold, A. (2013). Cost effectiveness comparison of certain transportation measures to mitigate greenhouse gas emissions in San Diego County, California. Energy Policy, 62, 428–1433.

[22] Takeyasu, K., & Kainosho, M. (2014). Optimization technique by genetic algorithms for international logistics. Journal of Intelligent Manufacturing, 25, 1043–1049.

[23] Thomopoulos, N., & Grant-Muller, S. (2013). Incorporating equity as part of the wider impacts in transport infrastructure assessment: an application of the SUMINI approach. Transportation, 40, 315–345.

[24] Wang, X., & Kopfer, H. (2014). Collaborative transportation planning of less-than-truckload freight A route-based request exchange mechanism. *OR Spectrum*, *36*, 357–380.

[25] Zawada, M. (2009). Koncentracja rynku energii elektrycznej w krajach Unii Europejskiej. In J. Pyka (Ed.), *Kreatywność i innowacyjność w unowocześnianiu przemysłu i usług*. TNOiK Branch in Katowice.

TECHNICAL MEANS FOR SAFE STOPPING OF VEHICLES – "AIR STINGER" (AIST)

Mario Milošević, B. Sc.
Postgraduate student of the Faculty of Maritime Studies and Transport
Milčinskega 11, 3000 Celje, Slovenia
milosevic.mario1@gmail.com

Peter Jenček, D. Sc.
University of Ljubljana
Faculty of Maritime Studies and Transport
Pot pomorščakov 4, 6320 Portorož, Slovenia
peter.jencek@fpp.uni-lj.si

ABSTRACT

If a country neglects traffic security due to financial savings, long-term destructive consequences could occur (exp. higher expenses) in comparison to take it into account. There are many strategies and diverse projects which should realise outlined traffic security goals. In the Republic of Slovenia, executives with their own accountability such as the Ministry of infrastructure and spatial planning should start to approach progressively to road users as potential victims and not as potential delinquents. Similarly, a repressive mentality should be changed with engineering tacking.

The project includes a chosen physical solution to increase the traffic security level called »Air stinger« (in the following text "AIST") system as my personal idea. The solution is a physical measure and which could be described as a device installed on a problematic road section (on the exact critical spot). The device is constructed of two main parts. The primary part, which includes a sensor loop device (such as DRSC – Direct Radar Scope Camera) which automatically distinguishes and transfers data about improper movements during observation. The secondary part includes a compression which fills adaptable material between the road and the vehicle which enables to stop the car and simultaneously avoid a potential crash. The HAZOP method of evaluation will be used to present the potential advantages and disadvantages. Slovenia, as a member of EU has to obey particular standardisation in the topic of traffic security, traffic flow etc. The EU has important documents to help their partner countries to improve on traffic safety (project KAREN and FRAME-NET). All the topics mentioned above were briefly combined, with consideration of potential elaborations in future for the "AIST" project.

Key words: Traffic safety, "Air stinger", HAZOP, KAREN, FRAME-NET, intelligent transport systems.

1 PREFACE

Traffic accidents represent a daily problem in different parts of the traffic systems. Most of the problems are caused due to negligence of drivers. They fail to acknowledge their own security and security of other drivers. The innocent participants in traffic are therefore dying. The main reasons of these traffic accidents are excessive speed and alcohol. The following chapters will expose one of the most dangerously repeated problem on highways, called "wrong-way driving." Drivers, mostly from unknown reasons, drive in the opposite direction and they threaten their lives and the lives of others. These kind of drivers have received their own term "Ghostdrivers". To prevent such situations and consequences we must identify the real causes of the problem and introduce preventive measures that will systematically decrease the number of mentioned issues.

In the past year of 2014, in Slovenia, we have noticed an increase in the number of runs in the opposite direction on highways.

Authorities of Slovenia (Ministry, police etc.) often interfere with the repressive solutions, for example they have constantly been increasing the penalties. It is difficult for countries to resist such solutions, because they do not require investment in long-term problem solving. The aim of this article is to present an engineering approach which pretends to increase driver's safety in traffic without treating him as a delinquent.

Many NGOs try to expose the importance of prevention through traffic safety workshops and fliers raising awareness among others. Accident prevention is a hard task and traffic safety culture establishment is a long-term challenge for any government.

The technical mean ("AIR STINGER") in the following text as (AIST) is a safety system to prevent such dangerous maneuvers as wrong-way driving. The AIST is classified as an intelligent transport system – ITS. It is not technically sophisticated due to the lack of research, laboratory equipment and financial reasons. However, the idea of the safety system is described below with its pros and cons and possible improvements.

1.1 Hypotheses and objectives

We have exposed two hypotheses as the common thread of research:

1. Government's higher financial investments to alternative solutions (prevention workshops, "engineering" approach, and education) and their favouritism would be more effective in the long-term (economically and ethically) in comparison with a repressive approach (an increase in fines) in traffic safety.
2. Considering the content and design guidelines of Slovenian ITS architecture from 2005, we could realise the safety system AIST and it would be a good basic alternative as a new technical mean in the field of road traffic safety.

2 PLACEMENT IN THE ITS ARCHITECTURE

Nowadays an ITS architecture is an international or local need of building systems and services. With ITS architecture it is possible for a country to enable a simpler and safer transport system and combine it with user's needs. That kind of approach is friendly for international standardisation measures and their requirements.[1]

For our system AIST, we took into account the Slovenian ITS Architecture – SITSA-C.[2] The Architecture includes chapters from other architectures such as Italian "ARTIST", French "ACTIF", Austrian "TTS-A" etc.). In the European area, the independent organisation ERTICO ("European Transport Telematics Implementation Coordination") with its head office in Brussels, is a core or association of ITS Europe.

[1] Zura, Maher and Rijavec, 2005: 1.
[2] SITSA-C was issued in 2005 as the first Slovenian ITS architecture.

The European Commission (EC) integrated these architectures and managed to combine them in the project KAREN ("Keystone Architecture Required for European Networks") between 1998 and 2000, with later improvements.

2.1 Legislation

Many countries try to follow the "Vision zero" tendency. The Swedish multi-national road traffic safety project which aims to achieve a highway system with no fatalities or serious injuries in road traffic will never be completely feasible. Accidents will stay a part of transport system as long as we use it, because humans are much more unreliable than machines.

Slovenia has in use a few legal acts which regulate traffic safety problem. The main one is the Penal Code with the article nr. 323 (causing a traffic accident by negligence).[3]

Also the article nr. 324 is important while considering AIST safety system (dangerous driving on the roads). The road transport safety act is one of the main tools for police officials. The main document which regulates the aims, improvements and vision of traffic safety is the National road safety program (2013-2022).

3 THE BASIC IDEA OF THE SAFETY SYSTEM - AIST

In the following chapter we expose why and how we have decided to tackle the issue based on the current situation. AIST is meant as a device to prevent collision between vehicles and between vehicles and other dangerous obstacles when an uncontrolled car moves off the road.

3.1 Statistical data and core problem

As we mentioned, in the last year (2014), the statistical data of Slovenian police has shown the sad results. Increased number in the number of road fatalities and seriously injured persons after "wrong-way" accidents happened. We draw attention to a specific cause. Despite this figure, the number of all road fatalities declined (in the Republic of Slovenia). The table below shows the number of detected movements.

Table 1: Wrong-way maneuvers detected between 1. 1. 2013 and 30. 6. 2014

	Consequences		
Cause of traffic accidents (wrong-way driving)	∑	Fatalities	Serious injuries
2013	2.229	9	57
2014	2.117	18	66

Source: Slovenian Ministry of the interior, Police, 2014

[3] Penal Code of Republic of Slovenia (KZ-1, UPB2, Ur. L. RS, nr. 50/12).

3.2 Tackling the problem

Comparing a pursuance of transport policies between Slovenia and Sweden is a good starting point. It is an interesting fact that Sweden, with a total population of about 9.7 million versus Slovenia, with 2 million people, has nearly three hundred and fifty percent less fatalities on the roads. Sweden has one of the safest traffic networks on Earth.

While Slovenia increases fines for traffic offences even from 300 EUR up to 1,200 EUR, Sweden is trying to re-built or develop their roads to be more friendly and safe for their citizens. The highest level of care between government and citizens, consequently brings higher "traffic culture" and lower numbers of road fatalities and serious injuries.

In the past, we could discern a few initiatives about how to improve on traffic safety and what are the most potential areas to achieve it. The model 3E (education, engineering and enforcement) is one of them.[4]

3.3 AIST as the road safety device

The basic idea refers to prevent wrong-way driving to keep drivers safe. When a topic of wrong-way driving arises, most of people think about metal "spikes" (also "road spikes") which penetrate through tube and finally stop the car which was in a wrong movement.

The metal road spikes have been observed in a few places like Israel, Bangladesh and USA. These types of them are mostly in use to ensure the right of way in parking areas. In other cases, police and other enforcement units are using them during vehicular pursuits. Nevertheless, this method is quite dangerous and moreover some people say it is unethical to use it. The spikes are also available to buy online for private needs (to prevent trespassing etc.)

In spite of this, we will present you with feedback from interviewees after we have presented them a similar system AIST friendlier and safer to road users. But most importantly is we have seen them as victims and not delinquents.

Figure 1: Road "spikes" in Israel

Source: Mr. Igor Zupancic (personal photo collection from Israel)

4 Zajc, 1997: 81-93.

The project AIST and its origins dates back to the year 2010 when the author and his mentor applied to the association of young researchers which took a place in the small city of Celje in Slovenia.[5]

We can't confirm that the same project doesn't exist or it hasn't been implemented yet somewhere on Earth, but it can be argued that it promotes quite a different way of solving such a problem. We have been trying to find a basic idea, which would be a viable alternative to road spikes. Since we started with the research of AIST, a few experts and professors (who partly helped with research process) have shown their positive response to the idea, but have also exposed a problem to obtain the funds for implementation.

AIST could be described as the safety system which includes physical and logical (functional) architectures. It is structured like many other systems in general. It could also be classified as a technical mean to manage traffic and prevent car collisions.

The technical mean is compound by two main sections. The primary part presents a solid framework made of special materials (a metal alloy) and contains internal and adaptable material (rubber, PVC in a shape of a balloon) which would be set in between the car and the road if the dangerous maneuver occurs in front of the system AIST. The secondary part is meant to be functional, with its programmed and installed devices. Both of them work actively as one and integrated safety system.

Practically, the AIST has four subsystems:

1. A device on the road (as a solid framework constructed nearby a road – horizontally, or constructed directly into a road surface or pavement – vertically with internal expansive material in a shape of balloon such as mechanical rubber, PVC, cellular materials)[6],
2. A device for detecting vehicles (works on the principals of wave frequencies as DRSC – "Dedicated short-range communications" with 5.8 GHz frequency),
3. Mission control for response (responsible management center)[7],
4. Intervention/response unit (intervention after collision, or other dangerous situation),
5. Driver assistance systems as subset of crash avoidance (CAS – "Collision Avoidance system", DADS – "Driver Alertness Detection System" etc.).

---

[5] The project called „Wrong-way driving on the highways", was an initiative to prevent wrong-way movements on the particular highway section in city of Celje. After six months the municipality of Celje set up a test plastic fence which physically separates the lanes. The source of entire project is available on website www.knjiznica-celje.si/raziskovalne/4201004069.pdf

[6] Turner, 1973.

[7] In summer of 2014, author had opportunity to be intern in the security company »Signal 8 Security Malta Ltd.« which has special equipment to response on such situations. Equipment they use is »Mobile Shelter Guard Room«, »Near Field Communication System« (NFC) with data broadcasting at 13.56 MHZ frequency and 14 KHz of bandwidht for users, »Spotmaster« navigation system and server for locating 24/7 and »Rapid Response Vehicle« for immidiate responses.

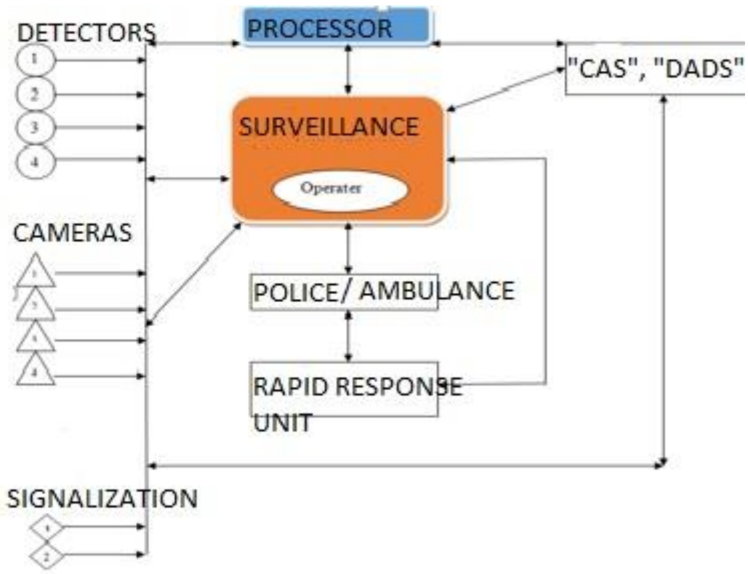


Figure 2: Networks of AIST system

Source: own

The best way to elaborate and realise AIST as a sophisticated and useful system would be testing on a polygon with appropriate equipment for measuring vehicle collision. That was meant in the terms of getting more accurate measured data. The cheaper way is to compare such collisions which are already documented and posted on websites. One of them is NHTSA ("National Highway Traffic Safety Administration") from Washington, DC. Experts provide various safety reports (such as biomechanical, crash injury research – CIREN, behavioral research etc.) online which are useful for other research procedures. Also, a lot of virtual software can be used to elaborate collision situations such as "Virtual CRASH version 3.0" or any other. It would be essential comparing the injury criteria testing results such as HIC (the "Head Injury Criterion").

3.3.1 Safety risk analysis considering AIST

However, the team of experts during actual research is needed to realise AIST. Such a system has its own pros and cons, so we should have to take into consideration the safety risk analysis too. For example, if we need an energy resource to ensure active pursuance of the system (such as electrical pump, gasholder, etc.) we have to make safety analyses depending on the structure of device. HAZOP ("Hazard and Operability Studies") is one example of how to structure an elaboration of specific part which is in use. Similar ones are FMEA ("Effect Analysis"), method "What-IF", etc.

Additionally, we have to consider that humans and systems are not infallible in their tasks. Many errors happen due to man and are therefore unpredictable. Systems could be assessed by methods such as deductive failure "Fault Tree Analysis" in which an undesired state of a system is analyzed using logic to combine a series of lower-level or failure events. This method gives a visual graph in shape of a tree with possible failure events and their numerical rates.

```
GTOP  A2  ST  KO
ST    R2  OS  OP
OP    R2  OH  HE
KO    R2  OK  OT

#NUMERICAL DATA

OS # 1.0 E-4
OH # 5.0 E-5
HE # 5.0 E-2
OK # 1.0 E-4
OT # 1.0 E-5

RESULTS

OP    # 5.0 E-2
KO    # 1.1 E-4
ST    # 5.0 E-2
GTOP  # 5.5 E-6
```

Figure 3: "Fault Tree Analysis" (FTA) example with electrical pump as component of AIST

Source: Practices with mentor of the Faculty of Chemistry and Chemical Technology, University of Ljubljana

The FTA is mainly used in the fields of chemistry safety engineering to understand how systems can fail, to find the best ways to reduce and avoid risks. A "failure rate" is to be calculated when considering reliability of systems. A test can be performed to estimate its failure rate as it is presented in the following example:

$$\frac{6\, failures}{7502\, hours} = 0.0007998 \frac{failures}{hour} = 799.8\ x\ 10^{-6} \frac{failures}{hour} \quad (1)$$

Depending on parameters that we would like to elaborate, we also search for the redundancy (duplication) of components. Redundancy is the intention of increasing reliability of the particular system, in other words it is a backup in working process.

$$p = \prod_{i=1}^{n} pi \quad (2)$$

Where "n" is number of components, "pi" is probability of the component "i" failing and "p" is the probability of all components failing (system failure). For example, if the required reliability of device in parallel structured system is 0.999 and the reliability of its components (subsystems) is 0.7, we can assume that we need another six additional components to ensure the smooth functioning of processes as shown below:

$$\begin{aligned} (1-0.999) &= (1-0.7)^n \\ 0.001 &= 0.3^n \\ n\, log\, 0.3 &= log\, 0.001 \\ n &= 5.74\ or\ 6 \end{aligned} \quad (3)$$

While we try to get a new idea (in our case AIST) we have to take into account many elements which integrate a system as one functional and sophisticated device. As we mentioned in the abstract, the article is presenting the basic or core idea with elements which may be implemented. First of all we made a frame of the basic idea or structure, secondly we presented how the collisions (inelastic and elastic) should be tested, thirdly was to given the safety risk measures such as risk analysis for every each component of the system AIST and, last but not least to consider jurisdiction and legal basis. Additional tasks may be management, improvements, renovation of materials and other. Materials which used to have been under regularities and standardisation are also to be considered in detail. AIST practically works as some kind of "outdoor air-bag" that attempts to mitigate possible collisions. These collisions make reference when a car heads towards another car or when an uncontrolled care heads towards a dangerous barrier (lamppost, street light etc.). Since the Swedish multinational manufacturing company "Volvo" invented the "air-bag" pedestrian safety technologies we think that the future of road safety has to be thought "out of the box" excluding financial matters. Lack of investment should not be an excuse when it comes to road safety and human lives.

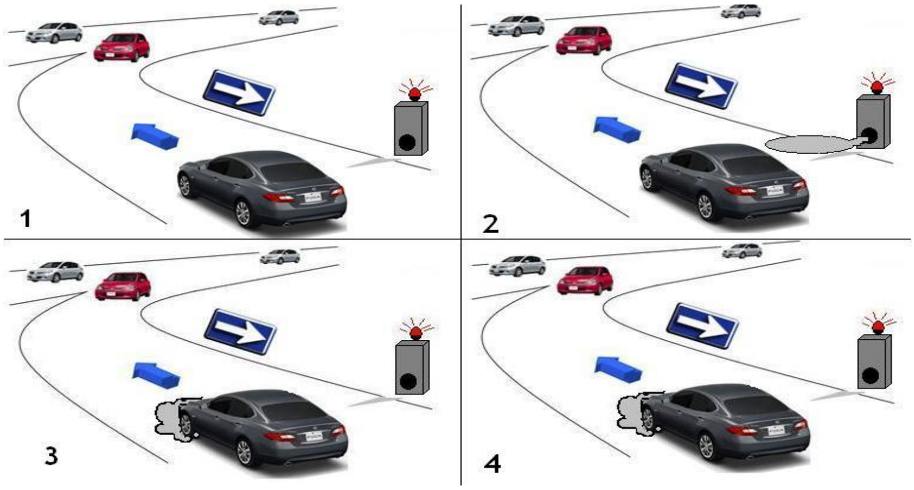


Figure 4: A simple demonstration of the AIST set on the road

Source: Author's

3.3.2 Questionnaire and feedback about AIST

Despite unfinished project AIST, a systematic questionnaire about the AIST system comparing known road spikes have brought a positive feedback results and critics.

A one of among positive answers we got was a weather resistance of the system (it would work fluently in any weather condition). They thought it might be possible to improve the system and make it cheaper to produce. They added that it is possible to renovate it quickly just after the collision (internal material in a solid framework), the system would be also durable against vandalism and other damages. An interesting positive function of AIST is that it protects a car before collision in the other car or any other objective, if moving forward. Among negative answers or cons, we distinguished that the main problem is investment in research and implementation. Experts argued that road spikes would be enough to prevent such movements on highways and is no need to waste money on the projects such as AIST. They said we would encounter many problems regarding how to prevent avoidance of safety devices (balloon could not cover all the surface of the road) and the friction problem during winter. They also exposed the problem of maintenance of the electrical power supply to the system in the case of dependency from public power supply. About the last weakness they recommended independent mechanism of gas bullets which would explode and make the internal PVC material to become filled with the gas. In this case a car would drive over the material and the special valve would regulate the pressure in the balloon even in the collision moment. The AIST should be set only on the highways and not others (regional, local).

3.3.3 Placement of the AIST system in the Slovenian Architecture SITSA-C using "FRAME Selection Tool" software

Terminology of ITS architectures is essential for understanding how a specific intelligent transport system has to be classified in. "User requirements" are actually needs of drivers, which use the particular traffic network. In our case we presented the AIST system as an important device in traffic safety area after we concluded that we have problems with wrong-way movements on our highways. In the following table we present how we distribute required needs.

Table 2: A placement of the AIST in SITSA-C (example)

(Area 2)	“Provide Safety and Emergency Facilities” with subgroup 2. 1. 2. 3 (“Plan Emergency Investigation”).		
(Area 3)	“Manage Traffic” with subgroup 3. 2 (“Manage Incidents”).		
(Area 5)	“Provide Advanced Driver Assistance System” with subgroups 5. 12. (“Provide Vehicle Communications Interfaces”) and 5. 12. 5 (“Provide vehicle ID”).		
(Area 7)	“Provide Support For Law Enforcement” with subgroup 7.2 (“Identity Violator”).		
Acronym	Description	Source	“User requirements”
Trfc-urban_traffic_flow_data	Contains analog data about traffic direction in given road section	trfc	3. 1. 1. 1

Source: Communication for eSafety, 2009.

3.3.4 Additional countermeasures detected preventing “wrong-way” driving

Scientific articles could be more than useful to take into consideration within AIST. In other to prevent wrong-way movements, we may find countermeasures based on informations exchange among cars, too.[8]

Other authors specify importance of proper signalization, especially at night. Improvements and alternative signalization is specific topic when older drivers are involved. In France, the statistical data is in use for studies of cognitive impairments among those drivers.[9]

A few researches made elaboration about “Do Not Enter” signs. They assessed the advantages and even failures of attention. Specific signalization and dynamic countermeasures were elaborated on highway sections (and also regional) trying to prevent wrong way entering.[10][11]

A patent such as a “Ramp Guard to Prevent Wrong-Way Driving” may be used to be set on roadways. It includes a base having a center cutout, and screw holes utilized to attach base to concrete frame.[12]

Similar countermeasures or technical means are presented on ITS annual meetings worldwide.[13]

---

[8] Conesa Cavas-Martínez and Fernández-Pacheco, 2013.
[9] Kemmel, 2015.
[10] Laurie, Zhang, Mundoli, Duffy, Collura and Fisher, 2004.
[11] Topolšek, Lipičnik, 2009.
[12] Invention nr. US 20140369748 A1 by inventors' name Peter Mitlo.
[13] Matsumot, Mizushima, 2011.

4 CONCLUSIONS

Overall feedback was quite encouraging. We have also been cooperating with the CEO of the University Medical Centre Ljubljana. They presented us approximation of the costs of injuries and fatalities (in terms of medical care). In the case of seriously injured person is accepted in the hospital, including intensive care and recover therapy it could cost up to 80,000 EUR. When doctors take care of the minor injuries including hospitalisation the expenses would be up to 15,000 EUR. A day on intensive care cost nearly 300 EUR, such care as well with all therapies included up to 3,000 EUR. Medical expenses care vary from case to case.[14]

The first hypothesis has been partly confirmed. During research we concluded that the government must change its approach to road safety and its users. The successful stories about high road safety in northern European countries such as Sweden, Denmark, and Austria should be an example of good managing practices. Since we noticed the willingness of individuals to participate in the improvements of this project it is possible that AIST has a good basis for further research.

The second hypothesis has been confirmed. Through the interviews we got positive feedback in general despite the project only being roughly described. We have demonstrated that AIST is compatible with Slovenian Architecture SITSA-C and wider. With the tool we have been using the KAREN project software "FRAME Selection Tool" we showed how AIST could be classified in areas required for such architectures.[15]

When considering AIST we finally concluded that from the given pros and cons we should assess it as a long-term project. At the moment it seems that government is not showing any scope or willingness for such approaches due to economic reasons. The responsible institutions should take into account comparison through "costs and benefits" methods. Assuming that the project would continue when it will be financed from private financial sources.

REFERENCES

[1] Communication for e Safety - COMeSafety. (2009). 6th framework program. *D31 European ITS Communication Acrhitecture.* Gained on http://www.comesafety.org/uploads/media/COMeSafety_DEL_D31_EuropeanITSCommunicationArchitecture_v2.0_01.pdf

[2] Conesa, J., Cavas-Martínez, F. and Fernández-Pacheco, D.G. (2013). And agent-based paradigm for detecting and acting on vehicles driving in the opposite direction on highways. *Experts Systems with Applications 40*(13), 5113-5124.

[3] Espacenet - European Patent Office. (2015). *Ramp Guard to Prevent Wrong-Way Driving: Mitlo Peter.* Gained by http://worldwide.espacenet.com/publicationDetails/biblio?FT=D&CC=US&NR=2014369748A1

[4] Kemmel, E. (2015). Wrong-way driving crashes on French divided roads. *Accident Analysis and Prevention (75). 69-76.*

[14] Data has gained by business manager Mr. Matjaž Tavčar, Division of Surgery, University Medical Centre Ljubljana.
[15] More informations about FRAME-NET tools could be found on www.frame-online.net

[5] Laurie, E. Nancy, Zhang, S., Mundoli, R., Duffy, A. Susan, Collura, J. and Fisher, L. Donald. (2004). An evaluation of alternative Do Not Enter signs: failures of attention. *Transportation Research Part F 7, 151-161.*

[6] Matsumot, S. and Mizushima, Y. (2011). Development of the device to prevent wrong-way driving. *18th World Congress on Intelligent Transport Systems and ITS America Annual Metting 2011* 7, 5568-5576.

[7] Penal Code of Republic of Slovenia (KZ-1). (2012). *Gazzete of RS*, (50/12).

[8] Slovenian Ministry of interior - Police. (2014). *Statistical data of traffic safety.* Gained on http://www.policija.si/index.php/statistika/prometna-varnost

[9] Topolšek, D. and Lipičnik, M. (2009). System Dynamic Model of Measures for Reducing the Number of Road Accidents Due to Wrong-Way Movement on Motorways. *Promet - Traffic&Transportation 40*(2), 85-91.

[10] Turner, S. (1973). A Psysical Testing of Plastics. A Preamble. *Mechanical Testing of Plastics* (pp. 1-12). London: Published for Plastics Institute.

[11] Zajc, L. (1997). Sistematičnost nekaterih prometno-varnostnih procesov kot del kvalitete upravljanja cestnega prometa. In M. Lipičnik (Ed.), *Upravljanje prometa - 4. mednarodni znanstveni in strokovni kolokvij* (pp. 81-93). Maribor: Faculty of civil engnineering.

[12] Zura, M., Maher, T. and Rijavec, R. (2005). Aktualni razvoj inteligentnih transportnih sistmeov in storitev (ITS). *Slovenska ITS arhitektura - modul ceste : (1) SITSA-C* (pp. 43-153). Ljubljana, Slovenia: Univesity of Ljubljana, Faculty of Civil and Geodetic Engineering, Traffic Technical Institute.

[13]

MICROSCOPIC SIMULATION OF TRAFFIC FLOWS FOR PERFORMANCE EVALUATION OF COMPLEX ROAD INTERCHANGE

Gabriela Mitran, D.Sc
Sorin Ilie, D.Sc
Viorel Nicolae, D.Sc
University of Pitesti
Targu din Vale, #1, Pitesti, Romania
gabriela.mitran@upit.ro

Adrian Vilcan, Eng.
AV Transport Planning
Ionel Perlea, #9E, Bucharest, Romania
adrian@vilcan.com

ABSTRACT

Social and economic changes, such as increase of the motorization index, the spatial redistribution of land use functions, the jobs crisis, the degradation of level of service provided by rail mode (reduction of commercial speed, decrease of transport supply), which occurred in Romania in the last 20 years, have led to increased demand for road transport mode. Given that during this time there were no major interventions in order to increase the transport capacity, now we are facing with the situation in which in the big cities and in their suburban areas occurs mainly the phenomenon of congestion. Diagnosing the current situation represents an important stage in the transport planning process, depending on its results being possible to propose solutions to improve traffic conditions. In situation in which we have to analyze isolated zones or intersections, the measured traffic volumes are sufficient, but in the case of complex intersections or groups of junctions is required the traffic simulation. The micro-simulation models offer a dynamic and stochastic representation of each vehicle in the composition of traffic flows, taking into account the physical characteristics of the vehicle (length, maximum acceleration rate, etc.), elementary traffic rules and psychological behavior of the driver (tracking interval, changing circulation lanes, etc.). Within this paper the authors present the analysis of performances provided by the road interchange in the suburban area of Pitesti municipality, situated at the junction of the A1 highway, the national roads network and the urban network, through the micro-simulation of traffic flows.

Key words: Microscopic simulation, traffic flow, road interchange, performance evaluation.

1 INTRODUCTION

It is an accomplished fact that in Romania in the last 20 years the evolution which has manifested at the level of land use functions was poorly controlled. The challenge we are facing now is focused on planning in the fields of transport and urbanism so as to satisfy the mobility needs of users, both for the transport of persons, and for the transport of goods.

This reality (meaning uncontrolled development in urban and peri-urban areas) has associated the consequences of manifesting congestion phenomenon, which is reflected through significant negative impact on citizens' quality of life. The main components with negative impact are related to (1) increasing the time spent in travel on relatively short distances, and

(2) generating health problems or worsening the existing ones, especially in the case of respiratory and cardiac diseases, due to higher concentrations of pollutants in the atmosphere. Moreover, the environment in which manifests the phenomenon of congestion is characterized by high concentrations of CO_2, which entails the contribution to enhancing greenhouse effect. Concomitantly with the above mentioned aspects, at the economic level, the deployment of traffic in congestion circumstances lead to increased fuel consumption, fuel that still comes predominantly from non-renewable sources.

Diagnosing the current situation represents an important stage in transport planning process, depending on its results being possible to propose solutions to improve traffic conditions. In this process, the first step consists in collecting real data to identify critical issues at the level of an area of study. In cases in which isolated areas or intersections must be analyzed, traffic volumes measured are sufficient; but for complex intersections or groups of intersections, traffic simulation is required. This method provides visual feedback based on the data collected, facilitating the identification of critical issues and testing the proposals for infrastructure redevelopment.

In the frame of this paperwork the authors present the analysis of performances provided by the road interchange from the suburban area of Pitesti municipality, placed at the junction between the A1 highway, the national roads network and the urban network, by means of traffic flows micro-simulation. For performing the micro-simulation it was used VISSIM software that owns comprehensive analysis options, representing a powerful tool for evaluating and planning the transport infrastructure in urban and extra-urban environment.

2 BACKGROUND

Micro-simulation of traffic flows is based on dynamic and stochastic (random) modeling of the movement of vehicles individually in the frame of a transport system. Each vehicle changes its position in the transport network in every split second depending on (1) its physical characteristics (length, velocity, maximum acceleration, etc.), (2) the fundamental laws of mechanics and (3) driver's norms of behavior, bearing in mind the road traffic regulation. The microscopic models for simulation the traffic flows require much more data and analysis resources than macroscopic models, but they reproduce with much higher accuracy and fidelity the real traffic conditions, in comparison with macro-simulation case. Sources from specialized literature indicate the advantages and the drawbacks characteristic of this level of traffic flow simulation [2]. The benefits offered by micro-simulation of traffic flows, in the process of traffic analyzing, can be oriented on three main directions: *clarity*, *precision* and *flexibility* [4].

- **Clarity.** The real-time running of traffic flows and graphical interface illustrate the operations performed in traffic in an understandable manner. By visualizing the micro-simulations in 3D format, is facilitated the verification process of sensitivity of modeling the transport network, and the driver's behavior in the frame of the model for micro-simulation the traffic flows.
- **Precision.** In the case of congested networks, by modeling the vehicle at individual level, there is the possibility to simulate with high accuracy the movements performed in intersections. The driver of each vehicle makes decisions individually, regarding speed, traffic lane change and choice of routes, which implies a good representation of the real conditions in comparison with other modeling techniques. For example, the models for simulation at macroscopic and mesoscopic levels use

fixed values of saturation flows, under the assumption that all vehicles behave in the same way. Within the micro-simulation models, *the saturation flow* represents an output parameter.

- **Flexibility.** This type of modeling allows the solving of a wide range of problems compared with conventional methods (vehicle - signals activations, demand - dependent on pedestrian amenities, management of waiting queues in intersections, prioritization of public transport, accidents, toll gates, roads works, roundabouts, shock waves etc.). It also allows the representation of the interaction between different vehicle types, as well as their interaction with other transport modes (bus, tram, light rail etc.).

The disadvantages arising from the use of micro-simulation models in the analysis of traffic flows can be grouped into the following categories: *high costs*, *large volumes of input data*, *manifesting characteristic phenomena of traffic lane change* and *extraction of results.*

The fundamentals of traffic micro-simulation were established by authors as *Chandler et al.* in 1958, *Gazis et al.* in 1961 [9], *Lee* in 1966, *Bender and Fenton* in 1972 [3] within some reference works in the field, in which were developed the analogies of traffic flow with fluid dynamics and circulation of gases through pipelines. *Lighthill and Whitman* in 1955 and *Richards* in 1956 postulated that traffic density is a function of position; *Newell* in 1955 associated the motor vehicle movement along a sparsely used road with gases circulation [9]. These models were subjected to improvements in the 1970s (*Gipps* in 1970 and *Widemman* in 1974). At present there are tens of software systems for micro-simulation of traffic flows that implement a large variety of theories and behavioral norms of drivers [1], [8].

3 CASE STUDY

3.1 Analysis area

Within the case study is presented the micro-simulation of traffic at the level of the complex road node where takes place the traffic change between A1 highway (Bucharest - Pitesti), national roads network (represented by DN 7 Stefanesti / Bucharest - Ramnicu Valcea and DN 73 Pitesti - Campulung) and urban network of Pitesti municipality represented by the connection road (bridge over the Arges River) (Figure 1).

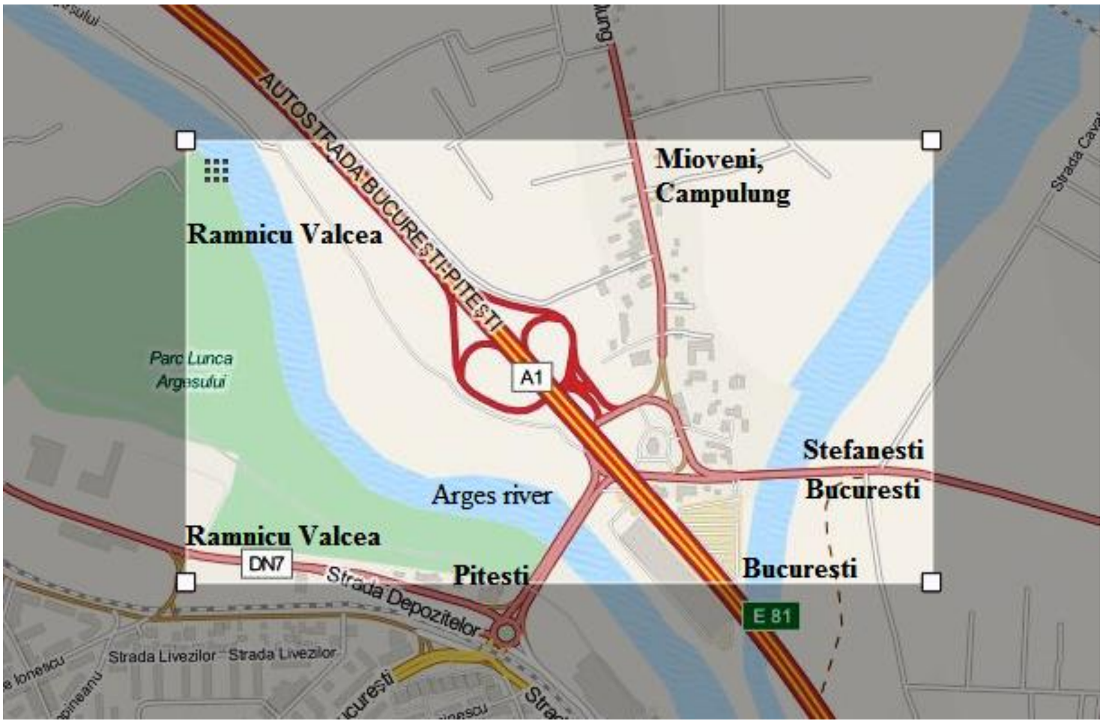


Figure 15: The study area

Source: OpenStreetMap

Pitesti municipality is a medium-sized city in Romania, with a population of 177965 inhabitants in 2014[1], and which holds the administrative role of the Arges County[2]. The urban transport network is located to the south of the Arges River, which represent a natural barrier on the direction North West - South East. Within the road transport system in the region there is only one crossing over the river through which is realized the connection between the street network and national network. From functional perspective, Pitesti municipality is in close interaction with its peri-urban localities situated to the north of the Arges River:

- localities serviced by DN 7 national road: cities Stefanesti (14901 inhabitants) and Topoloveni (9602 inhabitants), village Calinesti (11173 inhabitants),
- localities serviced by DN 73 national road: city Mioveni (34799 inhabitants), village Maracineni (5186 inhabitants).

3.2 Data collection and Analysis

The micro-simulation of traffic flows requires knowing the transport supply at an advanced level of particularization (meaning characteristics of infrastructure, as well as characteristics of traffic operating and controlling system), and the transport demand (meaning vehicle characteristics, traffic volumes and selected routes). The relationships between the components of the applied traffic micro-simulation model are shown in Figure 2.

[1] National Institute of Statistics, Population and its demographic structure
[2] Romania's territorial administrative division provides 41 counties

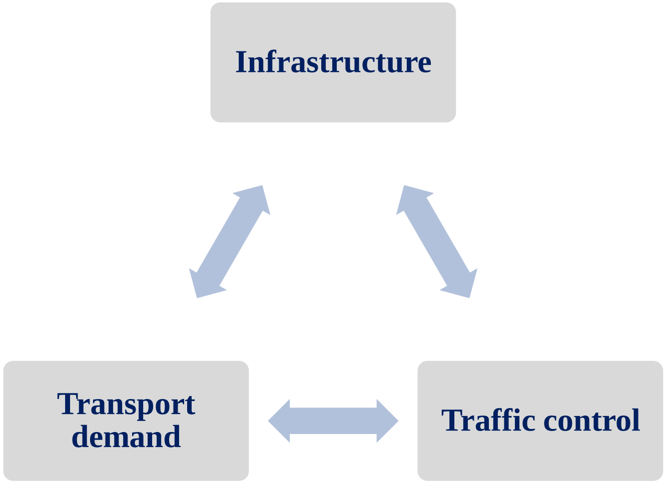


Figure 2: The structure of the traffic micro-simulation model

In order to model the transport supply represented by physical configuration of the network and the traffic control system operating at the level of analyzed road junction, were used information from technical project plan developed for building the A1 highway Bucharest - Pitesti (Figure 3). As can be seen, this junction road hasn't a configuration which can be framed in the typologies used preponderantly as typical examples of service interchanges: *diamond*, *cloverleaf* and *partly cloverleaf*[3]. Regarding the traffic control at the level of the road interchange, the access of vehicles is conducted through road signs. Another particularity of the road junction is given by placing a fuelling station inside the ring area, fitted with two entrances and also with parking spaces for heavy duty vehicles.

The transport demand, expressed through Origin - Destination matrices and associated routes, was extracted from macroscopic transport model of Pitesti municipality and its area of influence, developed by authors during other studies [6], [7].

The calibration and validation of transport model was realized for peak traffic period, determined by measurements made in the key points of the network, in the hourly intervals 7 - 10 AM and 15 - 19 AM.

---

[3] Connecticut Department of Transportation. Highway design manual, 2003 Edition (Including Revisions to February 2013)

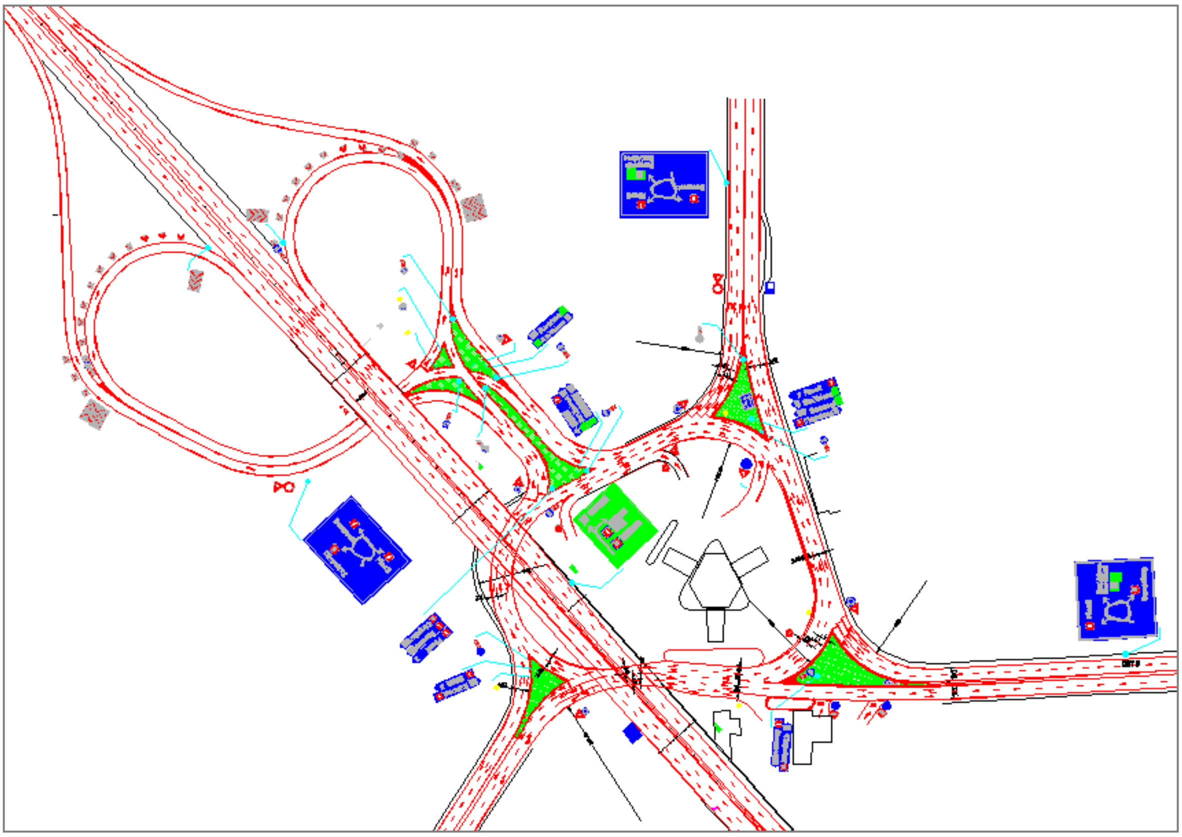


Figure 3: Representation of the transport supply

To exemplify, below is presented the variation of traffic flows on the bridge over the Arges River, the road segment linking the studied interchange and the urban street network of Pitesti (Figure 4).

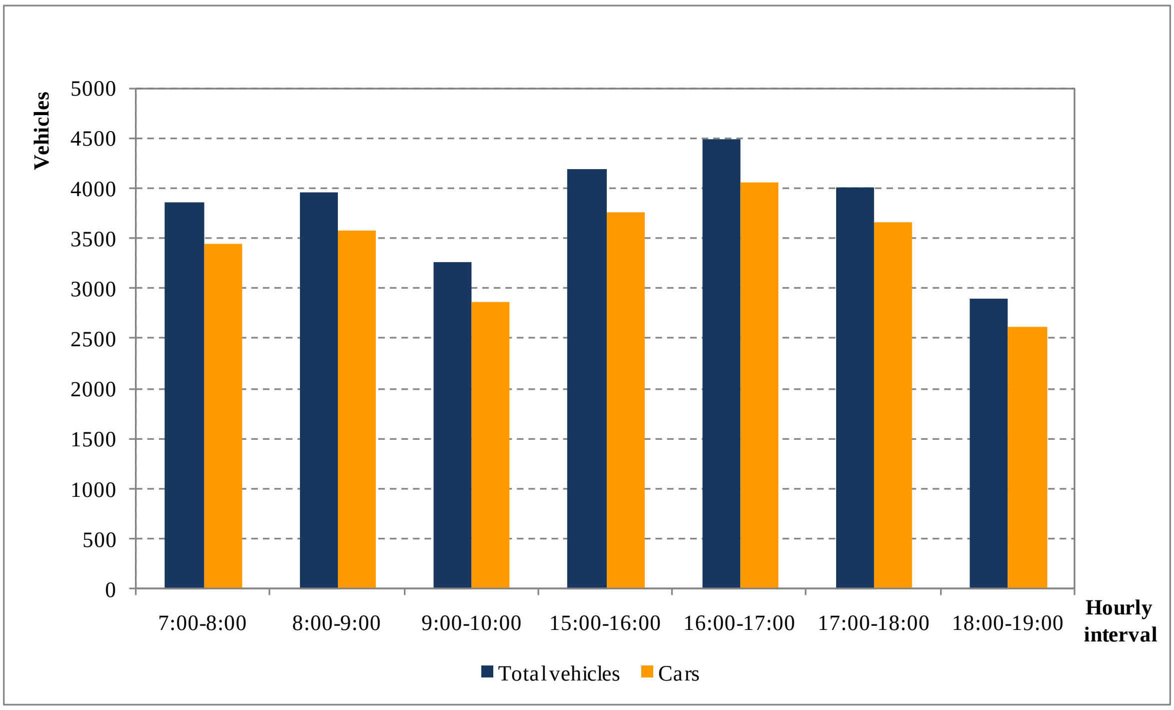


Figure 4: Hourly traffic flow distribution

The structure of traffic flows in terms of technical characteristics of vehicles represents essential inputs in the simulation process. It is compulsory to define the following characteristics of motor vehicles:

- length;
- acceleration and deceleration rates;
- maximum speed.

In the framework of the performed micro-simulation, the above mentioned technical characteristics were defined for passenger cars and freight motor vehicles.

4 RESULTS AND DISCUSSION

The performance of the complex road interchange was analyzed through simulation at the level of traffic rush hour 16 -17 AM, as was highlighted in Figure 5.

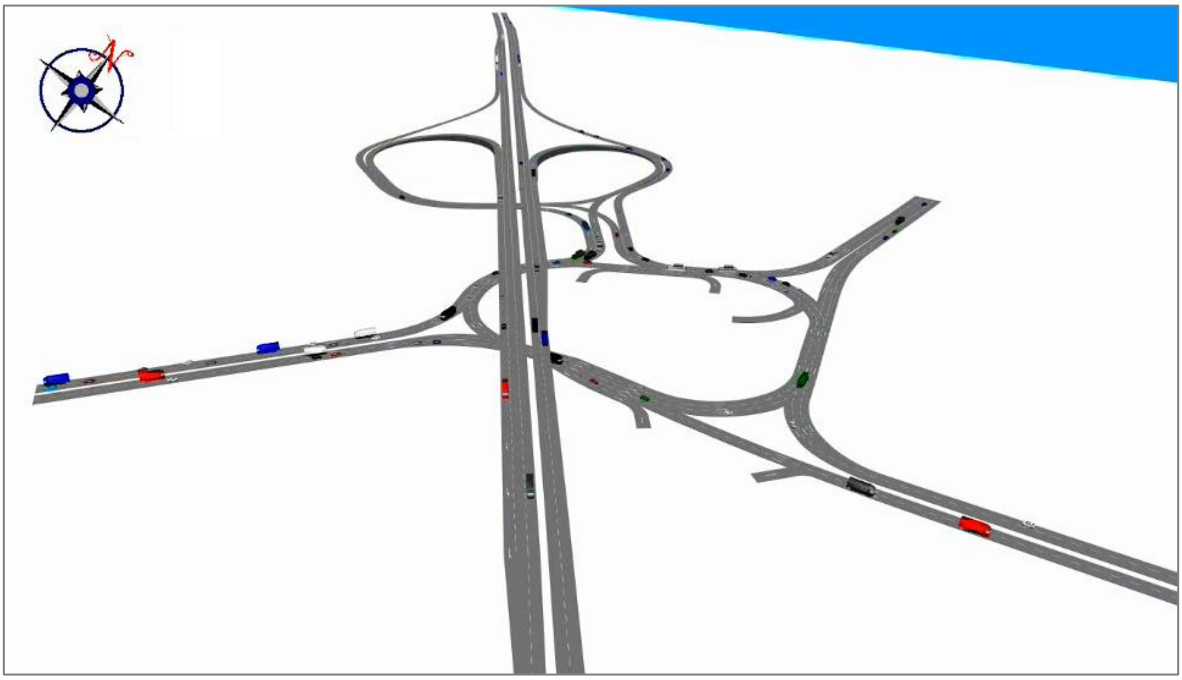


Figure 5: 3D representation of the realized micro-simulation model

Following the analysis, were determined the values of the following parameters:

- average delay time per vehicle, in seconds;
- average speed, in km/h;
- average number of stops per vehicle;
- number of vehicles that have left the network.

The results of simulations that have been run for 3900 seconds, including the recommended temporal warm-up period of 300 seconds (value recommended in specialized literature to obtain results with high accuracy [5]), are shown in Table 1.

Table 1: Simulation results

Parameter	Value
Average delay time per vehicle [s]	194.9
Average speed [km/h]	17.5
Average number of stops per vehicle	2.8
Number of vehicles that have left the network	4189

The values of those parameters indicate very low performances recorded at the level of road junction analyzed, which is manifested by congestion at traffic rush hour. The effects of congestion are the waiting queues occurred for crossing this infrastructure sector, each vehicle performing an average of 2.8 stops, the average moving speed being extremely low, only 17.5 km/h, in conditions of a regulated top speed of 50 km/h on that road sector.

An overview on the deployment of circulation extracted from the video recording of the simulation is shown in Figure 6.

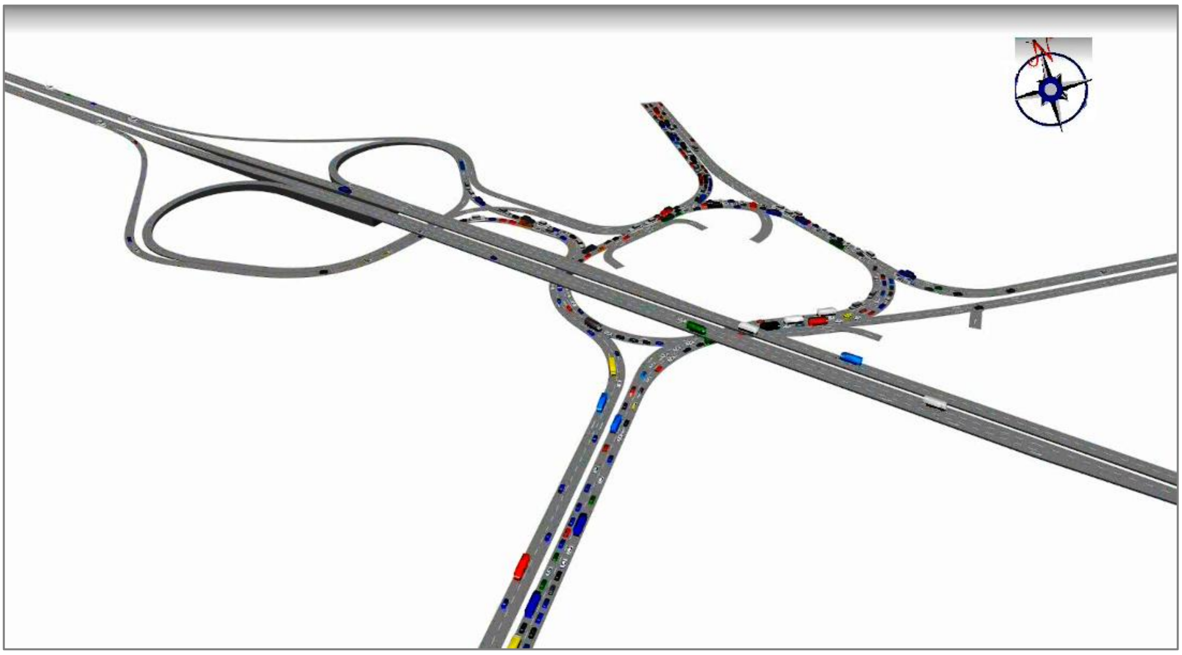


Figure 6: Micro-simulation results in the traffic rush hour of a working day

5 CONCLUSIONS

In this work are highlighted the performances of the transport infrastructure from the peri-urban area of Pitesti municipality, respectively the road interchange which links the network of national roads and highways with local street network, during the traffic rush hour recorded at the level of an average working day of the year *(Annual Average Daily Traffic - AADT).* The analysis of the current situation indicates averages delays of approximately 195 seconds for a vehicle, which translates into additional costs incurred by the users of the transport system, resulting from monetary quantification of the values of time required to perform the travel.

Another category of negative effects of the traffic carried in the current circumstances is represented by the emissions of pollutants and CO_2, associated with the acceleration and deceleration regimes of motor vehicles, imposed by 2.8 average stops which each vehicle performs while crossing through the road junction.

This characterization of traffic deployment in the analyzed area requires identification and implementation of rapid measures in order to improve the circulation conditions. The results obtained following this research will constitute the baseline scenario within future simulations, aiming to identify the best solutions for road traffic fluidization in the analyzed road interchange.

ACKNOWLEDGMENT

This work of Gabriela MITRAN was supported by the strategic grant POSDRU/159/1.5/S/138963 - PERFORM, co-financed by the European Social Fund – Investing in People, within the Sectoral Operational Programme Human Resources Development 2007-2013.

REFERENCES

[1] Algers, S., Bernauer, E., Boero, M., Breheret, L., Di Taranto, C., Dougherty, M., Fox, K., Gabard, J.-F. (2000), Review of Micro-Simulation Models – Deliverable D3, SMARTEST (Simulation Modelling Applied to Road Transport European Scheme Test) project, Institute for Transport Studies, University of Leeds, UK.

[2] Barcelo, J. (2010). Fundamentals of Traffic Simulation. Springer.

[3] Gipps, P. (1981). A behavioural car-following model for computer simulation. *Transportation Research Part B: Methodological*, 15(2), 105-111.

[4] Luk, J., Tay, J. (2006). The use and application of microsimulation traffic models. Austroads Research Report, Report AP-R286, ISBN 1-921139-34-X, Sydney, Australia.

[5] Manraj, S., Balaji, P., Shriniwas A. (2012). Modeling of Traffic Flow on Indian Expressways using Simulation Technique. *Procedia - Social and Behavioral Sciences 43*, 475 – 493, Published by Elsevier.

[6] Mitran, G. (2012). Modelling air pollution generated by traffic flows in urban areas. PhD Thesys University of Pitesti.

[7] Mitran, G., Ilie, S. (2014). Transport planning – a component of emergency plan. Case study: Pitesti metropolitan area. Journal of Traffic and Logistics Engineering, 2(1), 40-44.

[8] Treiber, M., Kesting, A. (2013). *Traffic Flow Dynamics. Data, Models and Simulation*. ISBN 978-3-642-32460-4, Springer.

[9] Wilson, E. (2001). An analysis of Gipps' car-following model of highway traffic. *Journal of Applied Mathematics*, 66(5), 509-537, Oxford University Press.

IDENTIFYING SKILL GAPS IN THE KNOWLEDGE AND TEACHING OF COLREGS

Đani Mohović, Ph.D.
Robert Mohović, Ph.D.
Mate Barić, B.Sc.
University of Rijeka
Faculty of Maritime Studie
Studentska 2, 51000 Rijeka, Croatia
dmohovic@pfri.hr, mohovic@pfri.hr, mbaric@pfri.hr

ABSTRACT

The term “navigation” implies actions undertaken to enable the vessel to sail safely from the port of departure to the port of arrival in a defined period of time. The navigation of the vessel is exposed to many dangers and accidents which can occur and may have far reaching consequences on people, society, property and marine environment. By analysing maritime accidents in the past, vessel collisions were identified as one of the most frequent type of accidents. Furthermore, it is known that human error and wrong interpretation of the Rules are the most frequent reasons for vessels collisions. Recognizing that issue, the European Union approved the project "Avoiding Collisions at Sea" (ACTs) funded by the European programme "Leonardo da Vinci". The purpose of this research is to identify skill gaps in the knowledge and teaching of COLREGs (*International Regulations for Preventing Collisions at Sea 1972 - Rules*) for nautical engineering students and maritime professionals and non-professionals. The research results obtained have clearly showed skill gaps in the understanding of some parts of COLREGs due to wrong interpretation and application of the Rules. The only way to change this in the future is to improve learning methods of COLREGs inter alia using these research results.

Key words: COLREGs misunderstanding, skill gaps, training needs, improving teaching methodology.

1 INTRODUCTION

The Faculty of Maritime Studies in Rijeka is the leader of the European Union project "Avoiding Collisions at Sea" (ACTs). Other partners on the project are maritime training institutions coming from Great Britain[1], Spain[2], Slovenia[3], Bulgaria[4] and Turkey[5]. The project started on November 2013 and is planned to be completed by November 2015.

The most frequent reason for collision between vessels is disregarding COLREGs[1,2,3,4]. Accidents analysis in the paper [5] shows that 85% of all accidents are either directly initiated by human error or are associated with human error by means of inappropriate human response. Analysis note that mistakes are usually made not because of deficient or inadequate regulations, but because the regulations and standards that do exist are often ignored. The

[1] C4FF – Center for Factories of the Future
[2] SeaTeach S.L.
[3] Spinaker D.O.O.
[4] Nicola Vaptsarov Naval Academy
[5] Piri Reis University

IMO MSC clearly indicates that the causes of many of the accidents at sea are due to deficiencies in maritime education and training of seafarers or disregard for current standards and regulations.

MAIB (Marine Accidents Investigation Branch) safety study [6] analyses accidents from 1994 to 2003, where 55% of all accidents were collisions. Study also notes that 19% of the vessels involved in collision were completely unaware of the other vessel until collision, 24% of them were aware too late and 57% of them were aware of the other vessel.

Safety report [7] conducted by the EMSA (European Maritime Safety Agency) analysed accidents from 2007 to 2010. The report shows that total number of all accidents including collisions is falling, however if number of collisions is compared with other types of accidents it can be seen that collisions constitute 40% of all accidents.

By using a questionnaire, the authors have studied the knowledge and understanding of COLREGs by nautical students and maritime professionals and non-professionals. The questionnaire has been designed in such a way as to test the understanding of the Rules in order to see what parts of the Rules are misunderstood. The questionnaire [9], in a paper form and on-line, has been distributed within the EU and all over the word. In that way all the various methods of learning the Rules in different countries have been included into the research.

Regardless of the learning methods, the results of the questionnaire have confirmed skill gaps by nautical students and experienced maritime professionals and non-professionals from all over the world. After identifying skill gaps, based on the research results, a proper learning methodology can be developed.

2 INDENTIFICATION OF THE TRAINING NEEDS

In order to achieve the project goals, COLREGs questionnaire has been prepared and distributed among nautical students, maritime professionals and non-professionals. Preparation of COLREGs questionnaire, distribution of questionnaire and participant profile are described in following subchapters.

2.1 Research instrument

The questions have been designed to determine which rules are difficult to understand and which rules are most often broken in practice. Such questions are more difficult than the questions which simply check the knowledge. In a technical sense, the questionnaire has been prepared according to the instructions of the professors from the Faculty of the Humanities and Social Sciences in Rijeka who are dealing with teaching and assessment methods. Preparing questions for testing the Rules understanding has been a very difficult task, only 4 questions from the total of 372 from the MCA COLREGs test have been taken.

In accordance with the suggestions given by colleagues from the Faculty of the Humanities and Social Sciences in Rijeka, some graphical scenarios have been prepared and used in the questionnaire. This type of questions has been the right choice as there have been many positive comments on. Some comments have referred to the language used in the questionnaire as being an archaic one, but this has been agreed upon between Partners to use words and phrases as much as possible from COLREG (IMO) [8].-

As the aim has been to examine the understanding of certain Rules, the scenarios with only two vessels has been used. In practice, multi-encounters scenarios are very often used, but they have not been used in this questionnaire.

Once the final version of the questionnaire in the English language has been prepared, partners from Croatia, Slovenia, Turkey and Spain have translated the questionnaire into their proper languages.

The Slovenian Partner has been in charge of a non-professional questionnaire. It has been decided that the questionnaire will be the same, with only the general questions section being a different one.

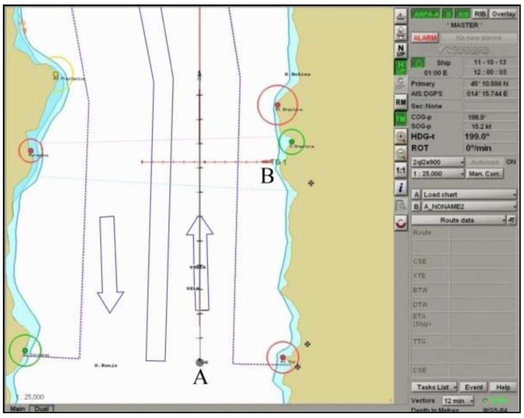
The questionnaire has been made up of four groups of questions:

- General questions for identifying the target group of respondents (12 questions).
- Questions that have had an answer in COLREGs (34 questions).
- Questions for testing the opinion and actions of seafarers (12 questions). This type of questions has been intentionally left to students in order to check if the professors have explained them some situations and what they will do when appointed junior officers.
- Optional questions for teachers and lecturers at maritime colleges (4 questions).

General questions aimed at enabling the analysis and extraction of desired characteristic groups of participants in order to obtain quality conclusions and comparisons among groups.

Group of questions that have an answer in COLREGs are the most important group of the questions for determining which Rules are hard to understand (Figure 1). On these groups of questions we have received some remarks because we have offered multiple-choice answers. That has been expected because of the misunderstanding of the Rules.

22. A power-driven vessel, vessel A, LOA = 187 meters, is proceeding in a traffic separation scheme lane. From her starboard side, a RO-RO passenger vessel, vessel B, LOA = 150 meters is crossing the traffic separation scheme.



If a risk of collision exists which vessel is the stand-on vessel?

a) Vessel A

b) Vessel B

Figure 1: Example of a question that have had an answer in COLREGs

In questions used for testing the opinion and actions of seafarers or students we have not defined the answer (Figure 2). In this group of questions, we have just wanted to see how respondents think. The questions of this group, with or without scenario, have been quite precise, so that, if everyone thinks in the same way, the answers would be the same or similar. However, the results have showed great differences.

39. In your opinion what is the "safe passing distance" between two power-driven vessels
LOA = 200 meters when meeting on the high seas?
The safe passing distance (CPA) in this case is ________

Figure 2: Example of a question testing the opinion and actions of seafarers or students

The last group of questions have been questions for professors who teach the rules. This group of questions has been put to see the experience and the opinion of persons teaching COLREGs.

2.2 Data collection

The questionnaire was distributed from January to the end of March 2014 through Lime survey and in a printed form. The results from the printed form have been inserted in the Lime survey. The questionnaire has been distributed to all maritime schools and colleges, seafarers on board merchant ships, teachers and lecturers at maritime institutions, VTS operators, employees of the port authorities, pilots as well as to masters of fishing boats and yachts.

The Partners have contacted crew managers who have sent questionnaires to all vessels and to seafarers ashore as well. They have also asked some seafarers to fulfil the questionnaire in their offices. High school and faculty students have fulfilled the questionnaire in their classrooms. The questionnaire has been announced and the persons questioned have been allowed to use books when filling in the questionnaire. The time for filling in the questionnaire has not been limited. In that way, we have managed to test the understanding of the Rules because they have been allowed to use all possible literature with no time limit. The respondents have taken 30-40 minutes to complete the questionnaire. By using such type of testing, we have avoided stress which is usually present on board a vessel. By the end of March 2014, the questionnaire was fulfilled by 1280 participants (professional seafarers, maritime high school and faculty students) and 285 holders of licenses for various types of ships/boats (pleasure craft and small fishing vessels). By January 2015, the questionnaire was fulfilled by 1498 seafarers and 288 non-professionals.

Most of the participants were maritime faculty students, ships officers and masters. Age of participants is from 19 to more than 63 years and the most of them were from Croatia, Turkey, Spain and UK. Participants in average have over 5 years of sea going experience and most of them navigate on liquid cargo vessels, container vessels and bulk carriers. Also 9% of participants were involved in collision and most of those collisions occurred in coastal waters and harbour areas and visibility was over 6 miles. Only 34% of all participants attended some additional COLREG training course.

3 ANALYSIS OF THE QUESTIONNAIRE RESULTS

The questionnaire results analysis for the understanding of the Rules has shown that maritime education and training lecturers have had the best results, followed by seafarers with sea experience who have on the average 15% better results than participants with no sea experience. The results obtained are shown in Figure 3.

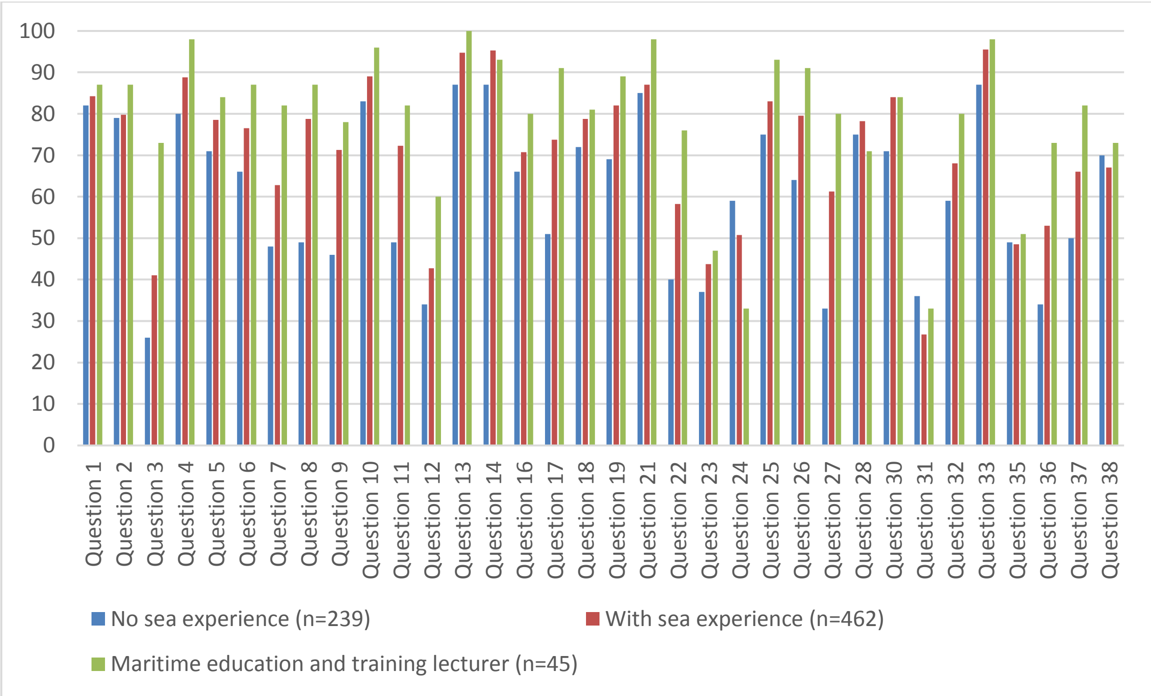


Figure 3: Percentage of correct answers by participant without and with sea experience and by maritime education and training lecturers

However, in questions regarding Rule 10 (TSS), participants with no sea experience have more correct answers and in questions regarding Rule 17 (Action by Stand-on Vessel) and Rule 18 (Responsibilities between Vessels) the results obtained from all participants are similar. Moreover, the results obtained from high school and maritime faculty participants have shown no difference in understanding the Rules.

Questions for testing the opinion of seafarers, like a minimum CPA, parallel course overtaking, and distance for start avoiding collision have received different answers because there are no correct answers in the Rules, but a difference between participants with and without sea experience has been noticed as is shown in Figure 4.

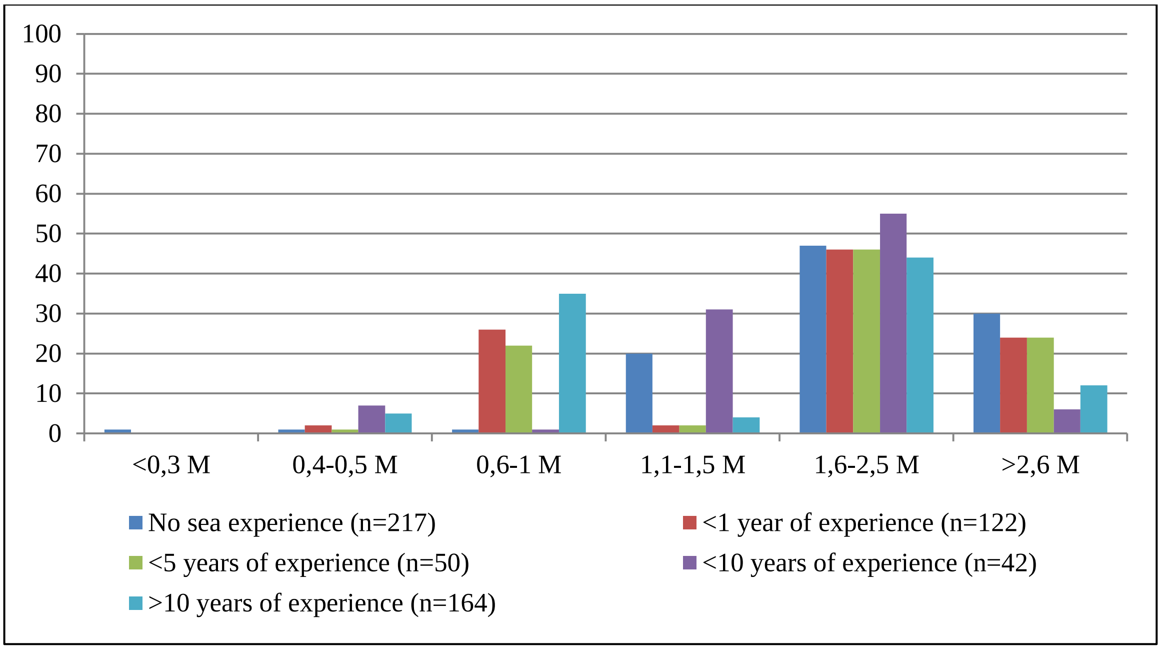


Figure 4: Percentage of answers for a minimum CPA opinion testing by different respondent groups

Rules which are hard to understand according to all participants are Rule 6 (Safe Speed), Rule 8 (Action to Avoid Collision), Rule 9 (Narrow Channel), Rule 10 (Traffic Separation Scheme), Rule 13 (Overtaking), Rule 18 (Responsibilities between Vessels) and Rule 19 (Conduct of the Vessels in Restricted Visibility). The results are showed in Figure 5.

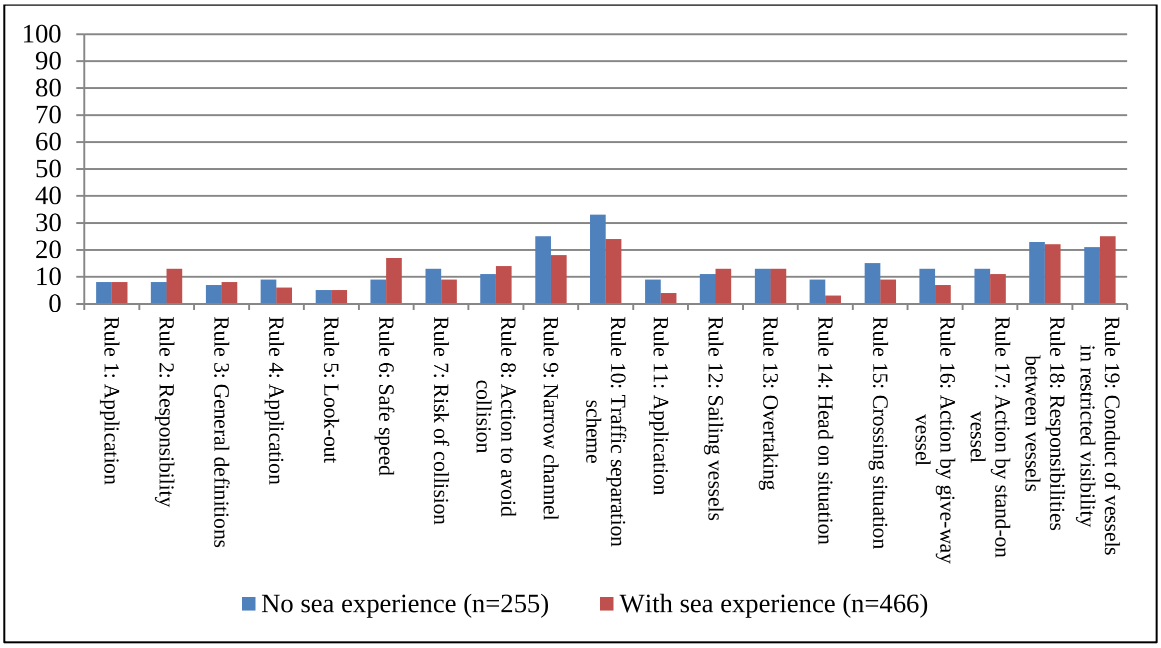


Figure 5: Rules which are most difficult to understand for participants without and with sea experience

Questions about using VHF in collision avoidance have shown that participants with sea experience less than 10 years use more VHF in collision avoidance than participants over 10 years of sea experience. Moreover, only 40 % of the participants with sea experience use more VHF communication after AIS equipment become mandatory, and 70% believe that VHF contact can be useful for preventing collisions at sea.

Questions for maritime education and training lecturers have shown that over 63% of students have problems in interpreting the Rules.

According to maritime education and training lecturers, Rules which are most difficult for students to understand are Rule 19 (Conduct of the Vessels in Restricted Visibility), Rule 18 (Responsibilities between Vessels), Rule 10 (Traffic Separation Scheme), Rule 6 (Safe Speed) and Rule 7 (Risk of Collision), and those answers are very similar to the answers given by other participants. The results are shown in Figure 6.

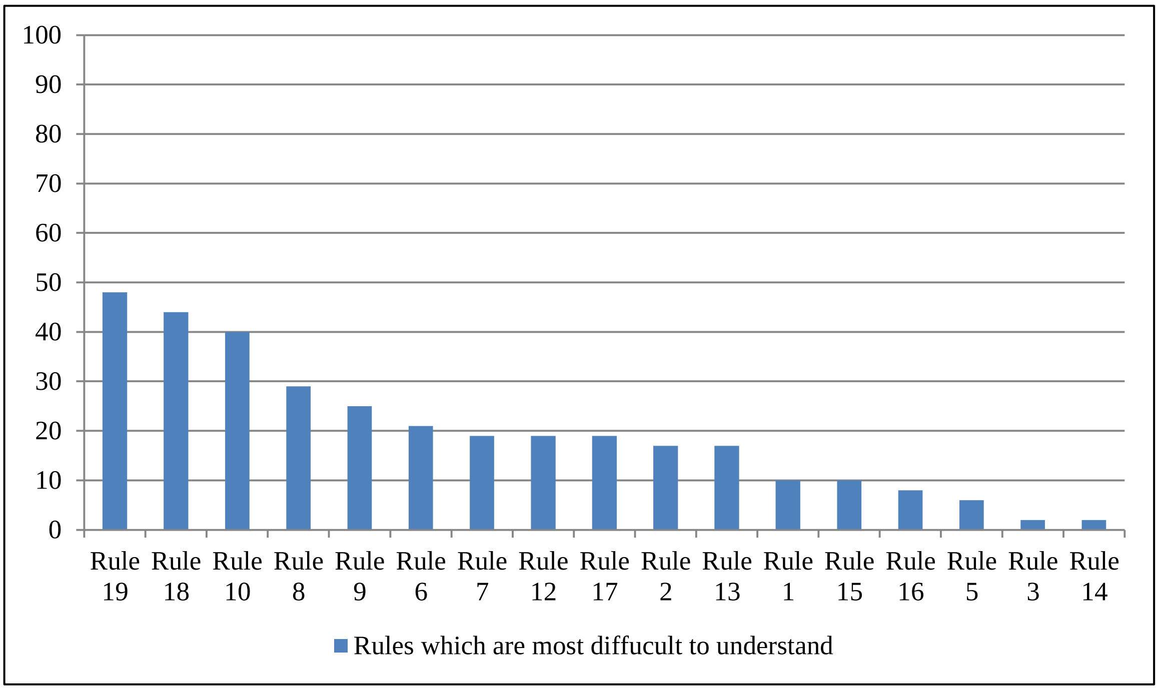


Figure 6: Rules which are most difficult for students to understand – answered by lecturers

4 VALIDATION OF THE QUESTIONNAIRE RESULTS

In order to validate the results of the questionnaire, workshops have been organized in all of the partners' countries and the research results obtained have been presented. The workshops aimed at presenting the results of the research, at validating the obtained results through discussions, at conducting discussion on the methods of learning the Rules and at determining the best way to use the results of the project for long-life learning.

In all partners' countries, workshops have been attended by 102 participants: teachers and professors at maritime colleges and faculties, seafarers, representatives of government authorities and maritime companies, pilots and members of various professional associations related to maritime shipping.

It has been concluded, on the workshops, that the results obtained have been in accordance with the workshop participants´ opinions and that there has been a strong need for the implementation of new methods of learning and teaching of COLREGs.

The questionnaire results and the conclusions from workshop discussions have clearly confirmed that there are significant differences in the understanding and application of the Rules.

5 FINDINGS OF THE RESEARCH

Taking into account all the facts stated above, the following conclusions can be drawn:

1. Need for the change or review of the COLREGs. The rules would have to have some minor changes or updates in accordance with evolving technology, and some drastic changes that are unlikely to expect. And what is more important is that the existing rules have to be interpreted precisely, so that they can be understood in the same way by everyone.
2. Necessity to determine the relationships and the hierarchy of the Rules. Rules that have priority over the other ones have to be clearly determined and navigation officers should be able to apply them without having any difficulty. A flow chart showing the priority of the rules is suggested. This would also lead to developing a sequence for learning/teaching the rules.
3. Establishing common understanding of the Rules – COLREGs guidelines. Establishing a common understanding of an individual rule through some kind of Guidelines is needed and standardizing the education, training and assessment of COLREGs through the COLREGs Model Course. COLREGs model course should be an integral part of the STCW. It is interesting that professional seafarers think that Rules and literature for learning Rules should be clarified, and non-professionals are satisfied with the learning materials. This has to be born in mind when preparing the COLREGs Model Course.
4. Need for a further clarifications of some Rules. At each workshop, it was pointed out that certain rules should be clarified. In some rules, certain definition should be added in order to clarify the rules. While explaining the rules, manoeuvring characteristics of the vessel should be included in order to make correct decisions on taking appropriate actions to avoid collision.
5. Establishing a brief COLREGs course and develop a COLREGs e-course. The COLREGs course should be easy to use by simple means of the information technology, rather than by expensive simulators.
6. Considering the results of the ACTs questionnaire and the analysis of the actual collisions, the conclusion is that the Rules are not easy to understand or apply in certain cases.
7. In order to improve the Rules learning methodologies for students and seafarers it is suggested as follows:
   - To use the case study scenarios to cover each individual rule
   - To include as many as possible scenarios as real life may pose within COLREGs training case studies
   - Radar view together with the bridge view should be included in the case studies
   - Use of Court decisions for the interpretation of case studies
   - Use of as much as possible visual images to make teaching COLREGs more effective
   - Training methodologies: use of images, simulators, CADs and visuals
   - Use of former accidents scenarios in an animated form

- Using of 3D dynamic animations, day and night, when cases and examples are used to support rules explanations
- Use of multi-ship situation scenario
- Use of materials such as animated scenarios or gamification of the Rules so that cadets can see the Rules in action and role play as vessels, to see the results of their decisions
- Scenarios must always be based on impartial reports e.g. MAIB reports or similar ones to ensure impartiality in the decision and report findings used for the scenarios
- Use of e-learning solution, software, mobile app to let students run short COLREGs

8. Need for official translation of COLREGs. Official translation of COLREGs in multiple languages could be made, but even more important are the explanations of the Rules.
9. COLREGs test should be prepared in the mother tongue language and in English as well.

6 CONCLUSION

The questionnaire results and conclusions of workshops discussions have clearly indicated problems in the understanding and application of COLREGs by nautical students and maritime professionals and non-professionals. As the research has been conducted in the EU and worldwide, the obtained results are relevant because different learning methods have been included into the survey and all those methods have shown same deficiencies. This gives clear results that it is necessary to improve the learning methods of COLREGs in the future.

The ongoing work on the ACTs project includes the development of a new learning methodology which will take into consideration the research results and will try to improve the learning method by using scenarios created for each Rule. It is possible to achieve decrement of collisions at sea by a better understanding and by applying the Rules by professional and non-professional seafarers, and it is believed that this new teaching methodology of the Rules will contribute to that goal. Further progress of the ACTs project can be followed on the web page: www.ecolregs.com.

REFERENCES

[1] Acar, U., Ziarati, R., Ziarati, M. (2008). Collisions and groundings – major causes of accidents at sea. Marifuture papers: 48 - 51. http://www.marifuture.org/Publications/Papers/Collisions_and_ groundings_major_causes _of_accidents_at_sea.pdf (last accessed, November 2014).

[2] Acar, U., Ziarati, R., Ziarati, M. (2012). An investigation into COLREGs and their application at sea. Marifuture papers: 40-47.

[3] European maritime safety agency. (2010). Maritime accident review. http://emsa.europa.eu/publications/technical-reports-studies-and-plans/item/1219-maritime-accident-review-2010.html (last accessed, September 2014)

[4] Macrae, C. Human factors at sea: common patterns of error in groundings and collisions. Maritime Policy & Management: The flagship journal of international shipping and port research: 33.

[5] Acar, U., Ziarati, R., Ziarati, M. (2008) Collisions and groundings – major causes of accidents at sea. Marifuture papers: 48 - 51. http://www.marifuture.org/Publications/Papers/ Collisions_and_ groundings_major_causes _of_accidents_at_sea.pdf (last accessed, November 2014).

[6] Marine Accident Investigation Branch. (2004) Bridge watch keeping safety study. http://www.maib.gov.uk/cms_resources.cfm?file=/ Bridge_watchkeeping_safety_study.pdf (last accessed, November 2014).

[7] European maritime safety agency. (2010) Maritime accident review. http://emsa.europa.eu/publications/technical-reports-studies-and-plans/item/1219-maritime-accident-review-2010.html (last accessed, October 2014)

[8] IMO Publications (2003). *COLREG – Convention on the International Regulations for Preventing Collisions at Sea 1972*, Consolidated Edition 2003, London.

[9] Maritime professionals' on-line survey: http://limesurvey.c4ff.co.uk/index.php?r=survey/index/sid/613743/lang/en (last accessed, January 2015).

SEAFARERS' APPROACH FOR SHIP MANOEUVRING IN HEAVY SEAS

Luka Mudronja
Marko Katalinić
Pero Vidan
University of Split
Faculty of Maritime Studies
Zrinsko-Frankopanska 38, Split, Croatia
luka.mudronja@pfst.hr, marko.katalinic@pfst.hr, pero.vidan@pfst.hr

ABSTRACT

Ship manoeuvring in heavy seas is procedure that can greatly affect ship safety. There was always a need to provide safe navigation route which reduces wave induced loads on ship construction and also affects transport cost and economy. Merchant ship manoeuvring in heavy seas is usually approached with mathematical methods of problem troubleshooting trough seakeeping validations of the ships. This paper is based on seafarers' view of the merchant ship manoeuvrability problem in heavy seas and describes interaction between mathematical calculations and real life decisions making. Research is made amongst experienced seafarers with additional questionnaire whose results are shown in this paper and are compared to previous seakeeping calculations. The aim is better seakeeping performances of the ships with final goal of better safety of the ships and seafarers.

Key words: Ship manoeuvring, heavy seas, seakeeping.

1 INTRODUCTION

Navigation in heavy seas represent treat for ship and seafarers safety. Behaviour of the ship in heavy seas is described as seakeeping characteristics of the ship which are evaluated by several seakeeping criteria such as slamming, deck wetness or propeller emergency (Prpic-Orsic & Čorić, 2006). Heavy sea is different term for different ships, depending on type and size of the ship and is described by significant wave height and wave period. In this paper, heavy sea is general term when seakeeping criteria may be exceeded which means that wave loads cause problems for merchant ships in navigation. Ship manoeuvring in heavy seas is procedure when ship has to change sustainable speed or course to prevent safety of the ship and seafarers. Seakeeping characteristics of the ship are determined by mathematical calculations and represent guidelines for ship manoeuvring procedures in heavy seas. Application of mathematically calculated procedures in real life decisions has been tested trough questionnaire presented in this paper. Questionnaire results show how seafarers react in heavy seas and are compared to mathematical calculations i.e. seakeeping characteristics.

1.1 Literature survey

Seakeeping criteria validation have been topic of interest for many authors since Aertsen and van Sluys (Aertsen & van Sluys, 1972) who were studying ship responses in heavy weather and recommended first limiting values for slamming seakeeping criterion. Limiting values for criteria such as deck wetness and slamming were recommended and improved by Ochi and Motter (Ochi & Motter, 1974) and Journèe (Journee, 1976). Review of previous recommendations made Lloyd (Lloyd, 1998). Moan (Moan, 2006) recommended limiting values for vertical acceleration at fore perpendicular and added it to list of seakeeping criteria.

Guedes Soares (Guedes Soares, 1990) recognized the importance of human actions in ship manoeuvring and highlighted the need for interviews and discussions with seafarers. Prpic-Orsic with colleagues (Prpić-Orsić, Parunov, & Šikić, 2014) conducted questionnaire among ship masters of the container ships and that research was fundament for questionnaire presented in this paper.

1.2 Seakeeping calculations

Seakeeping calculations mathematically describe ship behaviour on the waves. Authors made calculations for container ships and tankers (Mudronja, Vidan, & Parunov , 2014). Example for right ship manoeuvring decisions is shown in Figure 1.

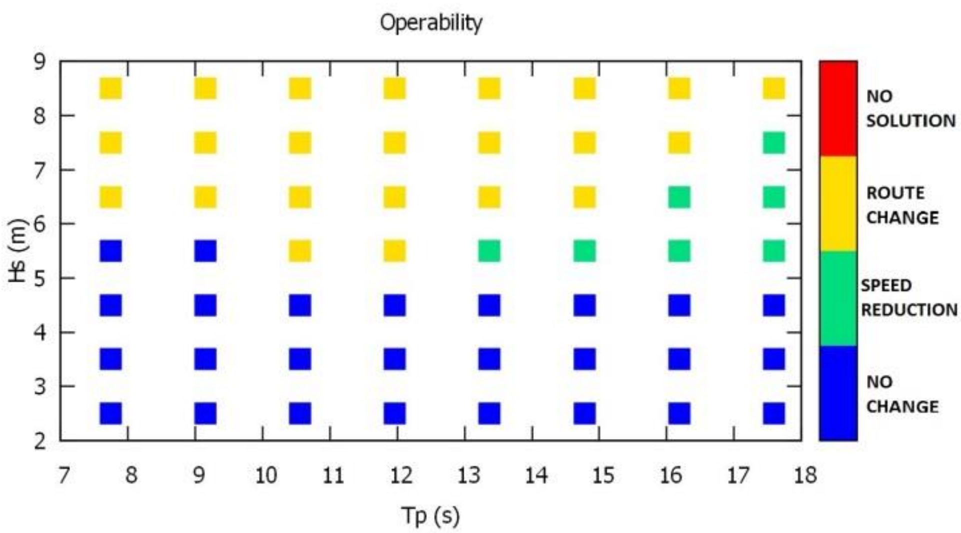


Figure 1: 9200 TEU container ship operability plot for manoeuvring decisions (route change and speed reduction) on interesting sea states described by significant wave height (Hs) and peak wave period (Tp)

Source: (Mudronja et al.: Review of seakeeping criteria for container ship sustainable speed calculation in rough weather)

Example of operability diagram for one certain 9200 TEU container ship in Figure 1 shows appropriate manoeuvers for navigation on different sea states which are described by H_s (significant wave height) and T_p (peak wave period). Manoeuvres that have to be done to reduce wave loads and prevent ship safety are speed reduction and route change. Which manoeuver has to be done is derived from correlation between seakeeping characteristics calculations and limiting values of the seakeeping criteria. Table 1 shows limiting values for seakeeping criteria used in 9200 TEU container ship operability calculation.

Table 1: Limiting values of the seakeeping criteria used in 9200 TEU container ship calculation

Limiting probability of slamming	1.12%
Limiting probability of deck wetness	5.00%
Limiting RMS of vertical bow accelerations	0.108g

Source: (Mudronja et al.: Review of seakeeping criteria for container ship sustainable speed calculation in rough weather)

Seakeeping calculations were done by using state-of-the-art seakeeping software Hydrostar while results are post processed using program Starspec. Hydrostar calculates wanted response amplitude operators (RAOs) for different sea states described and recommended for North Atlantic by International Association of Classification Societies. Calculations are based on 3D panel method and linear potential theory. RAOs are entrance parameter for significant responses of the ship calculations, calculated by program Starspec using 0^{o}-360^{o} wave heading. 2-P Pierson Moskowitz wave spectrum formulation was used for short term spectral analysis. Correlation between calculated ship responses and limiting values of the seakeeping criteria (Table 1) gives, as result, operability diagram shown in Figure 1.

Both manoeuvers have to be done by seafarers and questionnaire presented in this paper gives answer in which way seafarers reduce speed and change route in real life.

2 QUESTIONNAIRE FOR THE SEAFARERS ABOUT SHIP MANEUVERING IN HEAVY SEAS

Questionnaire, that covers the issue from the title, was developed on the Faculty of Maritime Studies from Split University. It is based on combination of nautical experience of the professors on the Faculty and knowledge from previous work of the authors. Previous work includes seakeeping calculations for different ship types in heavy seas. Questionnaire was provided among thirty seafarers that navigate on container ships and had attended courses on the Faculty of Maritime Studies in Split. All seafarers have had minimum three years of navigation on merchant ships.

2.1 Content of the questionnaire

Questionnaire was anonymous and includes three types of questions:

1. general questions such as number of years in navigation, current position on the ship, ship type, etc.,
2. questions related on experience in navigation in heavy seas,
3. suggestions of the seafarers for improving navigation in heavy seas in the future.

In this paper, the second group of the questions is going to be presented with results.

Here are shown the most relevant questions from the second group:

- Write maximum wave height value that you have ever encountered.
- Do you reduce ship speed in heavy seas?
- Do you change course of the ship in heavy seas?
- If you do change ship speed, write the maximum value of the ship speed reduction in heavy seas.

2.2 Questionnaire results

Results of four questions from the questionnaire are shown because have correlation with mathematical seakeeping calculations showed on Figure 1 which represents ship manoeuvring decisions. Results of the question WRITE MAXIMUM WAVE HEIGHT VALUE THAT YOU HAVE EVER ENCOUNTERED are shown in Figure 2.

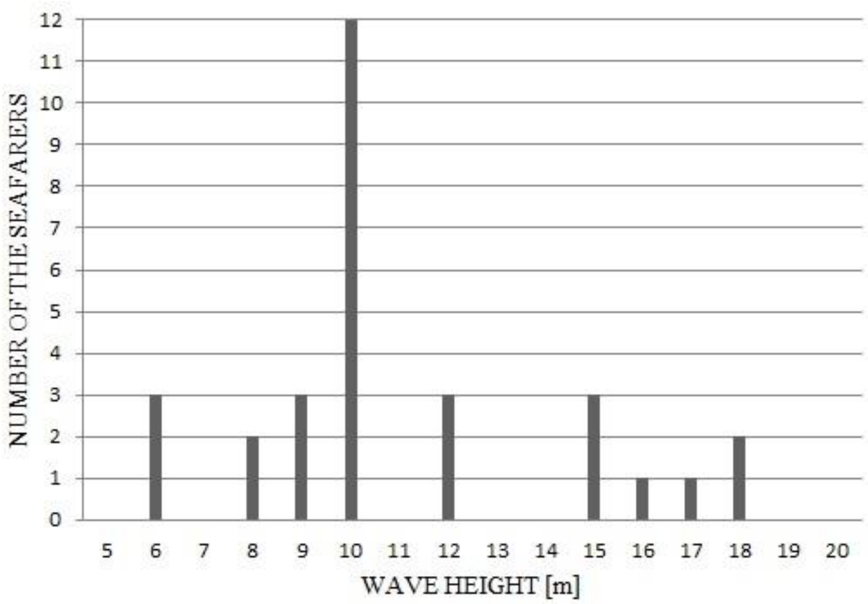


Figure 2: Maximum wave height that tested seafarers observed during navigation

Results shown in Figure 2 show that range of maximum wave heights observed during navigation is between 6 and 18 meters. The largest number of tested seafarers observed maximum wave height of 10 meters. Common value for Figure 1 and Figure 2 is wave height which is value used to describe sea state. The largest number of the seafarers navigated on the waves between 8 and 10 meters which is highest value in Figure 1. Comparison between Figure 1 and Figure 2 shows that interesting values of wave heights are between 5 and 10 meters. Navigation on those wave heights requires speed reducing or route change. Higher values are also interesting but seakeeping calculations show that on those wave heights there is no ship manoeuvring solution so high wave loads can not be reduced.

Results of the question DO YOU REDUCE SHIP SPEED IN HEAVY SEAS are shown in Figure 3.

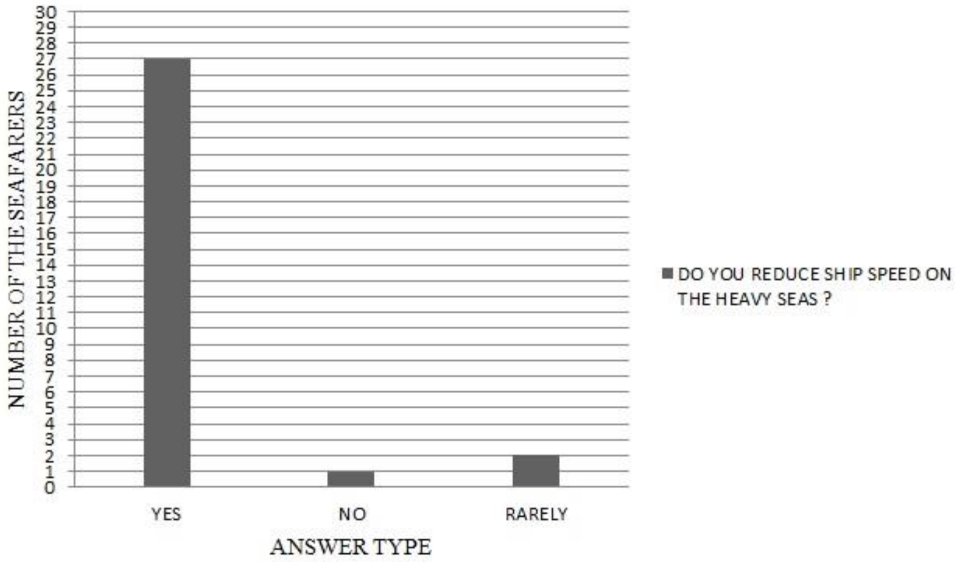


Figure 3: Type and number of the answers on question: DO YOU REDUCE SHIP SPEED IN HEAVY SEAS?

Speed reduction has to be done in heavy seas to prevent structure from high impacts caused by waves and wind. It is encouraging to see that 27 out of 30 seafarers reduce speed and, in that way, make navigation much safer. One seafarer gives answer NO, and more detail analysis of his questionnaire shows that he sails on container ship which usually changes route but without speed reduction. That is interesting introduction in third question.

Results of the question DO YOU CHANGE COURSE OF THE SHIP IN HEAVY SEAS are shown on Figure 4.

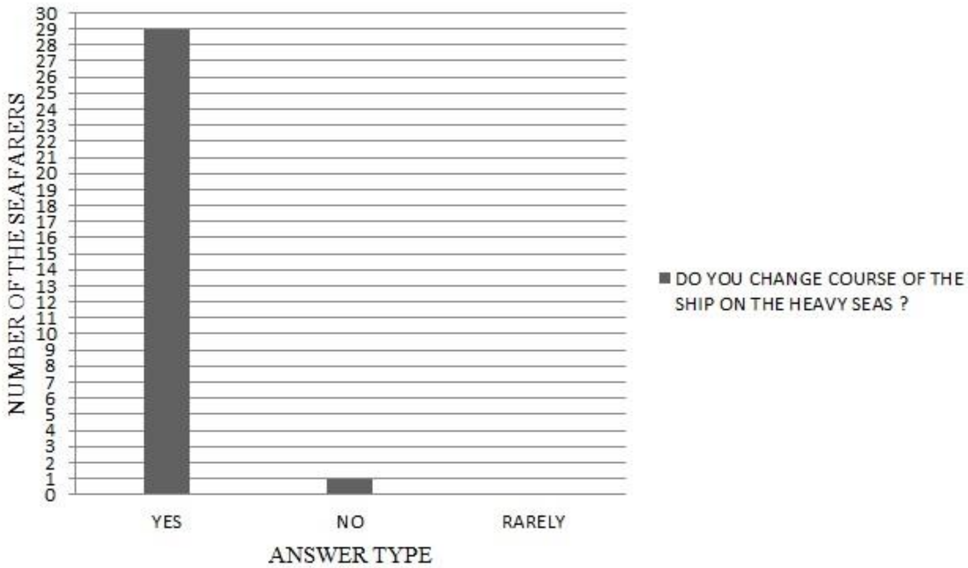


Figure 4: Type and number of the answers on question: DO YOU CHANGE COURSE OF THE SHIP ON THE HEAVY SEAS?

29 out of 30 seafarers do change route in heavy seas. Answer NO is not from the same seafarer that answered NO in previous question. Both answers, on second and third question,

show that seafarers do change route and do make speed reduction, which is very encouraging for further mathematical calculations of the operability in heavy seas.

Results of the question MAXIMUM VALUE OF THE SHIP SPEED REDUCTION IN HEAVY SEAS are shown on Figure 5.

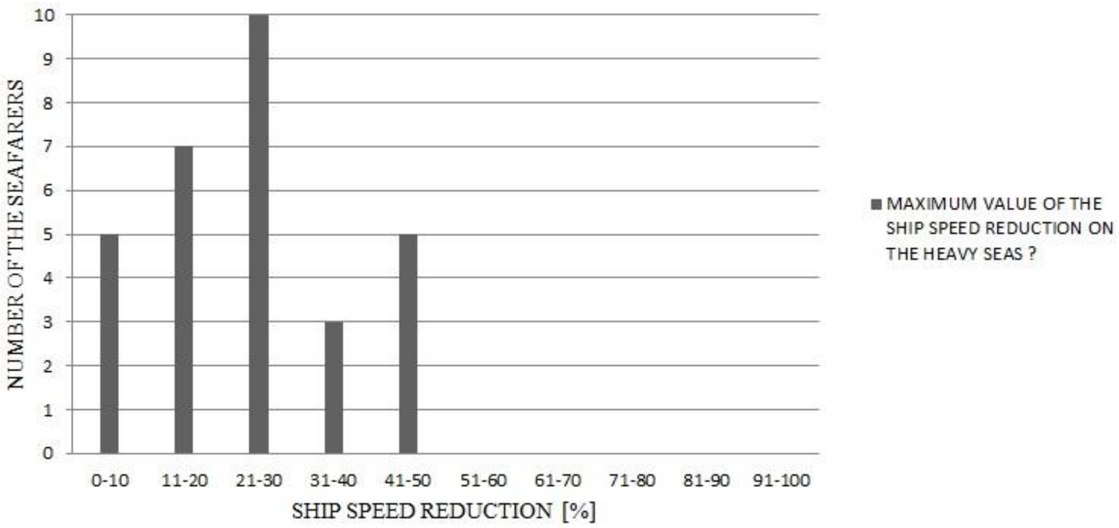


Figure 5: Type and number of the answers on question: MAXIMUM VALUE OF THE SHIP SPEED REDUCTION IN HEAVY SEAS?

One third of the answers show that ship speed reduction is around 1/4 of the normal speed in navigation. Almost the same number of the seafarers answered that makes 10% and 50% speed reduction. Detail analysis of their questionnaires shows that ships with more displacement and higher length value do little speed reduction and smaller ships do speed reduction of almost 50%. These answers include also two answers from question two who answered that rarely do speed reduction. Detail analysis, of these two answers, shows that their reduction is 10% when they do that ship manoeuvring step.

3 DISCUSSION

The results of the questionnaire show that seakeeping numerical evaluations were set on sound basis. Most of the seafarers do essential manoeuvres like speed reducing and route change which reduces forces on construction. Important question is how seafarers recognize moment when all manoeuvers have to be done? First step for making right decision is recognition of heavy seas which primarily involves recognitions of wave heights. Seafarers' recognitions of heavy seas i.e. wave heights are usually provided through visually observing from bridge of the ship during service by watch keeping officer. Wave height recognition is based on seafarers' ability to visually recognize wave height which ship encounters during navigation. Described method of wave height recognition has uncertainties because it is subject of seafarers' error and depends on seafarers' experience. Weather forecasts and satellite images can also predict wave heights. Combination of visually recognition and weather forecasts is the best way for right decision making. Another step for right decision making in manoeuvres is recognition of ship responses and phenomena that are result of wave loads. In the introduction to the questionnaire is important to explain all possibilities of mistakes and differences so the seafarers can give correct answer.

Example of the seakeeping calculation is shown for container ship and it is important to underline that all 30 seafarers were sailing on that type of the ship. Mathematical calculations have a lot uncertainties and simplifications, especially in the field of criteria limiting values. Intention of the authors is improving seakeeping criteria and its limiting values trough probabilistic approach. Intention is to more improve questionnaire and in that way validate mathematical calculations. Also to prove that the recommended procedures are implemented in the real life decision making.

4 CONCLUSSION

The intention of the authors was to show if seakeeping mathematical calculations have practical application real life on board. Based on the number of the seafarers (respondents) it is proved that previous mathematical calculations are correctly based. It is proved that procedures of the seafarers are ship speed reduction and route change which is seafarers' approach for ship manoeuvring in heavy seas. Constant interviews and discussions with seafarers will improve not only ship manoeuvring in heavy seas but also global ship safety. Future work of the author is questionnaire improving and comparison of questionnaire with seakeeping calculations for different type of the ships, not only container ships. Also development of mathematical approach and criteria limiting values will lead to better seakeeping calculation results. That steps lead to reducing of the wave loads on the structure. Constantly raising awareness of the ship structure safety and seakeeping of the ship leads to better global safety on board which is main mission of the all seafarers, naval architects and people connected with the sea.

REFERENCES

[1] Aertsen, G., & van Sluys, M. (1972). Service, performance and seakeeping trials on a large container ship. *TRINA 114.*

[2] Guedes Soares, C. (1990). Effect of heavy weather meneuvering on the wave-induced vertical bending moment in ship structures. *Journal of Ship Research*, 60-68.

[3] Journee, J. (1976). Prediction of speed and behaviour of a ship in a seaway.Rapport 0427-P. Delft.

[4] Lloyd, A. (1998). Seakeeping: Ship Behaviour in Rough Waves. Gosport: ARJM Lloyd.

[5] Moan. (2006). Comparative reliability analysis of ships-considering different ship types and the effect of ship operations on loads. *SMTC&E.* Fort Lauderdale: SNAME.

[6] Mudronja, L., Vidan, P., & Parunov , J. (2014). Review of seakeeping criteria for container ship sustainable speed clculation in rough weather. *Maritime Technology and Engineering* (pp. 1059-1064). Lisabon: Instituto Superior Tecnico.

[7] Ochi, M., & Motter, E. (1974). Prdiction of extreme ship responses in rough seas of the north Atlantic. *International Symposium on the Dynamics of Marine Vehicles and Structures in Waves.* London.

[8] Prpic-Orsic, J., & Čorić, V. (2006). *Seakeeping.* Rijeka: University of Rijeka.

[9] Prpić-Orsić, J., Parunov, J., & Šikić, I. (2014). Operation of ULCS-real life. *International Journal of Naval Architecture and Ocean Engineering*, 1014-1023.

THE IDENTIFICATION OF RELEVANT TECHNICAL-TECHNOLOGICAL PARAMETRES OF RAILWAY CHARGING SCHEMES TO BE USED FOR THE UPGRADE OF RAILWAY CHARGING SYSTEMS

Kristijan Novak, B.Sc.Econ.
Municipality Rogaška Slatina
Izletniška ul. 2, Rogaška Slatina, Slovenia
kristijan.novak@gmail.com

Tomislav Josip Mlinarić, Ph.D.
University of Zagreb
Faculty of Traffic and Transport Sciences
Vukelićeva 4, Zagreb, Croatia
tmlinaric@fpz.hr

Drago Sever, Ph.D.
University of Maribor
Faculty of Civil Engineering
Smetanova ulica 17, Maribor, Slovenia
drago.sever@um.si

ABSTRACT

The article focuses on the identification of those relevant technical - technological criteria of charging fees for the use of railway infrastructure, which most affect the efficiency and economic viability of a particular model for charging.

Railway charging system can be economically sustainable only if the charges (user fees) cover the desired percentage of funds for the maintenance and development of the railway infrastructure. User fees, on the other hand, should not be too high to discourage the railway operators from using the particular railway infrastructure.

The findings show that the determination of parameters of charging models is most affected by the desired level of covering the infrastructure costs of individual countries, while their charging schemes are basically quite similar.

The analysed case on the mixed railway line shows that to achieve the desired percentage of infrastructure costs coverage it is not enough only to fully exploit the available line capacities. It is also necessary to reduce the cost of infrastructure and/or to increase the price of train kilometers and/or modify the existing charging model, as the desired threshold coverage cannot be achieved without drastic interventions in the cost and revenue side of the railway infrastructure equation.

Key words: Railway infrastructure, charging schemes, railway technology.

1 INTRODUCTION

Slovenia is a Member State of the European Union and accordingly the Slovenian legislation has to follow the Union`s legislative system. The same is applied for the railway system, especially in proper implementation of EU Railway Directives and the establishment of new institutions.

Following the EU standards in railway system the fulfillment of certain preconditions (provision of non-discriminatory track access, interoperability etc.) has to be provided. The EU legislative provisions are generally incorporated and implemented in Slovenian legislation and therby incorporated in the actual railway charging scheme.

There is a well known fact that the actual state of Slovenian railway infrastructure is rather bad. The indicatiors that shows that are number of speed limits and results of measurements. By that the problem with the definition of charging basis, i.e. the initial state of the infrastructure, occurs. The initial state of the infrastructure should provide normal and non-stop usage of the railway infrastructure for all users. Such basis is urgent for the definition or real maintenance costs, needed for the decision makers to define the amount of charges and what percentage of maintenance and operations costs should be covered with them.

This is the reason why relevant technical-technological charging parameters need to be defined and analysed in order for charges to be economically sustainable. It means that the charges should be capable to cover some infrastructure costs and on other hand they should not be too high to prevent railway operators from doing bussines. By identification of relevant technical-technological parameters it is possible to compare existing charging regimes and models, define their strengths and weaknesses and for the networks with comparable transport mix define certain actions for better and more efficient use of the railway infrastructure.

Doing that it would be possible to efficiently upgrade existing charging regimes in order for them to be sustainable and that the infrastructure is better utilised and operated. By defining and pondering the relevant charging parameters the basis for optimized and sustainable charging regime will be given. The sustainability of the whole railway system can be reached in a way that has to be appropriate for each and every network manager on its own specific way.

2 THE ANALYSIS OF THE EXISTING CHARGING REGIMES

In the following chapter some existing charging models with their specific technical-technological parameters will be analysed in order to define the relevant parameters which have the most impact on the definition of the certain charging regime.

Basically, technical-technological parameters which are present in most European charging regimes are as follows:

- number of train kilometres made by the operator on main or regional line;
- ponders for main and regional lines – usually the ponder for regional lines is lower than for main lines as a stimulation for traffic on regional lines;
- price per train kilometre;
- coefficient for track usage, which is higher for heavier trains;
- timetable factor which reflects railway operators’ demands.

SWOT analysis was made for each of the models and is presented in this chapter. It should be emphasised that SWOT analysis is prepared only for strengths and weaknesses because of the specifics of the charging regimes.

Marginal railway infrastructure costs represent the basis of calculations within each charging regime. They can be:

- short-term marginal costs (they reflect the costs of the additional train on the existing railway infrastructure)
- long-term marginal costs (they reflect the costs of additional train in time frame where network capacities can be higher or lower – for example change in track capacities or railway safety and signalling system).

But generally these costs represent only small percentage (usually between 10% and 20%) of overall infrastructure costs (maintenance and operations costs).

In cases of saturated capacities the short-term marginal costs should include opportunity costs (railway manager`s lost income).

Long-term marginal costs reflect provision of additional trains in longer time period which allows improvements or deteriorations of the railway track. Short and long-term marginal costs are the same when the capacities are optimal adapted.

There are different approaches between different countries when it comes to charging schemes. Roughly the definition of charging parameters depends on:

- amount of charges which depends on infrastructure costs and what coverage of the infrastructure costs is to be achieved;
- structure: the charging models can be monopartite or bipartite (fixed and variable part) and
- ways and criteria of charging.

Table 1: Comparison of technical-technological charging parameters

ELEMENTS	Slovenia	Croatia	Italy	Hungary	Austria
Charging fees:					
- Fixed part	X	X	✓	✓	X
- Variable part	✓	✓	✓	✓	✓
Variable part depends on:					
- Train km	✓	✓	✓	✓	✓
- Brutto ton km	X	✓	X	✓	✓
- Stops on Stations	X	X	✓	✓	✓
Price per train km depends on:					
- Type of track	✓	✓	X	✓	✓
- Traffic density	X	X	X	X	✓
- Flexibility of demands in Time-Table	X	X	✓	X	X
- Type of train	✓	✓	✓	✓	✓

Source: own

It can be seen in the table how similar and different technical-technological parameters between various countries can be, although the compared countries have comparable networks and comparable transport mix.

For most of the countries it can be stated that they use monopartite scheme, while Hungary and Italy have bipartite charging system as they charge also fixed part (track reservation/booking).

In all countries the variable part depends on train kilometres. In Austria it depends also on brutto ton kilometres. In Italy, Hungary and Austria the station stops are also charged.

The structure of train km price is similar in all countries. In Italy it is specific situation as the price structure does not depend on track type, but on flexibility of demands in time-table. The traffic density is taken into account in Austria. The same for all models is that charging price depends on train type.

These facts have to be looked through the view of their sustainability in order to define better efficiency of each of the charging models.

3 COMPARATIVE ADVANTAGES AND DISADVANTAGES OF DIFFERENT CHARGING SCHEMES

For better comparison of technical-technological charging parameters they can be presented in a table of comparative advantages and disadvantages.

Both bipartite charging models (Italian and Hungarian) are different from others (Slovenian, Croatian and Austrian) in their basis. Therefore the focus will be given to three monopartite charging models (Slovenia, Croatia, and Austria).

Table 2: Comparative advantages and disadvantages of different charging regimes

Comparative advantages and disadvantages	Slovenia	Croatia	Austria	Italy	Hungary
Segmentation of track categorisation regarding their technical-technological characteristics	+	+	+-	-	+-
Compliance of actual state of network quality	+	+	+	-	+-
Division of trains regarding the type of transport (passenger, freight)	+	+	-	-	+
Differentiation of passenger trains	+	-	-	-	-
Promotion of better usage of freight trains	-	-	-	+-	+-
Promotion of auto trains	+	+	-	-	-
Promotion of optimal transport operations (for example the optimisation of empty and loco rides)	-	-	+-	+	+
Brutto train weight is directly taken into account	-	-	+	-	+
Deductions and allowances regarding the type of transport and train mass	+	+	+-	-	+-
Differentiation of towing vehicles regarding their type	+	+	-	-	-
Differentiation of towing vehicles regarding their mass	+	+	+	+	+
Elements of time and place deductions and allowances (for example transport during time peaks)	-	-	+	+	-
Promotion of combined transport	+	+	+	-	+
Different price for freight and passenger transport	-	+	-	-	+
Provision of methodology harmonisation between neighbouring countries	+	+	+	-	+-

Source: own

As it was mentioned and can be seen in the table the Slovenian, Croatian and Austrian charging models are similar when looking their technical-technological charging parameters. The main difference is that the Austrian charging regime is the oldest, most structured and tested in practice, which allows the model to be properly adapted and modified. That is what makes the Austrian charging model the most sustainable in Central Europe.

4 SUSTAINABILTY ANALYSIS OF THE VARIOUS CHARGING MODELS

When we speak of sustainability of the charging schemes we have to have in mind as optimal as possible mix of technical-technological charging parameters which should enable the model to cover certain percentage of maintenance and operations costs of the railway infrastructure. This is the reason why the price per train km varies a lot between observed countries.

For example, the price per train km in Slovenia is the same for freight and passenger transport, relatively low in Croatia and high in Hungary, while for the price Austria we can conclude that represents average amount between observed countries.

From the following figure it can be seen which percentage of maintenance costs is really covered with charges in various European countries. This percentage is the lowest in Norway, where charges cover only 1% of maintenance costs. The highest percentage is in Estonia, Latvia and Lithuania, where the charges should cover total maintenance costs. For neighbouring countries it can be seen that the coverage in Austria is 28%, in Hungary 80% and in Italy 17%

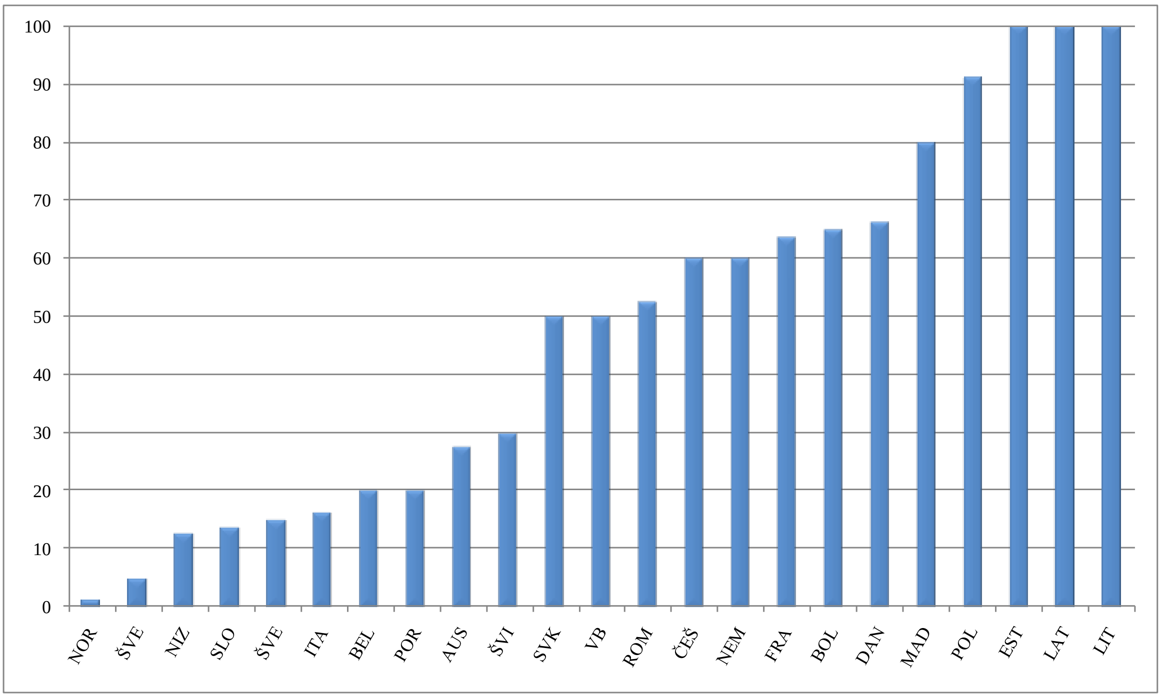


Figure 1: Percentage of cost recovery with charges

Source: OECD, ITF, Charges for the use of Rail infrastructure 2008

In general the well-known fact is that all countries would like to implement the most appropriate charging regime, which could cover part of railway infrastructure costs (maintenance, investments and operations). The hypothetical goal of every model is focused on getting 100% financial sources for railway infrastructure.

Slovenia has set itself a goal that the percentage for covering of maintenance and operations costs should be set at 30%. This goal should be reached gradually with the raise of initial percentage for 2% each year from 2008 when it was at 8.95%. If the costs of infrastructure should be the same each year and that the level of prices and coverage percentage is gradually raised, the goal would be reached in 2020.

In practice it can be seen that the goal will not be reached as the percentage coverage in 2012 was only at 5.96%. It can be concluded that Slovenian charging model is probably not optimal as it is not following the long-term sustainability of transport policy.

5 THE ANALYSIS OF SPECIFIC LINE SECTION IN SLOVENIA

As a typical mixed line section the railway line no. 32: State border – Rogatec – Stranje – Grobelno was analysed. The category of the line is C3; overall line length is 36.8 km of which 36.7 km is single lined. The line is not electrified; maximum line speed is 80 km/h, while on certain line sections only 40 km/h. Maximum allowed train length is 400 m.

From Slovenian Railway Network Statements 2009 – 2013 it can be seen that the limitation on the line presents the section between Stranje and Lupinjak (border crossing with Croatia). Theoretical and actual throughput of the line is 40 trains/day, while the timetable capacity is only at 48%[1].

5.1 Coverage of line section infrastructure costs with charging

For the calculation of line section cost recovery it is necessary to compare infrastructure costs of the line section (maintenance and operations costs) with the calculated charges.

In previous chapters it was stated that cost recovery for Slovenian railway network is just below 6 % and that its share is lowering from year to year from initial year 2008. The percentage of cost recovery will be calculated for selected line section in this chapter.

Table 3: Calculation of charges in EUR for railway line no. 32 in period 2009 – 2013

Year	No. of passenger km	Charges / passenger transport in EUR	No. of freight km	Charges / freight transport in EUR	Overall charges in EUR
2009	104.150,70	43.578,84	11.439,00	4.278,26	47.857,10
2010	105.796,80	44.267,60	11.271,60	4.215,65	48.483,25
2011	103.285,80	43.216,94	11.718,00	4.382,61	47.599,55
2012	103.481,10	43.298,66	10.797,30	4.038,26	47.336,92
2013	102.560,40	42.913,42	11.020,50	4.121,74	47.035,16
2014	95.836,50	40.100,00	9.625,50	3.600,00	43.700,00

Source: Own calculations

For calculation of line section`s cost recovery the above data should be compared with the costs of the line (maintenance and operations on the line) which is shown below.

1 Program omrežja RS 2014: http://www.slo-zeleznice.si/uploads/SZ/program_omrezja_2014_2/small_PO_2014_2_Priloga_3_1a_Proge.pdf

Table 4: Maintenance costs of line section no. 32 (2009-2013) in EUR

	Year	Overall own price	Total staff costs	Add-ons	Full price of service
Railway line no. 32: State border-Rogatec-Stranje-Grobelno	2009	717.999	103.020	53.600	874.618
	2010	760.831	137.782	53.918	952.531
	2011	497.264	91.454	38.999	627.716
	2012	433.250	87.516	36.118	556.884
	2013	450.273	41.511	47.127	538.910

Source: Slovenske železnice d.o.o.

Table 5: Operations costs of line section no. 32 (2009-2013) in EUR

Year	Production	Plant	Unit others	Unit salaries	Material	Management salaries	Add-ons	Full price of service
2009	407.933	31.416	5.531	12.345	0	0	0	457.225
2010	402.983	29.225	9.569	15.427	0	0	0	457.204
2011	432.091	27.390	9.265	17.037	0	0	0	485.783
2012	449.992	17.727	20.883	17.989	0	0	0	506.590
2013	514.242	0	33.646	33.451	25.285	30.872	62.496	699.991

Source: Slovenske železnice d.o.o.

For calculation of cost recovery it is necessary to compare total line revenues (charges) with total line infrastructure costs (maintenance and operations) which is shown in the following table.

Table 6: Cost recovery calculation for railway line no. 32 for period 2009 – 2013

Year	Maintenance costs in EUR	Operations costs in EUR	Total infrastructure costs in EUR	Charges in EUR	Cost recovery in %
2009	874.618,00	457.225,00	1.331.843,00	47.857,10	3,59%
2010	952.531,00	457.204,00	1.409.735,00	48.483,25	3,44%
2011	627.716,00	485.783,00	1.113.499,00	47.599,55	4,27%
2012	556.884,00	506.590,00	1.063.474,00	47.336,92	4,45%
2013	538.910,00	699.991,00	1.238.901,00	47.035,16	3,80%

Source: Own calculations

In the table it can be seen that cost recovery for selected line section in years 2009-2013 is between 3.5% and 4.5% which is lower than average cost recovery in Slovenia (6%).

In the next subchapter it will be shown what the cost recovery of the railway line could be if the line`s capacity is fully and optimally exploited. Moreover some technical-technological measures, which could raise the line`s utilisation will be presented

5.2 Cost recovery calculation in case of optimal line`s capacity utilisation

In previous subchapters it was presented that the railway line no. 32 is not optimally exploited. Its theoretical and actual throughput is 40 trains/day (14.456 trains/year). The actual number of trains is significantly lower so the line`s utilisation is only at 28.54%.

From timetables from 2009-2013 it is visible that 7 pairs (14 trains) of passenger trains use the line every day. Let's make an assumption that it is possible to employ hourly regime for passenger transport on the line. By doing that the number of passenger trains would be raised for 8 pairs/day, so the total number of passenger trains would be 30, while other 10 trains for fulfilling the line capacity would be freight trains.

In that case the following theoretical charges can be calculated for selected year:

- For passenger transport:

Upassenger $= Q_{vlkm(vv,i)} \, x \, F_{vv} \, x \, P_i \, x \, C_{vlkm} \, x \, C_{vp}$ *(in EUR), where:* (1)

Qvlkm(vv,i) = 222.546 pkm

Pi = 0,531

Fvv = 0,95

Cvp = 0,60 for diesel passenger trains

Actual Cvlkm = 1,382432869 EUR/pkm

We can conclude that theoretical charges at 100% line utilisation would be for passenger transport 93.118 EUR annually.

- For freight transport:

Ufreight = Qvlkm(vv,i) x Fvv x Pi x Cvlkm x Cvp (in EUR), where: (2)

Qvlkm(vv,i) = 74.182 tkm

Pi = 0,531

Fvv = 0,95

Cvp = 0,72 for freight trains up to 1000 ton

Actual Cvlkm = 1,382432869 EUR/tkm

We can conclude that the theoretical freight charges at 100% line utilisation would be 37.247 EUR annually.

Total charges in shown case would be 130.365 EUR annually.

As the average annual infrastructure costs of the line in the period 2009 – 2013 is 1.231.490,40 EUR, the cost recovery of the line could be up to 10,59% with the 100% line utilisation.

This percentage of cost recovery is significantly lower than Slovenian long-term goal (30% cost recovery), showed in previous chapters. That shows that it is not enough to 100% utilise the railway lines in Slovenia to reach the wanted cost recovery percentage. It is believed that along with the 100% utilisation some drastic measures in optimisation of railway infrastructure costs need to be taken, as well as optimisation of the existing charging scheme is urgent. In short: the costs of the infrastructure need to be lowered while charges need to be raised (either with higher train km price or/and modification of the existing charging regime).

It should be emphasised that such measures are extremely unpopular in both, train operators (higher train km price) and infrastructure managers (cost optimisation), so it is proposed that before starting to think about such measures it is extremely important to make the same calculations for all railway lines, compare the results and find the best practices before empowering the changes.

6 CONCLUSION

The technical-technological elements that were analysed are basis for the charging regimes within each charging model and are present in different ways in every existing charging regime. They form basis for calculation of minimum scope of services and for calculation of track access. Different countries have different approaches for these calculations.

The determination of charging parameters between countries differs: price of train km which depends on infrastructure costs and desired cost recovery percentage; charging structure (monopartite or bipartite – fixed and variable part); ways and criteria of charging.

It is similar for most countries that only variable part of charging is calculated, while Hungary and Italy have bipartite charging system as they charge also fixed part (track booking). Slovenian, Croatian and Austrian charging schemes are similar from the view of usage of technical-technological parameters.

Cost recovery percentage varies between EU countries (from 0,5% to 100%), while average cost recovery is between 25% and 30%. Slovenia has a plan to reach 30% cost recovery in 2020 but the practice shows that the percentage is lowering from 2008 to 2012 (from 8,95% to only 6%). Long term sustainability goals of Slovenian railway system are therefore endangered and charging regime is far from optimal.

It was shown on specific line section that with theoretical 100% line utilisation the cost recovery percentage could be raised up to 10,59%, which is still significantly lower than wanted 30% cost recovery.

In short: the costs of the infrastructure need to be lowered/optimised while charges need to be raised (either with higher train km price or/and modification of the existing charging regime).

REFERENCES

[1] Analiza možnih elementov uporabnine in izdelava variantnega modela uporabnine za uporabo javne železniške infrastrukture Republike Slovenije: Strokovna naloga. Ljubljana: Prometni institut Ljubljana d.o.o., februar 2010.

[2] CATRIN - Cost Allocation of TRansport INfrastructure cost: Sixth Framework Programme Priority [Sustainable surface transport], Statens Väg- och Transportforskningsinstitut (VTI), junij 2009

[3] Dela na glavnih in regionalnih cestah v letih 2009 in 2010; Zbornik referatov posvetovanja; DRC, Družba za raziskave v cestni in prometni stroki Slovenije in Društvo za ceste Maribor; Ljubljana – G. Radgona, april 2009.

[4] Dinamični model navzkrižnega financiranja železniške infrastrukture in železniškega prevoznika: Strokovna študija, Univerza v Mariboru, Fakulteta za gradbeništvo Maribor, marec 2005, str. 118.

[5] Hozjan, D.; Hozjan, T.; Mlinarić, T.J. (2002). Dijagnostički sustav željezničkog gornjeg ustroja u funkciji logistike željezničkog transporta, International Conference on Traffic Science, Portorož, Slovenija

[6] Mlinaric, T.J. (1997) How to establish trends in track quality , Proceedings of 4th International Scientific and Professional Conference on Traffic Management, pp. 245-249, Maribor.

[7] Mlinarić, T.J.; Nogo, G.; (2001). DETIM – Program Support for Track Maintenance Management, Proceedings of the 12th International DAAAM Symposium Intelligent Manufacturing & Automation : Focus on Precision Engineering, Jena, Germany

[8] Mlinaric T.J. (2002) Long-Term Assessment Of Track Geometry Quality With The Aim Of Maintenance Demand Identification, Ph.D. dissertation, University of Zagreb

[9] Primerjalna analiza ureditve in financiranja OGJS na področju železniške infrastrukture v Sloveniji in primerljivih državah s predlogi ukrepov - Zaključno poročilo, Ljubljana: Aleš Groznik s.p., junij 2014

[10] Programi omrežja Republike Slovenije za leta 2009, 2010, 2011, 2012, 2013 in 2014, Slovenske železnice, Ljubljana, december 2007, 2008, 2009, 2010, 2011, 2012

[11] Strateški načrt razvoja javne železniške infrastrukture v Republiki Sloveniji - predlog končnega poročila, Strokovno-razvojna naloga. Ljubljana: Prometni institut Ljubljana d.o.o., junij 2014

[12] Zaračunavanje uporabnine za uporabo železniške infrastrukture: Razvojno raziskovalna naloga. Ljubljana: Prometni institut Ljubljana d.o.o., marec 2000.

INTEGRATED MARITIME AND TRANSPORT POLICY OF SLOVENIA: A NATIONAL UTOPIA OR THE EU ULTIMATUM?

Marko Pavliha, PhD.
University of Ljubljana
Faculty of Maritime Studies and Transport
Pot pomorščakov 4, 6320 Portorož, Slovenia
marko.pavliha@fpp.uni-lj.si

ABSTRACT

In October 2014 the Slovenian Government has published a new version of draft Strategy on Development of Transport in the Republic of Slovenia which will probably result in the Resolution of National Program on Transport Development in the RS. Although this document could be seen as a well researched basis for a future transport policy, it is too theoretical with various deficiencies, e.g. it does not analyze critically the existing policies and omits costs of key projects, financial models and deadlines for their realization, such as the increasingly urgent construction of crucial second railway track between the Port of Koper and Divača which represents one of the major bottlenecks. It is argued that Slovenia needs a fresh integrated (holistic) transport and logistics policy arising from the EU Transport White Paper 2011, the Maritime Policy Blue Paper 2007 and other relevant European legislation, taking into consideration the privileged geographical location at the crossroad of most important corridors (especially the Baltic-Adriatic and the Mediterranean core network corridors) and focusing especially on fast, cheap, safe and confortable mobility of passengers and their rights, efficient supply of goods, logistics, transport infrastructure, safety, security, transport ethics and protection and improvement of quality of environment. The administrative ”mutant” of Ministry of Infrastructure should be reorganized and renamed into the Ministry of Maritime Affaires and Transportation and a new Resolution on Integrated Marine and Transport Policy would have to be implemented by specific and precise national programs on maritime affairs, civil aviation, railways, cableways, national roads, logistics, traffic safety, public transportation, environment protection in transportation, etc. Some of them have been already adopted, however, they are mostly outdated and thus insufficient. The holistic Slovenian marine and transport and policy is therefore not a national utopia but rather the European ultimatum for prosperity of our country which is rapidly facing an imminent danger of being bypassed by global cargo and related transport channels and logistics opportunities. The mission statement of this overall approach is exploration, legalization and implementation.

Key words: Strategy, integrated (holistic) maritime and transport policy, logistics, national programs, Ministry of Maritime Affairs and Transportation, Transport White Paper, Maritime Policy Blue Paper, Pan-European corridors, second railway track Koper-Divača, ultimatum.

"A plan is the transport medium which conveys
a person from the station of dreams
to the destination of success.
Goals are the transport fees."
Israelmore Ayivor

"Choisir le doute comme philosophie de vie
c'est comme choisir l'immobilité
comme mode de transport."
Yann Martel

1 INTRODUCTION

It is my humble intention hereby to propose to the Slovenian Government and Parliament a three-step approach towards a new holistic policy of transportation and logistics.

Firstly, the existing Ministry of Infrastructure should be reorganized and renamed into the Ministry of Maritime Affaires and Transport.

Secondly, we need to adopt a Resolution on Integrated Marine and Transport Policy of the Republic of Slovenia which would have to be implemented by specific and precise national programs, for instance on maritime affairs, civil aviation, railways, cableways, national roads, logistics, traffic safety, public transportation and environment protection in transportation.

Thirdly, all the policies and supporting legislation must be enacted and implemented as soon as possible to avoid further deterioration of our country's transport and logistic opportunities.

2 FIRST STEP: CREATION OF MINISTRY OF MARITIME AFFAIRES AND TRANSPORT

One of the preconditions for reviving and improving transport in Slovenia is to reconcile to the fact that the existing Slovenian Ministry of Infrastructure (*Ministrstvo za infrastrukturo*) is a thoughtless "mutant" created by a few short-sighted politicians who most probably did not base their decision on persuasive research (e.g. the SWOT analysis) and did not follow the prevailing government structures in other European countries.

The following is a comprehensive list of ministries of all EU member states which are in charge of transportation and/or maritime policy:

- **Austria:** Federal Ministry of Transport, Innovation and Technology.[1]
- **Belgium:** There is no federal ministry exclusively responsible for transportation and maritime affaires.[2] The regional and community parliaments and governments have jurisdiction over transportation, public works, water policy, cultural matters, education, public health, environment, housing, zoning, and economic and industrial policy.

[1] http://www.bmvit.gv.at/en/.
[2] http://www.belgium.be/fr/la_belgique/pouvoirs_publics/autorites_federales/gouvernement_federal/composition_gouvernement/.

- **Bulgaria:** Ministry of Transport, Information Technology and Communications.[3]
- **Croatia:** Ministry of Maritime Affaires, Transport and Infrastructure.[4]
- **Cyprus:** Ministry of Communications and Works.[5]
- **Czech Republic:** Ministry of Transport.[6]
- **Denmark:** (i) Ministry of Transport and (ii) Ministry of Food, Agriculture and Fisheries.[7]
- **Estonia:** Ministry of Economic Affaires and Infrastructure.[8]
- **Finland:** Ministry of Transport and Communications.[9]
- **France:** Ministry of Ecology, Sustainable Development and Energy, including a Delegate Minister for Transport, Sea and Fishing (*Ministre délégué aux Transports, à la Mer et à la Pêche*).[10]
- **Germany:** Federal Ministry of Transport and Digital Infrastructure.[11]
- **Hungary:** Ministry of National Development.[12]
- **Greece:** (i) Ministry of Infrastructure, Transport and Networks and (ii) Ministry for Development, Competitiveness and Shipping.[13]
- **Ireland:** (i) Department of Transport, Tourism and Sport and (ii) Department of Agriculture, Food and the Marine.[14]
- **Italy:** (i) Ministry of Infrastructure and Transport and (ii) Ministry of the Environment and Protection of Land and Sea.[15]
- **Latvia:** Ministry of Transport.[16]
- **Lithuania:** Ministry of Transport and Communications.[17]
- **Luxemburg:** Ministry of Sustainable Development and Infrastructure (*Ministère du Développement durable et des Infrastructures).*[18]
- **Malta:** Ministry of Transport and Infrastructure.[19]
- **Netherlands:** Ministry of Infrastructure and the Environment.[20]
- **Poland:** Ministry of Infrastructure and Development.[21]
- **Portugal:** (i) Ministry of Economy and (ii) Ministry of Agriculture and Sea.[22]

---

[3] http://www.government.bg/cgi-bin/e-cms/vis/vis.pl?s=001&p=0230&g=.
[4] http://www.mppi.hr/default.aspx?id=7397.
[5] http://www.mcw.gov.cy/mcw/mcw.nsf/index_en/index_en.
[6] http://www.vlada.cz/en/vlada/.
[7] http://www.stm.dk/_a_2820.html.
[8] https://valitsus.ee/en.
[9] http://valtioneuvosto.fi/en/government/how-does-the-government-work-.
[10] http://www.gouvernement.fr/en/composition-of-the-government.
[11] http://www.bundesregierung.de/Webs/Breg/EN/FederalGovernment/Ministries/BMVBS/_node.html.
[12] http://www.kormany.hu/en.
[13] http://www.primeminister.gov.gr/english/government/.
[14] http://www.gov.ie/tag/departments/.
[15] http://www.palazzochigi.it/Governo/Ministeri/ministeri_gov.html.
[16] http://www.mk.gov.lv/en/amatpersonas.
[17] http://www.lrv.lt/en/government/inistries/.
[18] http://www.gouvernement.lu/3313489/20131204-.
[19]https://www.gov.mt/en/Government/Government%20of%20Malta/Ministries%20and%20Entities/Pages/Ministries-and-Entities.aspx.
[20] http://www.government.nl/ministries.
[21] https://www.premier.gov.pl/en/people.html.
[22] http://www.portugal.gov.pt/en/the-ministries.aspx.

- **Romania:** Ministry of Transport.[23]
- **Slovakia:** Ministry of Transport, Construction and Regional Development.[24]
- **Slovenia:** Ministry of Infrastructure.[25]
- **Spain:** Ministry of Public Works (*El Ministerio de Fomento*).[26]
- **Sweden:** Ministry of Enterprise and Innovation, including Minister for Infrastructure.[27]
- **United Kingdom:** Department for Transport.[28]

It can be seen from the above that there are three different groups of the EU member states with respect to the governance of transportation:

- **4** countries with a specific ministry of transport;[29]
- **12** with a ministry of transport which is also responsible for other fields, e.g. communications or infrastructure;[30]
- **12** with ministries not bearing the word ”transport” in their names but also covering it[31] (however, in Belgium the regional and community governments have jurisdiction over transport and in France, there is a Delegate Minister for Transport, Sea and Fishing).

In addition, **6** countries have established ministries covering expressly maritime affairs,[32] fisheries,[33] shipping,[34] marine[35] or sea.[36]

It is worth observing that the ”European Government” itself, i.e. the EU Commission organizes its work in the fields of transport and marine affaires within two Directorates-General (”European ministries”), namely DG MOVE[37] for mobility and transport under the jurisdiction of Commissioner Violeta Bulc (Slovenia) and DG MARE[38] for maritime affaires and fisheries under the command of Commissioner Karmenu Vella (Malta).

In my opinion, Slovenia needs a new renamed and reorganized Ministry of Maritime Affaires and Transport for a number of convincing reasons.

Firstly, our sea-orientation has been already proclaimed by the *Resolution on Maritime Direction of the Republic of Slovenia* adopted by the former National Assembly in March

[23] http://gov.ro/en/government/the-cabinet-of-ministers.
[24] http://www.vlada.gov.sk/members-of-the-government/.
[25] http://www.vlada.si/en/about_the_government/members_of_government/.
[26] http://www.lamoncloa.gob.es/gobierno/gabinete/Paginas/index.aspx.
[27] http://www.government.se.
[28] https://www.gov.uk/government/organisations.
[29] Czech Republic, Latvia, Romania and UK.
[30] Austria, Bulgaria, Croatia, Denmark, Finland, Germany, Greece, Ireland, Italy, Lithuania, Malta and Slovakia.
[31] Belgium, Cyprus, Estonia, France, Hungary, Luxemburg, Netherlands, Poland, Portugal, Slovenia, Spain and Sweden.
[32] Croatia.
[33] Denmark.
[34] Greece.
[35] Ireland.
[36] Italy and Portugal.
[37] http://ec.europa.eu/transport/index_en.htm.
[38] http://ec.europa.eu/dgs/maritimeaffairs_fisheries/index_en.htm.

1991,[39] even before the country became independent. It is to be mentioned with pride that Slovenia is one of the few states in the world with the sea painted in the national coat of arms and consequently in the flag.

Secondly, the smaller a maritime country is, the more must promote its privileged location by the sea or ocean and do whatever necessary to benefit from it, starting with its politics and politicians.

Thirdly, according to the_Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions entitled *Guidelines for an Integrated Approach to Maritime Policy: Towards Best Practice in Integrated Maritime Governance and Stakeholder Consultation,*[40] the Member States are to develop their own national integrated maritime policies and should ”consider creating internal coordinating structures for maritime affairs within their government frameworks” which should include ”a mechanism providing political guidance at the highest level.” Furthermore, a responsibility to act as ”political leader and as a catalyst for the integrated approach at political level should be clearly assigned” and this function ”must have sufficient weight to be able to structure the dialogue between sectorial interests.”

The Slovenian Maritime Administration clearly cannot fulfil those requirements because it is only responsible for the economic development of the port infrastructure and safety at sea, inland waters and lakes.[41] Thus, the maritime affaires are literally hidden, left and almost forgotten in a small sector within the Directorate for Infrastructure of the Ministry of Infrastructure which is, to say the least, a very unfortunate and damaging approach. In addition, maritime issues are spread fragmentarily amongst other ministers, e.g. Ministry of Agriculture, Forestry and Food (fisheries, aquaculture), Ministry of the Interior (maritime police), Ministry of the Environment and Spatial Planning (coastal zone management, protection of marine environment), Ministry of Labour, Family, Social Affairs and Equal Opportunities (status and rights of seafarers), Ministry of Defence (navy), etc.

In order to reform the existing Ministry of Infrastructure, Article 8 of the *Government of Slovenia Act*[42] has to be amended, as well as certain other legislation, e.g. the *State Administration Act*,[43] which can be done in a relatively short period of time, together with management, personnel and financial adjustments. The scope of portfolio of the new ministry would integrate all transport and maritime matters which would increase efficiency and decrease costs. At least what needs to be accomplished as soon as possible is to prepare a special study to evaluate strengths, weaknesses, opportunities and threats of such a refreshment of the Slovenian public transport administration.

---

[39] Resolucija o pomorski usmeritvi Republike Slovenije, Off. Gaz. RS, No. 10/91.
[40] COM/2008/0395 final: http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52008DC0395.
[41] http://www.up.gov.si/en/areas_of_work/.
[42] *Zakon o Vladi Republike Slovenije*, Off. Gaz. RS, No. 4/93, as amended, http://www.dz-rs.si/wps/portal/Home/deloDZ/zakonodaja/izbranZakonAkt?uid=739D2A8A247C6296C1257D4F00272646&db=urad_prec_bes&mandat=VII.
[43] *Zakon o državni upravi*, Off. Gaz. RS, No. 52/02, as ameneded, http://www.dz-rs.si/wps/portal/Home/deloDZ/zakonodaja/izbranZakonAkt?uid=5A2BD60E20278710C1257DC6002E49DE&db=urad_prec_bes&mandat=VII.

3 SECOND STEP: ADOPTION OF HOLISTIC MARITIME AND TRANSPORT POLICY

In October 2014 the Slovenian Ministry of Infrastructure[44] has published a new version of draft *Strategy on Development of Transport in the Republic of Slovenia*[45] which will probably result in the Resolution of National Program on Transport Development, although this is not clear from the text. Although this document could be seen as a well researched basis for a forthcoming transport policy, it is too vague and theoretical with various deficiencies which have been identified and argued against by the leading civil and academic societies[46] and sent at the beginning of February 2015 to the Government, together with the suggestions for improvement.

The following are some of the major imperfections of the Strategy:

- It is too extensive and inconsistent.
- There is too much emphasize on infrastructure.
- It does not analyze critically the existing policies[47] and omits costs of key projects, financial models and deadlines for their realization, such as the increasingly urgent construction of crucial second railway track between the Port of Koper and Divača which represents one of the major bottlenecks but it is not even mentioned expressly as a national priority in the Strategy.[48]
- There are to many notorious facts which belong to a master thesis or dissertation, not to a strategy.
- Analyses should not be part of the Strategy but rather of its enclosures or appendixes.
- Definition of transport logistics is not in accordance with the internationally accepted definitions.[49]

[44] Under the wach of Minister Peter Gašperšič within the Government of Miro Cerar.
[45] *Strategija razvoja prometa v Republiki Sloveniji*, Ministry of Infrastructure, Version 9.6, 15 October 2014.
[46] Slovenian Logistic Association, Chamber of Commerce and Industry of Slovenia – Transport Association, Faculty of Logistics of the University of Maribor, Faculty of Economics and Business of the University of Maribor, Faculty of Maritime Studies and Transportation of the University of Ljubljana and the Association of Freight Forwarders.
[47] E.g. a very modest transport policy of 2006 – Resolucija o prometni politiki Republike Slovenije (Intermodalnost: čas za sinergijo), Off. Gaz. RS, No. 58/06.
[48] Two professors of economy Jože P. Damjan and Aleš Groznik have prepared an excellent study proposing a very realistic model for financing the second track Koper-Divača: 25% of estimated costs of the project in the amount of EUR 1.350 billion shall be received from the EU funds and 75% borrowed from the European Investment Bank for 25 years whereas the annuities can be paid by concession fees due by Port of Koper to the Government, the Port's dividends, the charges for the use of infrastructure collected by the Slovenian Railways and the so called "gas cent". See J.P. Damjan, A. Groznik: *Avstrijski železniški obvoz okrog Slovenije in slovenska nesposobnost*, Delo, Sobotna priloga, 24 January 2015, pp. 11-12 and M. Pavliha: *Fatalni drugi tir*, Večer, 10 February 2015, p. 11. There are, of course, other unexploited sources of financing, e.g. public-private partnerships with the gigantic shipowner Maersk, various partners from Bavaria and China, etc. Damjan and Groznik have also prepared a *Resolution on Developments od Slovene Logistics and Transport Infrastructure*: http://www.ef.uni-lj.si/media/document_files/dokumenti/Resolucija-final_1b.pdf. A commendable approach was taken by Minister Patrick Vlačič (2008-2011) by "his" *Act on Providing Financial Resources for Investments into Transport Infrastructure* establishing a special fund within the state budget, but it was unfortunately dissolved by the succeeding government. See *Zakon o zagotavljanju sredstev za investicije v prometno infrastrukturo*, Off. Gaz. No. 28/10.
[49] See the website of Transport & Logistics Industry Skills Council, http://tlisc.org.au.

- The authors of Strategy have not been disclosed to the public, although it must be stressed without hesitation and with substantial regret that the leading Slovenian academic institution - Faculty of Maritime Studies and Transportation of the University of Ljubljana - was not invited to participate.[50]

It is asserted that Slovenia needs a fresh integrated (holistic) maritime and transport policy arising from the EU Transport White Paper 2011,[51] the innovative and holistic Maritime Policy Blue Paper 2007 and other relevant European legislation.

The main objectives of the new EU transport policy[52] are preparing the European Transport Area for the future, a vision for a competitive and sustainable transport system,[53] and the strategy how to implement the policy (”what needs to be done”).[54] The EU has been working for years towards a model of sustainable mobility ”which involves an integrated approach to optimizing the efficiency of the transport system as well as to reduce energy consumption, congestion and other negative environmental impacts;” the objective is to develop ”a framework for optimal integration of different modes.” [55]

The European Commission adopted a roadmap of 40 concrete initiatives for the next decade to build a smart, green and competitive transport system that should increase mobility, remove major barriers in key areas and fuel growth and employment. The proposals are also intended to reduce dramatically the Europe's dependence on imported oil and cut carbon emissions in transport by 60% by 2050. The long term key goals include *inter alia* the abolishment of conventionally-fuelled cars in cities and a 50% shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport. One of the ”hot” topics is an increasing focus on intelligent transport systems.

The most significant aspects of the new European maritime policy are blue growth, marine knowledge, maritime spatial planning and integrated coastal zone management, sea basin strategies, integrated maritime surveillance and maritime security. The projects of particular

---

[50] E.g., this is commendably not the case in Croatia where the Faculty of Transport and Traffic Sciences of the University of Zagreb plays a crucial role in creating a new transport strategy and related documents and models.

[51] *WHITE PAPER Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system*, COM/2011/0144 final, http://eur-lex.europa.eu/legal-content/EN/ALL/;ELX_SESSIONID=rpw4JT0CGF81Dp9r1fLYLvvkTNy17TfLn25cF1DYnfX5hcDHTBJJ!537741541?uri=CELEX:52011DC0144.

[52] Despite of a separate title in the former EC Treaty on the subject of transport (now Title VI of the *Treaty on the Functioning of the European Union*, Articles 90 – 100), it was only after the European Court of Justice in Luxemburg condemned the inactivity of the Council of Ministers and the latter agreed to a program of legislative measures to achieve an internal market by the end of 1992, that a common transport policy ”began to emerge s a cornerstone of the internal market.” See Case 13/83 *European Parliament* v *EC Council* (1985) ECR 1513; R. Greaves: *EC Transport Law*, Longman, Essex, 2000, pp. 3-4; compare to N. Radionov, J. Marin (Eds.): *Europsko prometno pravo*, Sveučilište u Zagrebu, Pravni fakultet, Zagreb, 2011, pp. 11-13.

[53] I.e. a growing transport and supporting mobility while reaching the 60% emission reduction target, an efficient core network for multimodal intercity travel and transport, a global level-playing field for long-distance travel and intercontinental freight, clean urban transport and commuting, and ten goals for a competitive and resource efficient transport system: benchmarks for achieving the 60% GHG emission reduction target.

[54] Single European Transport Area, innovating for the future – technology and behavior, modern infrastructure and smart funding and the external dimension.

[55] See a very comprehensive paper by E. Eftestøl-Wilhelmsson, A. Bask, M. Rajahonka: *Intermodal Transport Research: A Law and Logistics Literature Review with EU Focus*, European Transport Law, Vol. XLIX No. 6, 2014, pp. 609-674.

importance are, for instance, a European maritime transport space without barriers, a European strategy for marine research, national integrated policies to be developed by member states (*sic!*), a roadmap towards maritime spatial planning by member states, elimination of pirate fishing and destructive high seas bottom trawling and a strategy to mitigate the effects of climate change on coastal regions.

An ”ideal” *Resolution on Integrated Marine and Transport Policy of the Republic of Slovenia* would have to take into consideration the privileged geographical location at the crossroad of most important corridors (especially the Baltic-Adriatic and the Mediterranean core network corridors), focusing on fast, cheap, safe and confortable mobility of passengers and their rights as consumers (*in dubio pro consumatore*), efficient supply of goods, logistics, transport infrastructure, safety, security, transport ethics[56] and protection and improvement of quality of environment (sustainable transport).[57] It should be implemented by specific and precise national programs (by way of resolutions) on maritime affairs, civil aviation, railways, cableways, national roads, logistics, traffic safety, public transportation and environment protection in transportation. Some of them have been already adopted, however, they are mostly outdated and insufficient.

National programs need to be adopted or upgraded mostly in the following fields (the list is probably not comprehensive):

- **Maritime affaires:** The existing national program on development of shipping is too narrow as it does not cover all maritime affaires, e.g. it is silent about energy policy, fisheries, aquaculture, climate change, etc.[58] The idea of establishing a Slovenian coast guard should be reconsidered again.[59]
- **Railways:** The national program still in force was adopted in 1996 and is absolutely obsolete.[60] A new draft version seems to be caught in the political *circulus vitiosus*.
- **Cableways:** There is no vision or strategy for this transportation mode and the legislation is out-of-date.
- **Highways:** The program of 2004 is almost a perfect example of good practice despite of few deficiencies and problems which are always to be taken into account.

[56] Compare to B. van Wee: *Transport and Ethics: Ethics and the Evaluation of Transport Policies and Projects*, Edward Elgar, Cheltenham, 2011, and M. Pavliha: *Essay on Ethics in International Maritime Law***,** European Transport Law, Vol. XLVII, No.5, 2012, pp. 461-472.

[57] Perhaps one should reexamine the first transport policy of the independent Slovenia adopted by the Government of Anton Rop in July 2004 (then I had a privilege to serve as the Minister of Transport), which was unfortunately withdrawn from the parlamentarian procedure by the new Government of Janez Janša and his Minister of Transport Janez Božič: *Resolucija o prometni politiki Republike Slovenije – Predvidljivo v skupno prihodnost*, EPA 1452 – III, Poročevalec Državnega zbora Republike Slovenije (the Reporter of the Parliament), 24 July 2004, No. 97, pp. 11-72. My chief external advisor for the policy was Livio Jakomin who was the father of the 1977 Transport Policy of the Socialist Republic of Slovenia in the former Yugoslavia, then in his capacity as Minister for Transport and Communications. See M. Pavliha: *Nevarnosti, še bolj pa priložnosti na evropskem križišču*, Na križišču V. in X. vseevropskega koridorja: priložnosti in nevarnosti za Slovenijo, Zbornik referatov in razprav, Državni svet Republike Slovenije, Ljubljana, 2008, pp. 9-12.

[58] Resolucija o Nacionalnem programu razvoja pomorstva Republike Slovenije, Off. Gaz. RS, No. 87/10.

[59] More in E. Twrdy, A. Androjna, M. Pavliha: *Proposed Model of Coast Guard Enhancing Maritime Security and Safety in the Republic of Slovenia*, Promet – Traffic & Transportation, Vol. 26, 2014, No. 6, pp. 497-506.

[60] Nacionalni program razvoja Slovenske železniške infrastrukture, Off. Gaz. RS, No. 13/96.

The bottom line is that Slovenia can now brag with a solid basic highways network, however there are still some road sections to be built.[61]

- **Other national roads:** They are literally collapsing and the disastrous situation is more than urgent. The national program is still under preparation.
- **Civil aviation:** The national program of 2010[62] was adopted for the period until 2020 and should be reviewed and upgraded after the expiry.
- **Road traffic safety:** The valid national programme of 2007[63] should be updated by the Parliament (not only by the Slovenian Traffic Safety Agency) for the period of 2015-2025.
- **Public transportation:** Given the increasing importance of public carriage of passengers a special national program would be in order.
- **Logistics:** It can be included in the umbrella holistic policy or in the implementing programmes or in a special program *alias* action plan.
- **Protection and improvement of environment (sustainable transport):** Environmental threats (and opportunities!) arising from transportation are of such an importance and *sui generis* that they deserve a separate action, although the national, European and international environmental protection regulations are already in abundance.

4 CONCLUSION: THE THIRD STEP

The mission statement of the new Slovenian holistic maritime and transportation policy should be exploration, legalization and implementation, as well as inspiration, innovation an impact. It should motivate flexibility, ”innovativity”, openness and ”coopetition” (cooperative competition). This_is not a national utopia but rather the implied ultimatum by the European Union for prosperity of our country which is rapidly facing an imminent danger of being bypassed by global cargo and related transport channels and logistics opportunities.

”If you fail to plan,” said Benjamin Franklin, ”you plan to fail.”

Initia in potestate nostra sunt, de eventu fortuna iudicat – we control the beginning and the end is decided by fortune which is supposed to favor the brave and bold, hopefully also the visionary, the intelligent, the diligent, the compassionate, the fair and the honest.

---

[61] Resolucija o Nacionalnem programu izgradnje avtocest v Republiki Sloveniji, Off. Gaz. RS, No. 50/04.

[62] Resolucija o Nacionalnem programu razvoja civilnega letalstva Republike Slovenije do leta 2020, Off. Gaz. RS, No. 9/10.

[63] Resolucija o nacionalnem programu varnosti cestnega prometa za obdobje 2007–2011 (skupaj za večjo varnost), Off. Gaz. RS, No. 2/07.

MOORING ANALYSES OF THE RO-RO VESSEL EXPOSED TO A STRONG WIND; BREAKAWAY CASE STUDY

Marko Perkovič, M.Sc.
Milan Batista, D.Sc.
Peter Vidmar, D.Sc.
University of Ljubljana
Faculty of Maritime Studies and Transport
Pot pomorcakov 4, 6320 Portoroz, Slovenia
Marko.Perkovic@fpp.uni-lj.si, Milan.Batista@fpp.uni-lj.si, Peter.Vidmar@fpp.uni-lj.si

ABSTRACT

Encouraged by technical developments on land as well as sea, RoRo vessels have become indispensable for the deep-sea transport of large quantities of cars, trucks and tracked vehicles. Unfortunately, this rather simple (and ancient--see horse carrying galleons, for instance) type of ship has become synonymous with some of the worst disasters at sea in recent years, not to mention a considerable number of incidents. These have been related to design concepts such as: lack of bulkheads, instability, problems with cargo access doors, stowage, securing cargo and lifesaving appliances. In addition, their extremely high, box-like superstructure, extending over the whole of the vessel creates an extensive windage area, which may cause some difficulty not only in keeping course and stability in general, as well as during manouvers, but can seriously affect a vessel while berthed, where cargo manipulation is in progress. This paper will present a case study of an accident at the Port of Koper, where a RoRo vessel moored and anchored at a VNT (multipurpose) berth was suddenly exposed to a tramontana.

Key words: RoRo, Port of Koper, windage, tramontana, mooring analysis, simulation, breakaway.

1 INTRODUCTION

Luka Koper is a multi-purpose port that tranships different types of cargo, with three basins and two piers around which the terminals are arranged (*Perkovic et al. 2013*). In recent years, the Cruise terminal and Car Terminal, where the incident studied occurred, has been increasingly active. The unique aspect of this terminal is that it has no dedicated mooring location in the port. Ships arrive to all three basins, wherever there's a free berth. One of the landings for ships with a stern ramp is in the third basin. This VNT (multi-purpose terminal), seen in Figure 1, has only a shore ramp for a berth, so the ship must be anchored and moored to the buoy, leaving the vessels quite exposed to the bora and tramontana, winds that tend to act roughly perpendicular on ships berthed in this manner and space because of their specific direction.

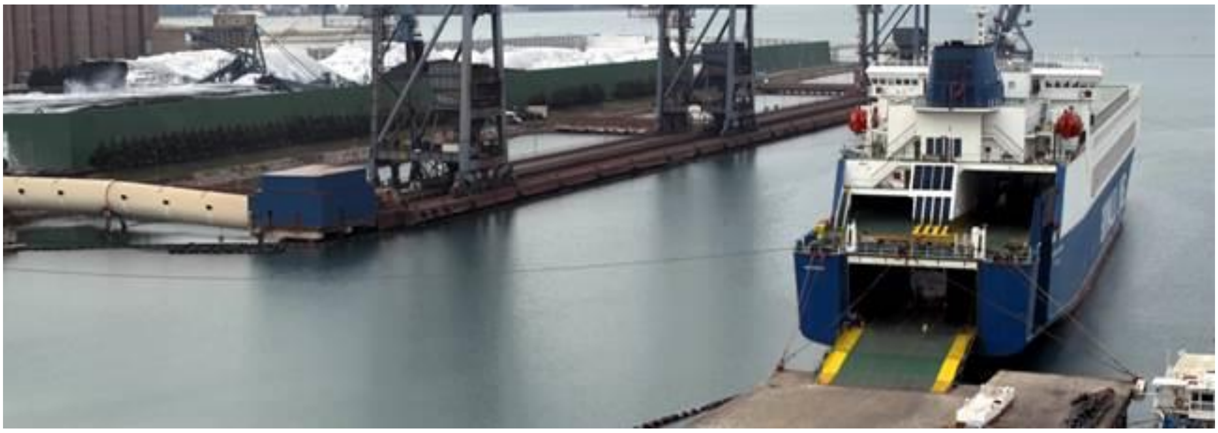


Figure 1: Mooring layout at the VNT terminal

Source: (Port of Koper – security camera)

2 CAR TERMINAL AND VNT BERTH AT PORT OF KOPER

The Port of Koper Car and RoRo terminal consists of seven berths with four shore ramps with 800 meters of operational shore with several shelters (covered storage) and open storage areas with a total storage capacity of 600,000 vehicles.

2.1 VNT mooring layout

The existing system of tethering pure Car Carrier and Ro-Ro ships, geometrically speaking, guarantees security in berthing to ships up to 140 meters (if the size is expressed by the length of the ship). In recent years longer RoRo and Car Carrier ships - up to 200m long - have increasingly been moored at the VNT terminal. In the future, it is expected that the size of the ships calling in the Port of Koper will continue to increase. For this purpose it will be necessary to analyze the sustainability of the VNT berth for different weather conditions. When analyzing the mooring ropes and anchors the size of a ship expressed in GT or as indicated in Table 1 in GT tonnage needs to be addressed.

$$GT = K \times V, \tag{1}$$

Wherein V is the total volume of the vessel, multiplier K is calculated in accordance with the formula below:

$$K = 0.2 + 0.02 \times \log_{10}(V) \tag{2}$$

This illustrates, for instance, that the ship "Neptune Thalassa," with a length of 170 meters, is a lot "*larger*" than Eurocargo Istanbul," which is 195 meters long. To analyze the sustainability of the berths for larger ships it is necessary to first describe the current state of individual elements of the berth (*Perkovic & Batista, 2015*):

- RoRo ramp:
  - width: 20 + 12= 32m
  - length: 48m
  - water depth at the head of the terminal ramp: -10.8m to 10.9m (hydrographically)
  - height: + 3.0m on the shore side + 1.5m on the sea side (at the head) – the southern part with a width of 20m and the northern part with a width of 12m + 3.0m height at the head

- Berthing equipment:
  - At the shore ramp are 2 bollards each with a load capacity of 60t. There are two cylindrical fenders placed at the head of the ramp (1000x600x1000mm)
  - on the shore side; 3 mooring bollards each with a load capacity of 60t
  - at sea are 2 dolphins with mooring bollards. Two dolphins are set in the extension of the TRT terminal, available for a berthing vessel's left stern side and a number of bollards that are available for mooring Ro-Ro ships when the TRT berth is not occupied.
  - Additionally, at sea one mooring buoy is available (Φ 3000mm, 3000kg), located 139m south and 82m west from the head of the RoRo ramp.
- Other features of the coastline and seabed:
  - In the area of Pier 3 a marine clay layer extends virtually to the flysch base. The thickness of the layer of gravel or the flysch weathered layer is practically negligible.
  - At the eastern part of the southern coastal line the flysch base occurs at a depth of -22m, on the western its estimated completion is at a depth of -30m. At the northern line of the future pier the flysch base is at a depth of -12m, in the eastern part and -25m in the western. It is important to consider that the type of sea bottom has a significant effect on anchoring.
  - The northern part of basin 3 along the coastal line of pier 3 was excavated to a depth of -5m to -7m. At the forefront of the future pier the depth of the seabed is around -7m. The depth of the seabed along the north line of pier III varies from between 2 to -5m and increases to the west.

Table 1: Main particulars of RoRo and CarCariers

Ime ladje	IMO številka	Dolžina ladje	Širina ladje	BT
Transporter	8820858	122,00 m	19,04 m	6620
Eurocargo Valencia	9195310	195,10 m	25,20 m	29410
Eurocargo Istanbul	9165310	187,10 m	20,53 m	25654
Elisabeth Russ	9186429	159,50 m	20,60 m	10471
Europa link	9319454	218,20 m	30,52 m	45923
Neptune thalassa	9668506	170,00 m	21,00 m	37602
City of Oslo	9407677	140,24 m	22,43 m	20209
Neptune Ithaki	9440083	169,59 m	23,02 m	36852
Express	9131993	154,50 m	22,74 m	12251
Neptune Thelisis	9306718	161,40 m	26,24 m	27788
Neptune dynamis	9240976	158,50 m	24,44 m	21554

Source: (Authors' analysis based on the data from the Port of Koper)

3 "EUROCARGO ISTANBUL" ACCIDENT ANALYSIS

On the 25th of June 2014 there was a minor accident at the VNT terminal. "Eurocargo Istanbul" was moored that day in the standard "*medmoor*" (Mediterranean Mooring) way to bollards (at the RoRo ramp) and five shackles of starboard anchor was dropped. The bow was additionally secured to a mooring buoy. A few minutes after midnight there was a westerly wind, which quickly turned into a tramontana (north to north-northeast). The ship slid from the berth and collided with a bulk carrier moored at the TRT 3 berth. This case was the reason for the analysis of the sustainability of the existing mooring layout with the deployment of additional mooring buoys and, further, to assess whether larger Ro-Ro ships can be safely accommodated (Perkovic et al. 2015).

The cinemagram in Figure 2 shows the movement of "Eurocargo Istanbul". The first photo captures the moment when the ship starts to sway at the bow (16 minutes after midnight); the ship only moves enough so that the mooring line from the buoy became tightened. This line is usually slack or slightly tightened, otherwise the bow would get pushed against the buoy as there is nothing to hold the ship on the port side (when the TRT terminal is occupied). The second sequence shows the 20th minute after midnight, the north wind having increased and the bow thus sliding against the TRT terminal. The time of the third sequence is 21 minutes after midnight. The anchor chain tightens and holds the bow of the ship, which results in accelerated movement of the vessel’s stern. This accelerated movement caused a mooring breakaway and the vessel stern ramp slid into the sea (the fourth sequence, 30 seconds after the third). The last figure shows the position about 28 minutes after midnight, where the port stern side of the RoRo vessel is in the alignment with the bulker at the TRT terminal. Initially it was thought that the accident was caused because the mooring line was detached from the buoy.

Later it was found that the mooring rope from the buoy had remained intact. Most likely the mooring rope was not wound tightly enough on the drum; maybe winch brake failed or the winch was in self-tension mode where torque limit was too low.

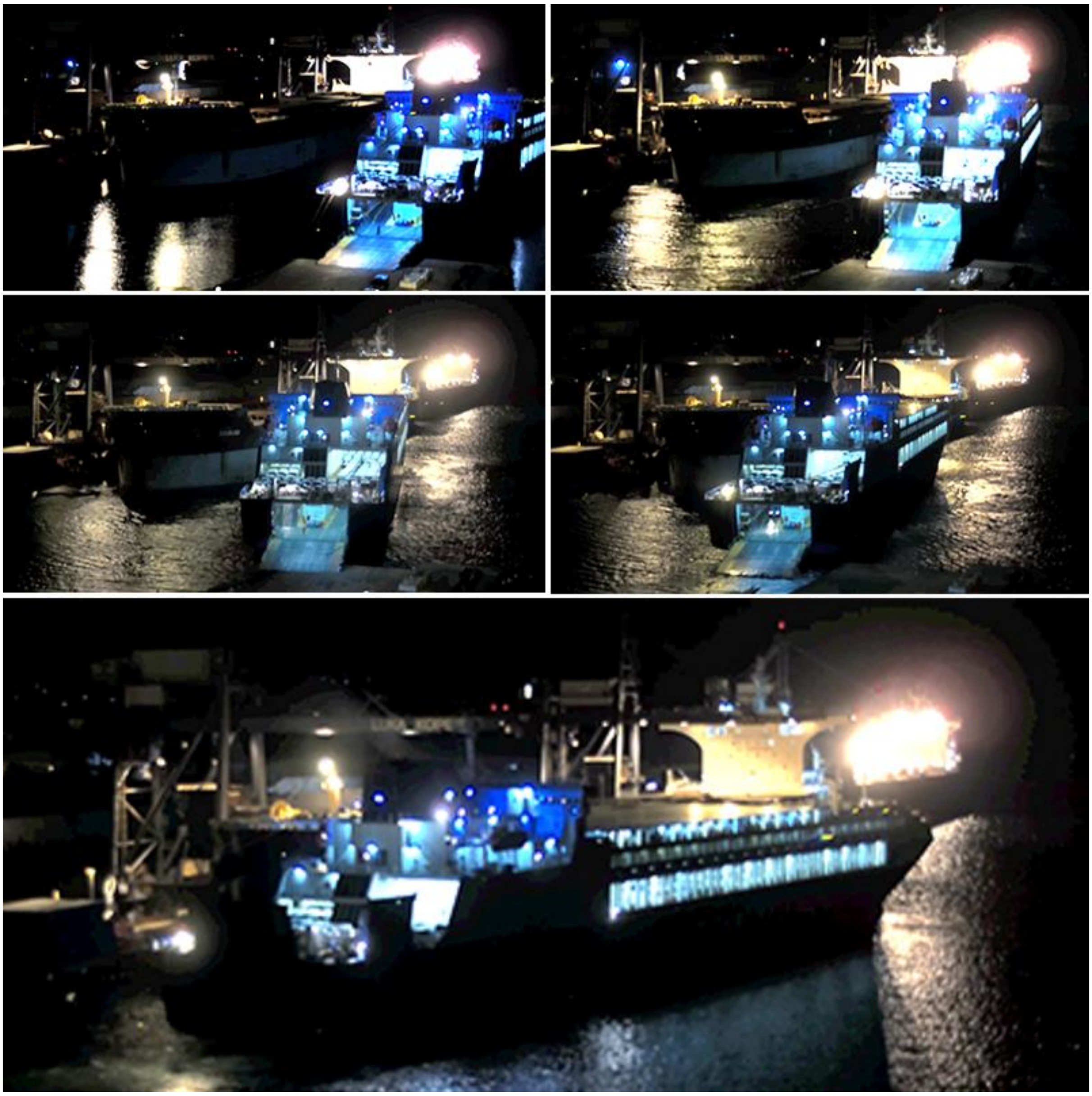


Figure 2: Cinemagram of the »Eurocargo Istanbul« breakaway

Source: (Authors' analysis based on the data from the Port of Koper)

3.1 Analysis of the weather conditions

Depending on the measured wind speed and direction, which are shown in Figure 3, the existing mooring system should remain sustainable – even for this slightly larger RoRo ship. The image illustrates that the maximum of the measured wind speed was 16m/s (30 knots, gray line). The 3D anemometer (installed by the University of Primorska) is located on the roof of the state reserve warehouse (SRW), at a height of around 33 meters. Of course, it is expected that the wind speed around basin 3 is higher than on the SRW, but because of the height of the sensor up to 10% of variation in the speed for a northerly wind can be expected. In the same picture, the blue line shows the wind speed and direction from a mobile anemometer, where both parameters (wind speed and direction) are averaged in minute intervals. The red line shows the hourly average of the mobile anemometer. It can be seen that the hourly averaged interval is too long, because it does not detect the tramontana, which usually develops and settles within an hourly interval.

Figure2: Correlation of two sensors (mobile and 3D) located at different places and heights with various averaging intervals.

Source: (Authors' analysis based on the data from the Port of Koper & University of Primorska)

Figure 4 shows the highest recorded wind gusts measured at both locations. The averaging resolution is just 3 seconds for the 3D anemometer located on the roof of the SRW (nearby basin 1) at a height of 33 meters and 3 minute averages for the mobile 2D anemometer at a height of 10m located near basin 3. It is interesting that the mobile anemometer measured the strongest gusts from the right (east) quadrant, while the 3D anemometer measured the maximum wind from the western quadrant as well. The maximum gust of a bora has been measured by a mobile anemometer--the bora is stronger in the vicinity of basin 3 than around the first basin. The maximum wind speed measured in 2014 was over 24m/s from the 56° (blue line; three-minute interval). According to the recommendations at a wind speed of 20m/s and over (minute interval) a vessel must have the engine ready and if necessary leave the berth.

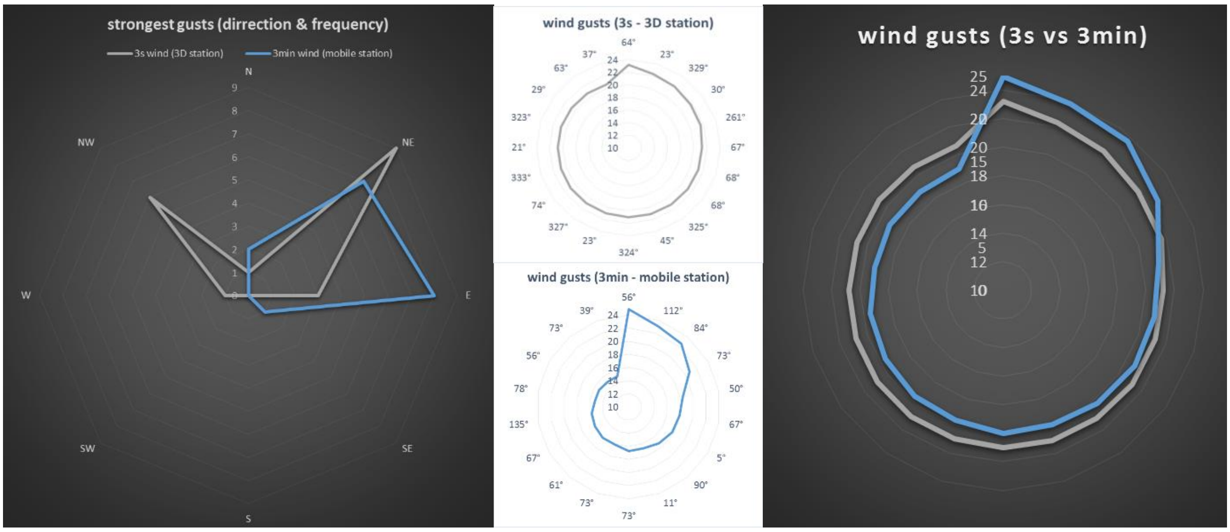
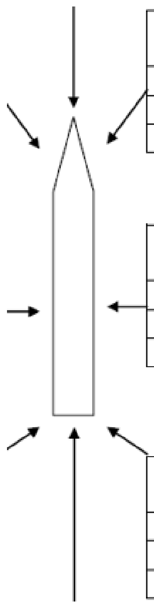


Figure 4: Comparison of the strongest gusts between the 3D and 2D anemometer

Source: (Authors' analysis based on the data from the Port of Koper & University of Primorska)

3.2 Effect of wind load on a Car-Carrier vessel

The figure below shows the parameter forces and moments of different wind speeds and directions for three different Car-Carriers. Displacement, deadweight and gross tonnage are also shown.



	Car Carrier 4 D/dwt=24.186t/14.650t GT=44.408		Car Carrier 5 D=46.092t/27.492t GT=56.550		Car Carrier 7 D=68.229t/31.340t GT= 71.543	
Wind speed	**Force, t**	**Moment, tm**	**Force, t**	**Moment, tm**	**Force, t**	**Moment, tm**
10 knots	-9.1	-105.7	-8.8	-29.6	-9.1	-42.9
20 knots	-36.4	-422.7	-35.1	-118.4	-36.2	-171.7
30 knots	-81.9	-951	-78.9	-266.5	-81.5	-386.2

Wind speed	**Force, t**	**Moment, tm**	**Force, t**	**Moment, tm**	**Force, t**	**Moment, tm**
10 knots	-10.2	-1.3	-11	70.7	-14.6	102.5
20 knots	-40.9	-5.3	-43.9	282.9	-58.4	409.8
30 knots	-92.1	-11.8	-98.7	636.6	-131.5	922.1

Wind speed	**Force, t**	**Moment, tm**	**Force, t**	**Moment, tm**	**Force, t**	**Moment, tm**
10 knots	-9.1	120.4	-8.8	321	-9.1	465
20 knots	-36.4	481.8	-35.1	1283.9	-36.2	1859.9
30 knots	-81.9	1084	-78.9	2888.8	-81.5	4184.8

Figure 5: Effects of wind speed and direction

Source: (Authors' analysis based on the data from the Transas)

4 SIMULATIONS

Simulations of arrival, mooring and departing of selected/characteristic RoRo ships, in different weather conditions, were carried out by the latest ship handling simulator, manufactured by Transas (*Transas, 2015*). Real time simulations were applied where the latest available software including physic was applied (5.35). As objects, we used validated mathematical models of ships whose basic parameters are shown in Figure 5. The simulation was based on the configuration of the "full mission" simulator with real pilots on board (*Webster, 1992*). The simulator for the purpose of research was specifically expanded with additional visualization channels. All together we performed 12 simulations using three different RoRo ships in various environmental conditions (*PIANC 2012, 2014 and Canadian Coast Guard, 2001*). The 3D simulation area is designed with Transas Model Wizard 6 software. The design of the modeling area was based on the dwg model of the Port of Koper layout and on the plan of the conceptual design of a new RoRo terminal in the northern part of basin 3. In the simulation model the latest available depths measured with high spatial resolution were included as well. An example of approaching, dropping the anchor and mooring at the VNT terminal is shown in Figure 6, where the upper part depicts the real maneuver, and the bottom a simulation maneuver including the screenshot acquiered from the pilot navigation application (marimatech), the map already layered with high-resolution biometry.

The sustainability of the berth was simulated for various environmental conditions and mooring layouts; using one anchor, two anchors, one mooring buoy, two buoys, and at the end with a special breasting/mooring dolphin placed at the port stern quarter (*Gomes, 1998 & Coastal Engineering Manual, 1995*). Image 6 shows an example of a basic mooring layout where the load of mooring lines and anchors are tested in a northerly (tramontana) wind with a speed of 13m/s. In Figure 7 the loading of the anchor "*anchor holding power*" and mooring lines alternately on the buoy can be seen (they are acting in opposite directions). The mooring load is in the range of 9 to 33 tons, which is close to the maximum for standard mooring ropes. However, short ropes at the ship's stern are loaded at more than 40 tonnes, exceeding the rated load of ropes and bollards on the VNT ramp.

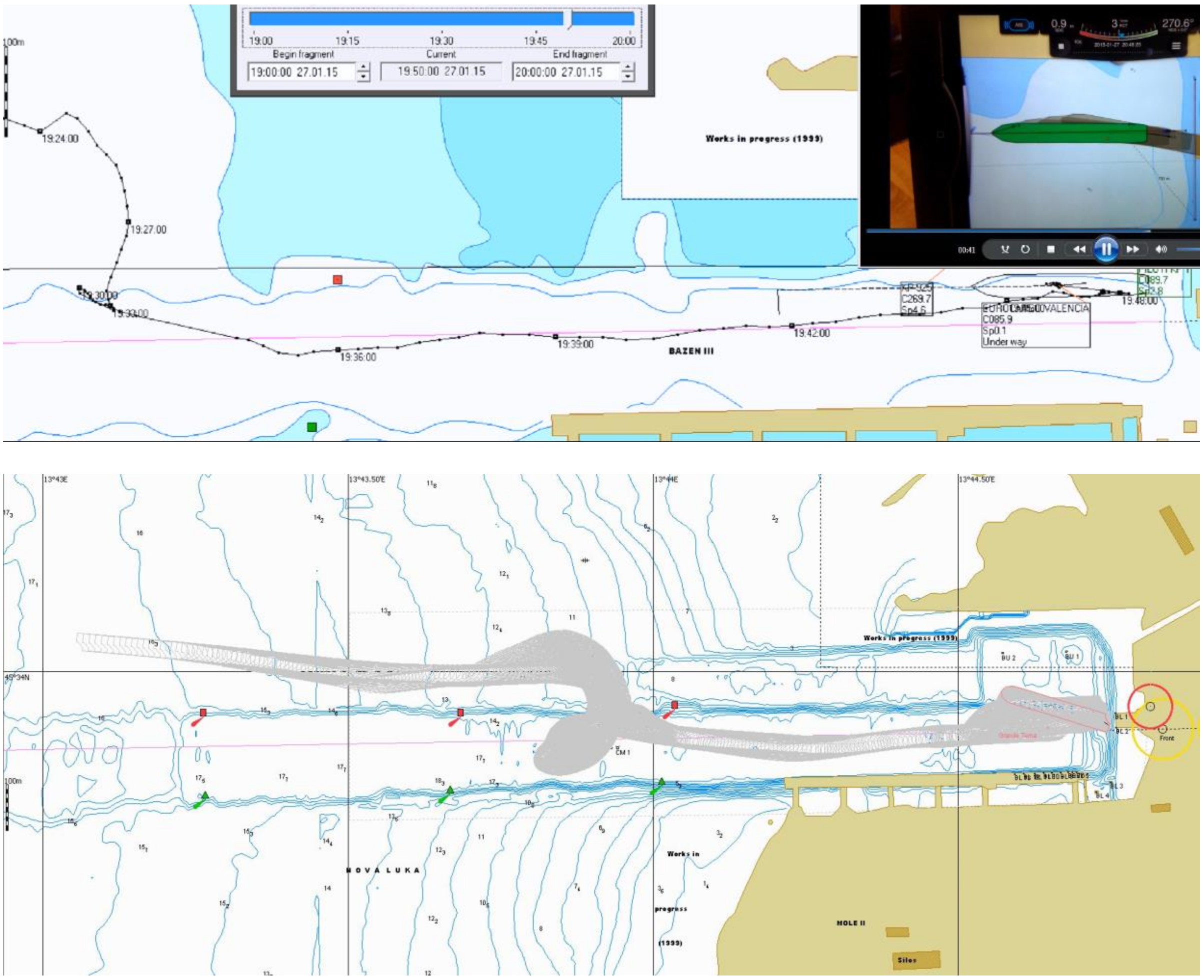


Figure 6: Real (top) and simulation based (bottom) maneuver of approaching and mooring CarCarrier at VNT terminal

Source: (Authors' analysis based on the data from the Transas VTS system and full mission simulations)

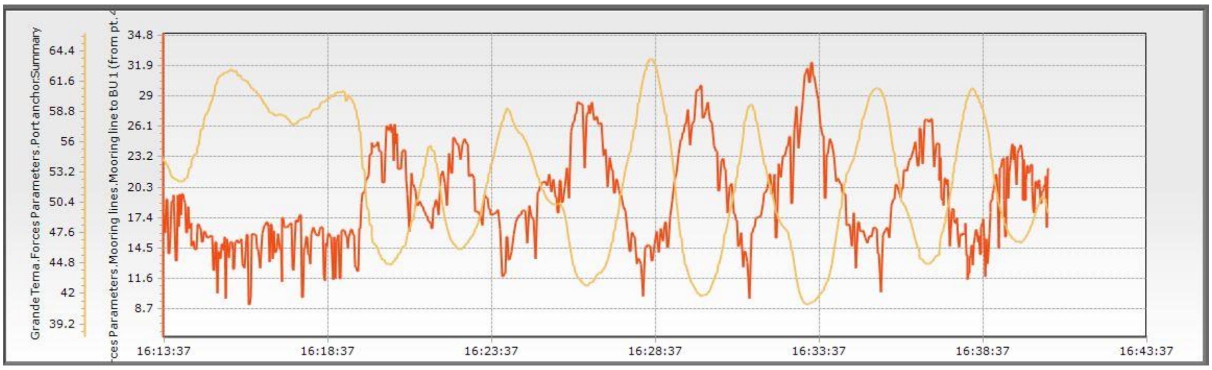


Figure7: Loads of anchors and mooring line on the buoy

Source: (Authors' analysis based on the data from the Transas NTPro ship-handling simulator)

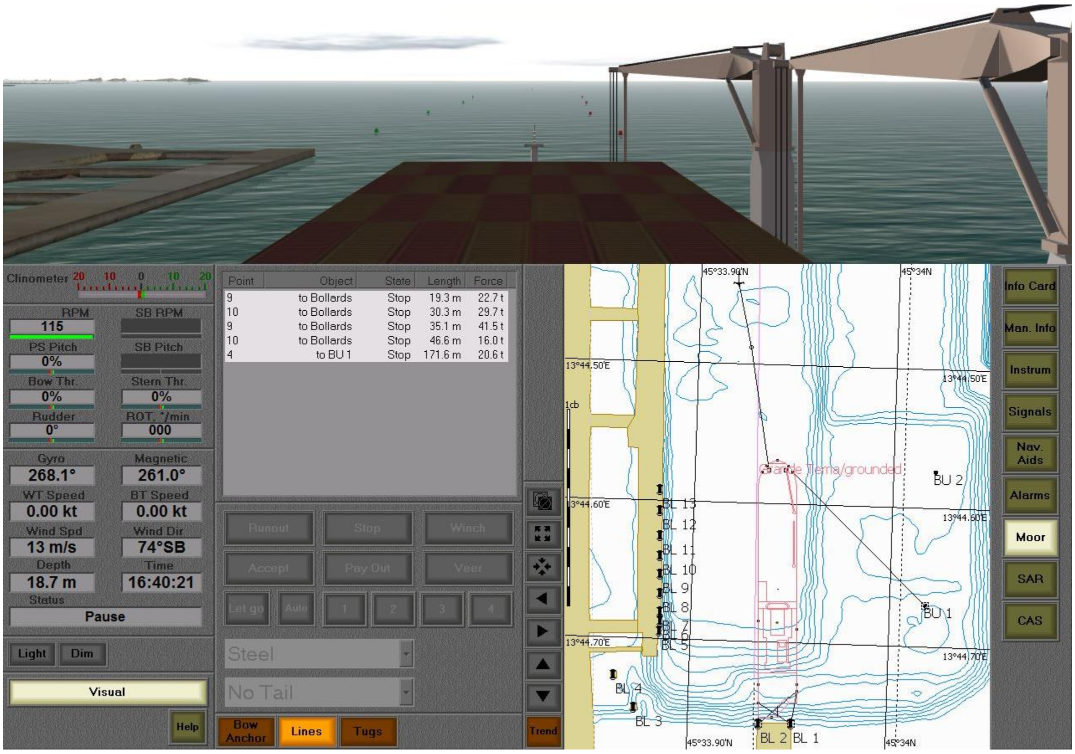


Figure 8: Mooring layout with loads in Tramontana 13m/s

Source: (Authors' analysis based on the data from the Transas NTPro ship-handling simulator)

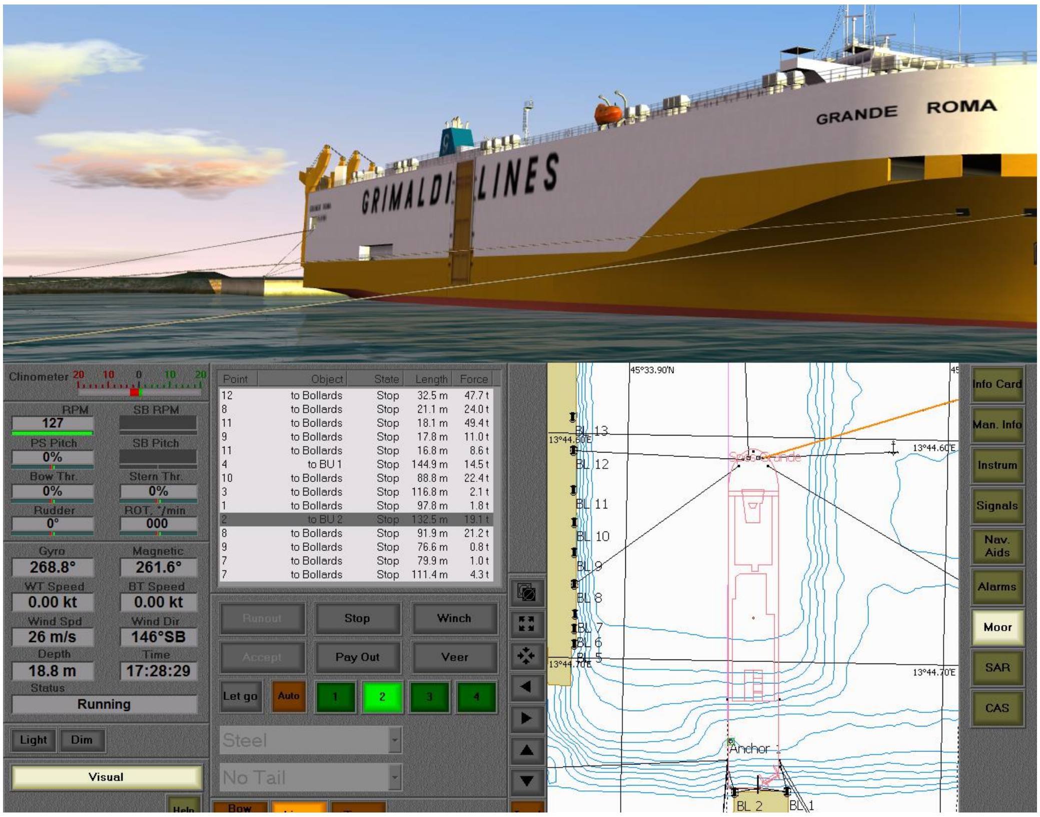


Figure 9: Sustainability of the modified mooring layout; deploying an additional buoy, breasting dolphin and dropping two anchors – in a bora with the speed of 26 m/s.

Source: (Authors' analysis based on the data from the Transas NTPro ship-handling simulator)

Image 9 shows the modified mooring layout and loads at a wind speed of 50 knots (26m/s). Even in such extreme conditions where the wind load is enormous, Car Carriers remain at berth. The deployment of an additional mooring/breasting dolphin at the starboard stern quarter should prevent extreme vessel list (listed only 3°, while without the dolphin the list would be up to 7°). The maximum load of the mooring ropes at the stern is 49 tons, while the anchor holding the vessel in the longitudinal direction is loaded with 64 tons and a transversely positioned anchor is loaded with 79 tons. Without the dolphin, those loads would increase by approximately 30%.

5 CONCLUSION

The mooring breakaway accident of the Eurocargo Istanbul led us to question the mooring safety for large vessels at the port of Koper. Through simulation we were able to conclude that this type of accident in a wind not greater than 20 m/s (minute interval) is preventable. The accident was possible because the ship was anchored with only one anchor, which was placed in the canal (acting only longitudinally). The mooring line on the bow of the vessel was completely slack and remained at the winch drum, which later succumbed to the tramontana. The movement of the bow was stopped by the anchor, following which the stern side of the vessel accelerated and collided with the bulk carrier berthed at the TRT terminal. Full mission real time simulations show that it is possible for a VNT terminal to receive larger Ro-Ro and pure-Car Carriers if they use two anchors and the additional bollards already placed at shore are used for mooring of the vessel’s stern side. By deploying an additional buoy the sustainability of the berth for a longer ship is guaranteed. In an extremely strong wind, the berthing is weaker at the stern side, so a breasting/mooring dolphin must be deployed there.

REFERENCES

[1] Canadian Coast Guard (2001), *Safe Waterways (A Users Guide to the Design, Maintenance and Safe Use of Waterways)*, Waterways Development Division, Fisheries and Oceans, Canada.

[2] Coastal Engineering Manual. (1995), U.S. Army Corps of Engineers, (CH5- Navigational projects), http://smos.ntou.edu.tw/CEM.htm

[3] Gomes, V. (1988), Ships and berth Structures Interactions, In E. Bratteland (Ed.), *Advances in Berthing and Mooring of Ships and Offshore Structures*, *Nato Science Series E* (Vol. 146, pp.338-357). University of Trondheim, Trondheim

[4] Perkovic, M., & Batista, M. (2015), Maritimna podlaga k projektni dokumentaciji za postavitev privezne boje za RoRo ladje na VNT terminalu - v Bazenu III, FPP, Portorž.

[5] Perkovic, M., Twrdy, E., Batista, M., Gucma, L. (2013). Container Transport Capacity at the Port of Koper, In Weintrit, A & Neumann, T. *(*Ed.). *Marine Navigation and Safety of Sea Transportation: Maritime Transport & Shipping*, pp.2007-213, CRC Press.

[6] PIANC (2012), *Use of Hydro/Meteo Information for Port Access and Operations*, Report 117, Brussels, 2012

[7] PIANC (2014), *Harbour Approach Channels - Design Guidelines*, MarCom Working Group 121, PIANC, Brussels,

[8] Transas (2015), NTPro 5000 5.35 technical manual, Transas ltd

[9] Webster, W. C. (1992), *Ship-handling Simulation: Application to Waterway Design*, National Academy of Sciences.

WINDS AND WAVES IN ADRIATIC METEOROLOGY

Ph.D. student Ružica Popović
Meteorological and Hidrological Service of Croatia
Maritime Meteorological Center Split
Glagoljaša 11, 21000 Split, Croatia
popovic@cirus.dhz.hr

Ph.D. student Dario Medić
University of Split
Faculty of Maritime Studies
Zrinsko-Frankopanska 38, 21000 Split, Croatia

Zvonimir Lušić, Ph.D
University of Split
Faculty of Maritime Studies Split
Zrinsko-Frankopanska 38, 21000 Split, Croatia
dmedic@pfst.hr, zlusic@pfst.hr

ABSTRACT

The aquatorium of the east coast of the Adriatic sea from the Savudrija peninsula and the Prevlaka peninsula on its southeastern part belongs to the territory of the Republic of Croatia. That part of Croatia with the coastline of 5790 km belongs to the most rugged coastlines in the world. Croatian islands cover almost all the islands of the east coast of the Adriatic and its middle part, making the second biggest island group in the Mediterranean. There are 1185 islands which are geographically divided into 718 islands, 389 cliffs and 78 reefs. The knowledge about wind and wave characteristics next to the coastline, islands and in the open sea serves as a benefit in maritime economy, shipping industry, fishing, nautical tourism and especially in navigation safety of merchant and passenger ships. The winds at sea which generate windy waves influence the shape and state of the sea surface and sometimes represent an aggravating circumstance in navigation. Weather and climate characteristics along the east coast of the Adriatic change and differ depending on latitude, closeness of hills and mountains to the coast, as well as on air pressure and other dynamic and stationary forms above the Adriatic and its closer and farther spatial surrounding. The paper provides an examination of wind and wave climates in certain locations along the east coast of the Adriatic.

Key words: The Adriatic sea, wind, waves, navigation safety.

1 INTRODUCTION

Although sailing along the Adriatic coast thanks to numerous islands and coves has always been thought of as considerably safe compared to outside Mediterranean navigation, the remains of many ships from shipwrecks along our coast show that the safety at sea is a misleading term. Even though the Adriatic Sea is a small closed bay of the Mediterranean Sea, many incredible and extremely dangerous maritime meteorological phenomena occur there. There is a certain number of meteorological phenomena which directly limit and endanger the course of marine traffic and therefore deserve our attention. In addition to the wind, there are also waves (as oceanographic element) and reduced visibility.

Commercial seamanship has greatly reduced dependency on weather conditions, but financial profitability and navigation regularity still depend on it, so it is important to quickly deliver meteorological notifications. However, at the same time general recreational navigation and many other navigational activities are increasing and they are searching for meteorological development in the sense of safety.

Maritime meteorology materially participates in safety, regularity and efficiency of marine traffic and it studies meteorological elements and phenomena from the viewpoint of influence on navigational technique and navigation conditions. It elaborates and perfects the ways and shapes of meteorological insurance and aid to navigation. Weather conditions sometimes complicate, and in other cases, with regular and timely estimation, help the navigation. Weather conditions negligence leads to unfulfillment of navigational tasks, sometimes even accidents.

2 WIND

Wind appears as a consequence of horizontal difference of atmospheric air pressure. Wherever these differences exist, and they appear due to different air temperatures, air current appears which tries to annul them. Wind direction is greatly determined by the position of higher and lower air pressure: wind blows from higher pressure towards lower, turning to Northern Hemisphere on the right and finding the easiest way among the obstacles which are made by the terrain configuration. Wind speed, as well as its influence on exposed objects, depends on air pressure gradient size. The greater the air pressure difference on certain distance, the greater the wind speed. Wind speed decreases above uneven ground due to friction and it increases in places where the air flows through narrow passages. In certain places there are special circumstances that increase wind speed from certain direction. On the eastern coast of the Adriatic it happens in the coastal area as the cold air from the ground flows towards the sea.

Gradient wind which is simply determined from the ground distribution of atmospheric air pressure together with centrifugal and Coriolis force, coincides with the real wind only at open sea far away from the coast, in conditions of great air pressure gradient. Closer to the coast gradient approximation of the wind does not work because air friction on the ground can no longer be ignored. Besides that, numerous uneven terrains change the wind direction and even produce special air currents.

2.1 Wind at open sea

Above the Adriatic pool, air current in smaller heights is being directed by the Dinarides, Apennines and Alps. In other words, the wind chooses the way along which the ground gives the least resistance, if the great air pressure gradient is not opposed to that. That is why directions along the Adriatic line are highlighted at open seas. Besides that, on the northern part of the Adriatic, directions vertical to that line are important. They occur when the air current circles the Alps next to their eastern edge, wherein the wide lowland of the river Po facilitates its passage.

Accordingly, at open sea of the middle and southern Adriatic the most frequent winds are NW and SE, for which the fetch above the sea is the longest. This is shown in the best way with the measurements from Palagruža (figure 1.). Other wind directions at open sea of the middle and southern Adriatic appear less frequently and mostly belong to a certain part of the year. Thus NE wind is more frequent in the winter while W wind during the summer. On the northern Adriatic far away from the coast, the situation is somewhat different: winds from NE, SE, SW and NW directions stand out.

The resulting air flow, i.e. the one that is achieved by vector addition of all winds, and it shows the final air movement in certain period, at open sea is NW.

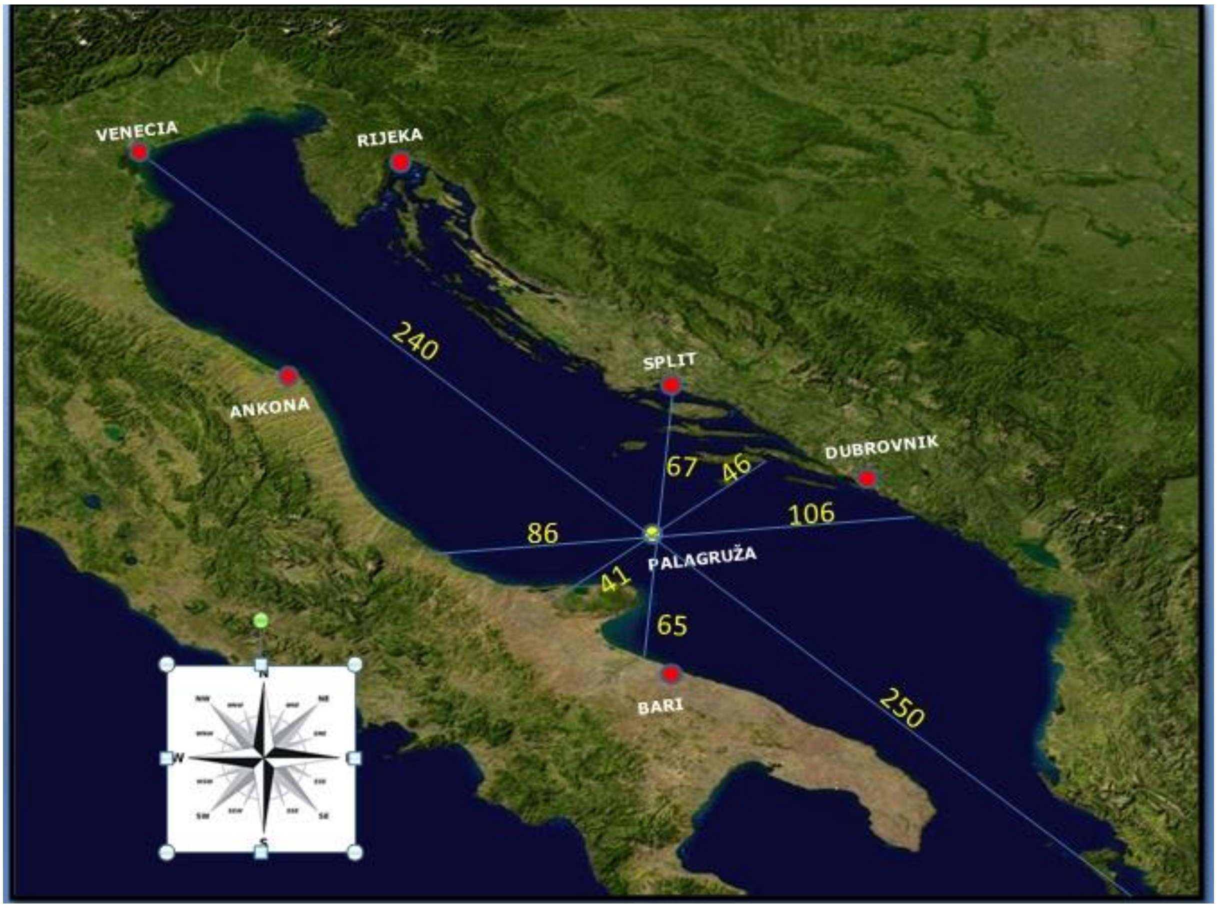


Figure 1: Position of Palagruža and length of sea fetch (NM) for 8 main wind directions

Source: Vrijeme i klima hrvatskog Jadrana, Penzar, Penzar, Orlić, Zagreb 2001., p.118

2.2 Wind in coastal and insular belt

In the eastern Adriatic coast air flow is complex which is why wind roses look very different (figure 2.). Air current from the land towards the Mediterranean goes over those mountains vertically, no matter which direction exactly it was before it came to the mountains on the Adriatic coast, i.e. the shortest way. This causes more frequent NE wind along the coast, at the cost of other winds, N and E. On the other hand, again due to orography, it increases along the great part of the coast the frequency of S wind at the cost of S and SW winds. In this way, the wind which blows towards the northern edge of the Adriatic parallel to the coast is the most prominent one, hence SE and the wind which blows towards the sea vertically to the mountain chain, i.e. NE. Those winds, which differ in their direction only by 90° occur during the entire year, especially in colder period, when their speed is higher. Wind from NW directions is less important than it is at open sea and is more frequent in the summer period, as well as the W direction (because of summer maestral).

In picture 2 the influence of terrain on the flow is recognizable, the most easily in places where certain direction stands out, which does not appear in wind roses of the surrounding area. This is the case with, for instance, SW wind in Rijeka, because it shapes in Vela Vrata and from W and S winds which enter the Kvarner. With summer SW winds in Split originated between Drvenik and Šolta from NW and W winds together with W wind in the Pelješki canal (Orebić), where winds interflow from almost the entire western half of the horizon.

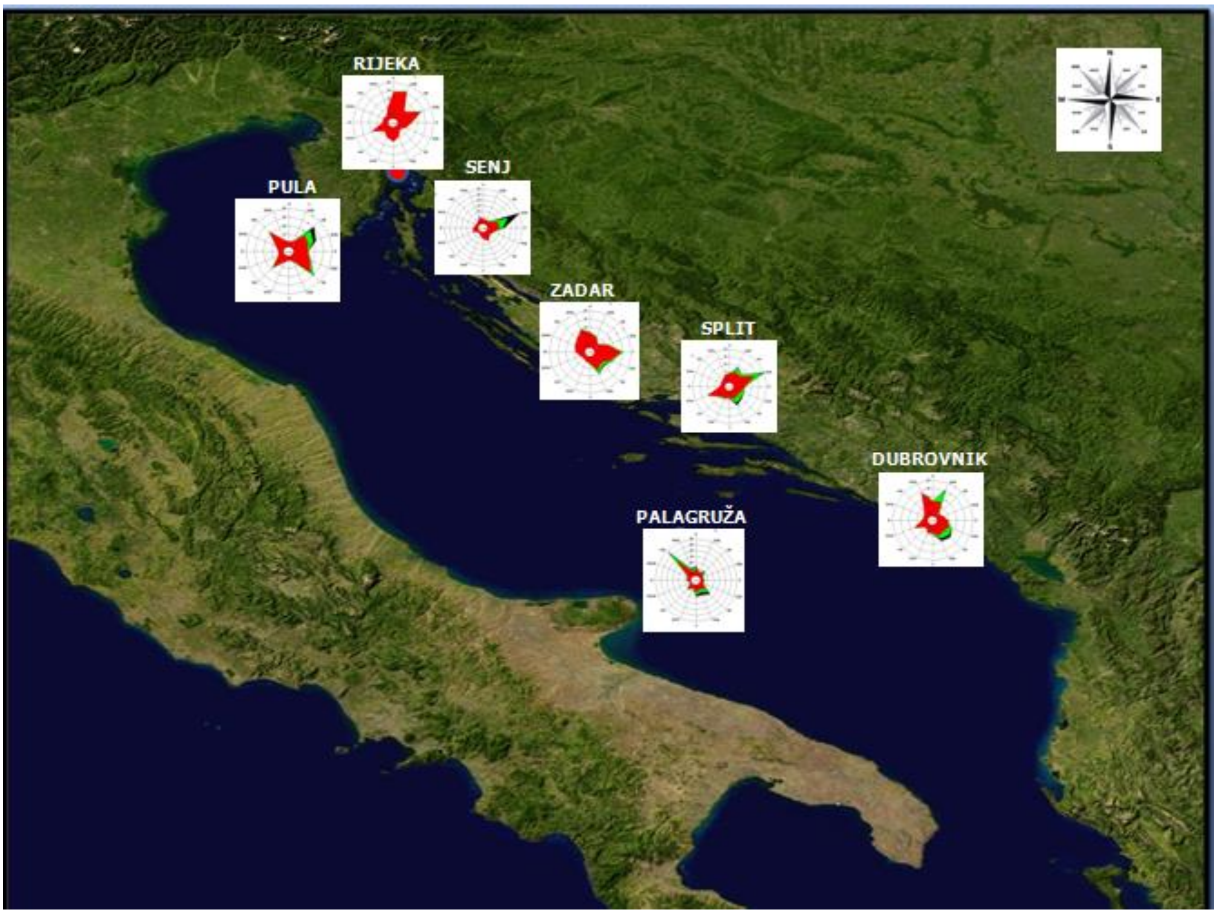


Figure 2: Medium annual frequency of the wind directions and shares of each strength in each direction (annual wind roses) on chosen locations of the eastern Adriatic coast in the period from 2004 until 2013

Source: Authors, according to the DHMZ data

Wind is an accidental natural phenomenon. Its speed accidentally varies and it can be described by the speed spectrum. If the wind is observed on one geographic point, general quantitative wind picture in an average year in certain observed area (or some other period) such as directions, speed (m/s) and wind frequency (%) is shown by the wind rose.

3 WAVES

The influence of different meteorological elements, especially air pressure and wind, is reflected at sea in the series of oceanographic processes which significantly differ between themselves regarding their weather dimensions. Short periodic waves which are caused by the wind are the only ones that can be at least somewhat documented based on observation.

Definition of significant and maximum wave heights and wave periods of surface gravitational windy waves in certain part of the aquatory is normally done indirectly, based on the wind characteristics data, i.e. its intensity, direction and duration. Except from the wind data, an important parameter is also the fetch. In the area of the eastern coast of the middle and southern Adriatic, due to numerous islands and developed canal system, the most frequent case is that fetch is relatively short and represents a limiting factor in the development of waves. Thereby the wind duration does not limit the transfer of the wind energy into the surface gravitational windy waves, even during the appearance of short-termed atmospheric transient situations with sudden development of storms. First observations related to determination of significant wave heights in the area with limited fetch have been made by Sverdrup and Munk (1946), and somewhat later by Bretschneider (1952). Recently, studies of that area have been made by the authors Kahm and Calkoen (1992). The very process of the development of waves from the initial stadium to developed energy transfer of the wind into the wave energy has not been entirely solved.

Significant contributions to the generic wave theory have been made by Lamb (1932), Phillips (1957), Miles (1957), Donelan (1977), Cavaleri and Malanotte-Rizzoli (1981) and Janssen (1989, 1991, 1992, 1998) and Johnson (1998) as well as Johnson and Kofoed-Hansen (2000). Considering the relatively high technical and economic requirements of monitoring spectral wave features with wave graph, in deepwater areas the results of ship observations can be used alternatively. On the other hand, in the coastal area, the use of wave measurements from surrounding automatic meteorological stations is normal, based on which basic wave features are calculated indirectly. Automatic meteorological stations of the Meteorological and Hydrological Service (DHMZ) are situated along the Croatian coast in: Rijeka, Mali Lošinj, Zadar, Šibenik, Split, Hvar, Makarska, Ploče, Dubrovnik, Komiža, Lastovo and the island Palagruža.

5.1 Influence of the atmosphere on the sea

When during the 1960s on the eastern Adriatic coast the measurements of windy waves started, first with ship wavemeters and then wavemeter stations, the earlier thought of them significantly changed. It had been showed that characteristics of waves depend on wind strength, wind duration of a certain direction and the fetch length. Thus, in one of the stations in the north Adriatic the maximum height of the wave, 10.8 m, has been noted in a winter situation during which sirocco was blowing over the entire Adriatic which lasted for a day and reached the speed of 25 m/s[1]. Applying the extremes theory for that station it has been estimated that with the return period of a 100 years the waves 14 m high could appear.[2] In the Palagruža area the maximum height of the wave in the situation with scirocco measured 8.4 m, while the maximum wave height in the situation with gale measured 6.2 m.[3]

The influence of the atmosphere on the sea causes forced motion which occurs under continuous influence of factors which cause them, i.e. under the influence of air pressure and the wind. However, in the sea, they do not cause just forced motion. Sudden changes of those meteorological parameters lead to the appearance of different kinds of sea waves. One kind of waves reflects as fluctuation of sea level and as currents which are changeable in time and in

[1] Smirčić, Gačić (1983)
[2] Leder at al (1998)
[3] Smirčić, Leder (1996)

horizontal level, but are of almost constant speed and direction in different depths. That is how surface wave occur, which have the greatest influence on navigation and navigation safety.

However, sudden changes of meteorological parameters also cause inner waves in the sea. What is characteristic for them is that they are reflected in termoclimate[4] and haloclimate[5] shifts that are significantly greater than sea level shifts and they do not have big influence on navigation.

5.2 On winds and waves in certain aquatoriums

According to the table 1 where significant wave heights are determined using the Gröen-Dorestein diagram (WMO, 1967) and using the Tabain prognostic wave roses for the quadrant of Rijeka bay aquatory, it is clear that middle highest wave heights are during maximum wind scirocco from 1.25 to 2.09 m, for gale from 2.77 to 4.64 m, for libeccio from 1.77 to 2.96 and for tramontane from 1.17 to 1.96 m. The most frequent waves occur during gale with 21.7 % frequency, scirocco with 9.56 %, tramontane with 7.98 % and libeccio with 4.46%.

Table 1: Wave heights: $H_{1/3}$, $H_{1/10}$, $H_{1/100}$ obtained using the Gröen-Dorestein diagram (G.-D.), Tabain prognostic wave roses for the quadrant of Rijeka bay aquatoium, for medium annual wind (W_{year}), medium maximum annual wind (W_{mimax}) and maximum wind (W_{max}) and medium wave height for both methods: MWH/W_{year} (medium wave height for medium wind in a year), MWH/W_{mimax} (medium wave height for maximum wind in a month), MWH/W_{max} (medium wave height for maximum wind in a period) and MWH/ship (medium wave heights obtained from ship data during the course of 30 years)

wind direction		**SCIROCCO** SE, SSE				**GALE** NE, NNE				**LIBECCIO** SW, SSW				**TRAMONTANE** NW, NNW			
method		**spe/str**	**$H_{1/3}$**	**$H_{1/10}$**	**$H_{1/100}$**	**spe/str**	**$H_{1/3}$**	**$H_{1/10}$**	**$H_{1/100}$**	**spe/str**	**$H_{1/3}$**	**$H_{1/10}$**	**$H_{1/100}$**	**spe/str**	**$H_{1/3}$**	**$H_{1/10}$**	**$H_{1/100}$**
***1**	***m/s***	2,2	0,21	0,27	0,35	3,0	0,28	0,36	0,47	1,9	0,18	0,23	0,30	1,6	0,18	0,23	0,30
***2**	***m/s***	2,7	0,26	0,33	0,43	3,3	0,31	0,39	0,52	2,3	0,20	0,85	0,33	2,1	0,19	0,24	0,32
***3**	***m/s***	12,3	1,10	1,40	1,84	22,6	2,45	3,11	4,09	15,5	1,85	2,35	3,09	12,3	1,15	1,46	1,92
***4**	***Bf***	2	0,40	0,51	0,67	2	0,40	0,51	0,47	2	0,40	0,51	0,67	2	0,50	0,63	0,83
***5**	***Bf***	2	0,40	0,51	0,67	2	0,40	0,51	0,52	2	0,40	0,51	0,67	2	0,50	0,63	0,83
***6**	***Bf***	6	1,40	1,78	2,34	9	3,10	3,94	4,09	7	1,70	2,16	2,84	6	1,20	1,52	2,00
MWH/W_y			0,31	0,39	0,51		0,34	0,43	0,57		0,29	0,37	0,48		0,34	0,43	0,56
MWH/W_{mjmax}			0,33	0,42	0,55		0,35	0,45	0,59		0,30	0,68	0,50		0,35	0,44	0,57
MWH/W_{max}			1,25	1,59	2,09		2,77	3,52	4,63		1,77	2,25	2,96		1,17	1,49	1,96
MWH/ship			0,60	0,76	1,00		0,73	0,93	1,22		0,50	0,63	0,83		0,47	0,60	0,78

*1 – G.-D./W_{year} *4 – TAB/W_{year}
*2 – G.-D./W_{mjmax} *5 - TAB/W_{jmax}
*3 – G.-D./W_{max} *6 - TAB/W_{max}

[4] Termoklina is a layer in the sea which divides the surface, most frequently warm layer from the deeper, mostly cold layer

[5] Haloklina is a layer in the sea in which sudden salinity changes occur

According to the wind analysis in Rijeka area, it can be concluded that the winds from the first quadrant are dominant, i.e. NNE, N, NE and ENE winds, while winds from other directions are almost negligible.

According to table 2, where significant wave heights are also determined using the Gröen-Dorestein diagram (WMO, 1967) and using the Tabain prognostic wave roses for the quadrant of the island Palagruža aquatory, it is visible that during maximum wind speed at open sea waves during scirocco were from 7.21 to 10.28 m, during tramontane from 5.38 to 8.49, libeccio from 4.53 to 8.49, and the least during gale, from 3.76 to 6.27 m.

According to ship meteorological observations during the period from 1970-2000, in the summer period, waves from the fourth quadrant (etesia) are more noticeable and in the winter period those from the second quadrant, i.e. scirocco waves.

Table 2: Wave heights: $H_{1/3}$, $H_{1/10}$, $H_{1/100}$ obtained using the Gröen-Dorestein diagram (G.-D.), Tabain prognostic wave roses for the quadrant of the island Palagruža aquatorium, for medium annual wind (W_{year}), medium maximum annual wind (W_{mimax}) and maximum wind (W_{max}) and medium wave height for both methods: MWH/W_{year} (medium wave height for medium wind in a year), MWH/W_{mimax} (medium wave height for maximum wind in a month), MWH/W_{max} (medium wave height for maximum wind in a period) and MWH/ship (medium wave heights obtained from ship data during the course of 30 years)

wind direction		**SCIROCCO** SE, SSE				**GALE** NE, NNE				**LIBECCIO** SW, SSW				**TRAMONTANE** NW, NNW			
method		**spe/str**	**$H_{1/3}$**	**$H_{1/10}$**	**$H_{1/100}$**	**spe/str**	**$H_{1/3}$**	**$H_{1/10}$**	**$H_{1/100}$**	**spe/str**	**$H_{1/3}$**	**$H_{1/10}$**	**$H_{1/100}$**	**spe/str**	**$H_{1/3}$**	**$H_{1/10}$**	**$H_{1/100}$**
1	***m/s***	8,1	1,61	2,03	2,67	6,4	1,22	1,57	2,0	6,1	0,80	1,02	1,34	7,2	1,20	1,52	2,0
2	***m/s***	9,7	2,12	2,70	3,50	9,5	2,15	2,73	3,59	7,4	1,35	1,71	2,25	8,4	1,80	2,29	3,011
3	***m/s***	28,6	10,4	13,2	-	19,4	4,50	5,71	7,51	23,9	4,60	5,84	7,68	22,8	7,85	9,97	13,1
4	***Bf***	5	2,3	2,9	3,84	4	1,1	1,40	1,84	4	0,8	1,02	1,34	4	1,3	1,65	2,17
5	***Bf***	5	2,3	2,9	3,84	5	1,7	2,16	2,84	4	0,8	1,02	1,34	5	2,3	2,92	3,84
6	***Bf***	11	7,9	10,03	13,27	8	4,3	5,46	7,18	9	4,2	5,33	7,01	9	6,6	8,38	11,02
MWH/W_Y			1,86	2,36	2,86		1,21	1,54	2,02		1,11	1,41	1,85		1,32	1,68	2,20
MWH/W_{mjmax}			2,13	2,71	3,56		1,83	2,32	3,06		1,37	1,74	2,08		1,81	2,30	0,03
MWH/W_{max}			7,21	9,16	10,28		3,76	4,76	6,27		4,43	5,63	7,40		5,38	6,83	8,99
MWH/ship			1,03	1,31	1,72		0,87	1,11	1,45		0,96	1,22	2,63		0,78	0,99	1,30

5.3 Interaction of winds and waves

Constant experimentation of wind based exploration of waves in the Adriatic Sea, started in 1967 and finished in 1977, was necessary to gather information about the relationship between wind speed and significant wave height for the purpose of determining project spectrum during the projection of mainly war ships. The research was carried out by Tonko Tabain and it resulted in sea condition scale in 1974 and empirical spectrum formula in 1977. Compared to other authors and many applications in ship projection and sea technology engineering, it has been revealed that the formula gives good results in the description of measured wave spectrums.

Tabain´s spectrum was set as follows:

$$S\varepsilon(\omega) = 0{,}862\frac{0{,}0135g^2}{\omega^5}exp\left(-\frac{5{,}186}{\omega^4 H_{1/3}}\right)1{,}63^{exp\left(-\frac{(\omega-\omega_m)^2}{2\delta^2\omega_m^2}\right)} \quad (1)$$

Where modal frequency ω_m is tied to significant wave height with the expression:

$$\omega_m = 0{,}32 + \frac{1{,}80}{H_{1/3}+0{,}60} \quad (2)$$

And parameter δ can adopt following values:

$$\delta = 0{,}08\ za\ \omega < \omega_m \quad (3)$$

$$\delta = 0{,}10\ za\ \omega > \omega_m \quad (4)$$

Except for the waves spectrum Tonko Tabain set the relationship between situation scale in the Adriatic Sea sea state scale of the World Meteorological Organization (WMO). It was then revealed that the sea state 7 ($H_{1/3}$ = 6.1 to 9.1 m) is the most difficult sea state which in the Adriatic Sea can be expected with wave heights of maximally 80 m and zero periods to maximally 10.5 s. Considering the fact that we know that in the Adriatic wave height of 10.8 m during scirocco was already measured, it is evident that the research in this segment has to be intensified. Weather situation which clearly shows mutual interaction between winds and waves happened on March 6, 2015. General weather situation was under the influence of a cyclone above the Tyrrhenian Sea which was becoming deeper, and from the northwest towards the Adriatic anticyclonic ridge was becoming stronger. In such weather conditions, gusts of wind measured 40-90 knots, and under the Velebit up to 130 knots. The sea was 5-6.

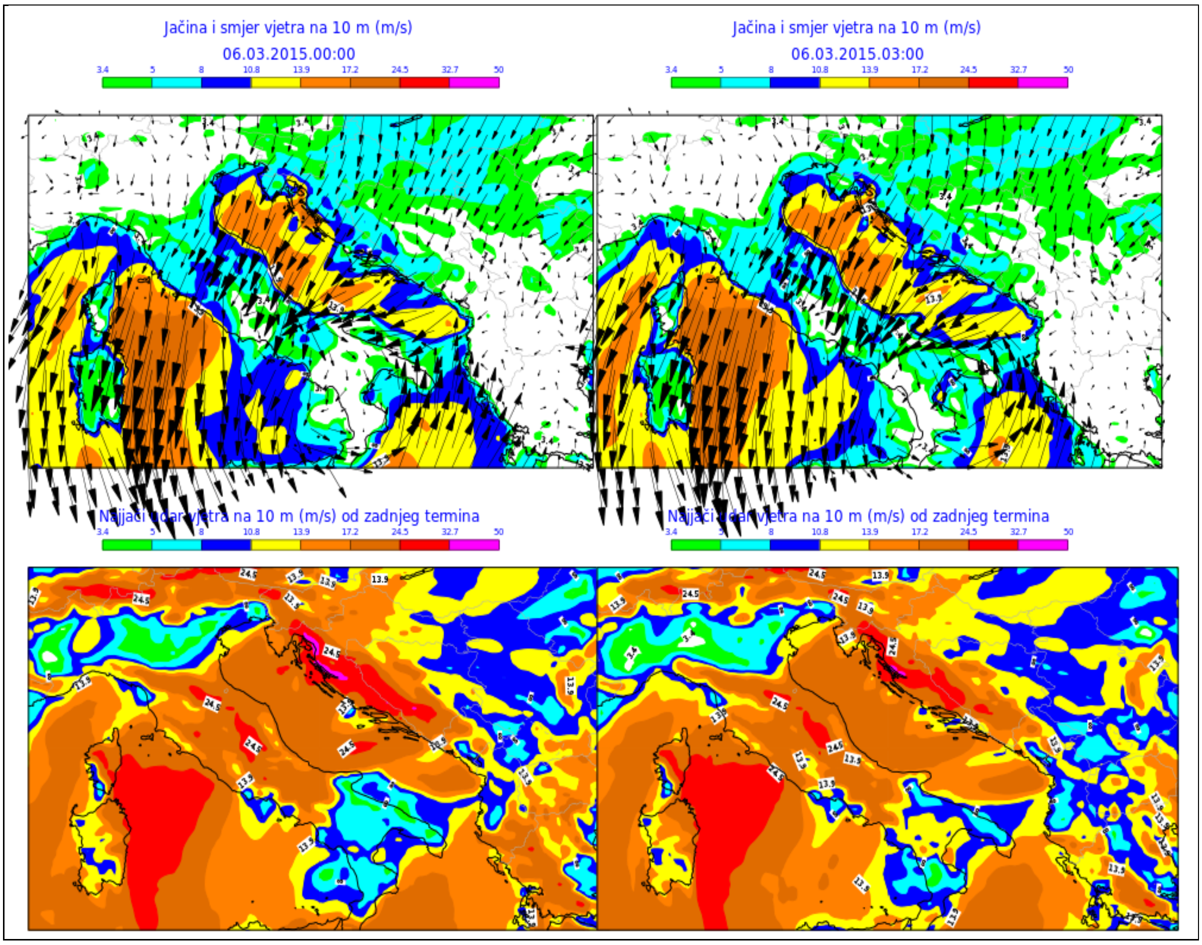


Figure 3: Wind strength and direction (m/s) forecast at 10m on March 06, 2015 at 00:03 o´clock

Observing figure 3 and 4, the connection between the wind direction and wave direction is clear, which speaks in favor of the wind influence on waves, and the wind speed has significant influence on wave direction and sea state in general.

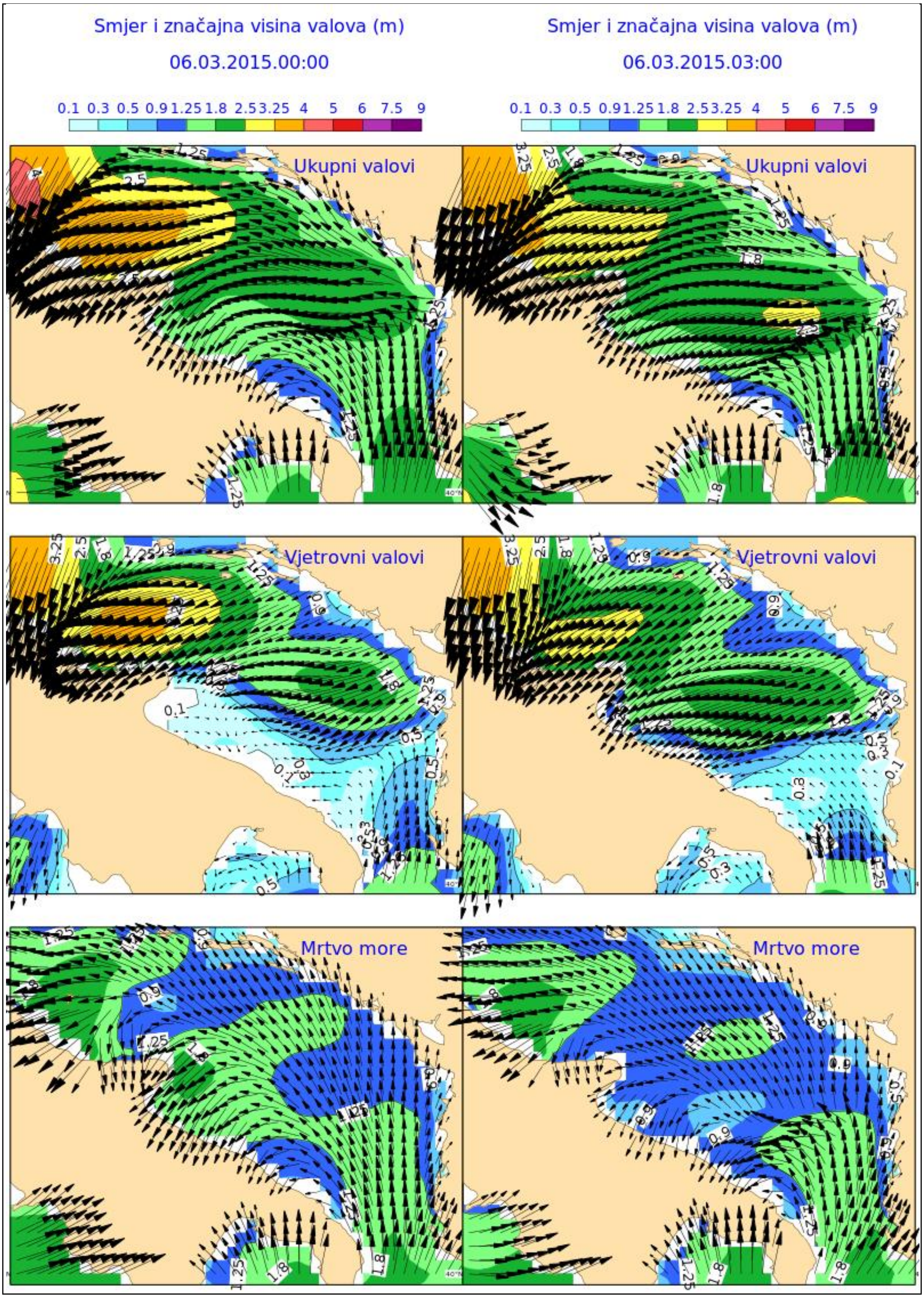


Figure 4: Direction and significant wave height (m) forecast on March 06, 2015 at 00:03 o´clock

6 CONCLUSION

In modern marine traffic it is very important to bring the ship from one port to another, with indispensable care of people, of journey duration and of the loaded cargo. Among other factors which make that journey safe, good meteorological journey preparation is necessary as well as monitoring of weather conditions during navigation. Very well organized meteorological service in inland and worldly proportions can be helpful.

The mechanism of creating sea waves due to wind indicates that there is a correlation between wind strength and waves height that it causes. From the descriptions of maritime and meteorological phenomena it can be concluded that the Adriatic, although very closed sea, is sometimes full of surprises and dangers to people, ships and generally navigation. Dangers are brought and caused by stormy and hurricane winds generating high and dangerous waves in this area, with height of up to 10.8 meters.

The fact that expert services of Marine meteorological center Split are included in constant work of Commission for navigation safety by the Department of sea, tourism, transportation and development of Republic of Croatia says a lot about significance and perspectivity of Marine meteorological center Split, and all to increase navigation safety on the Adriatic east coast. Also, teams of experts from the field of marine meteorology are permanent members of commission for investigation of marine accidents by the same Department. We should continue the practice of involving marine meteorological service and marine meteorologists in VTS – Vessel Traffic Service system, in the sense of increasing meteorological navigation safety.

REFERENCES

[1] Gelo B.,: Meteorološko osiguranje plovidbe morem i unutrašnjim vodama, Rijeka, 1992, Zbornik FPS

[2] Gelo B.,: Opća i prometna meteorologija, Zagreb, 2000.

[3] Gelo, B.: Mezomodeli atmosfere i sigurnost prometa, Suvremeni promet 10, 1988.

[4] GMDSS Manual, 2009 Edition, IMO, 2009

[5] Hodžić, M., Šore, Ž.: Jadranska meteorologija, O vjetrovima i valovima na hrvatskom Jadranu, Matica Hrvatska , 2014.

[6] Hodžić, M.: Ekstremne pomorsko meteorološke opasnosti na hrvatskom Jadranu, Jadranska meteorologija, LIV – 13

[7] Hodžić, M.: Modro i plavo, zbornik, Matica hrvatska, Kaštela, 2007.

[8] http://www.agencija-zolpp.hr/tabid/1534/articleType/ArticleView/articleId/1157/PROMET-PUTNIKA-I-VOZILA-U-2013-GODINI.aspx

[9] http://www.dynamics-approx.jku.at/lena/Workshop2012/Janssen.pdf

[10] http://www.hrbi.hr/brodogradnja/images/stories/2010/210/11%20Coric.indd.pdf

[11] http://www.zadarskilist.hr/clanci/26012011/jadran---morska-autocesta

[12] Klimatološki atlas Jadranskog mora (1960.- 1990.), Državni hidrometeorološki zavod Hrvatske, Split, 2000.

[13] Lončar, G., Ocvirk, E., Andročec, V.: Analiza generiranja površinskih vjetrovnih valova u kanalskom području istočnog Jadrana

[14] Peljar za male brodove, HHI, 2000.

[15] Penzar, B. And all.: Meteorologija za korisnike, Školska knjiga, Zagreb, 1996.

[16] Penzar, B., Penzar, I., Orlić, M.: Vrijeme i klima hrvatskog Jadrana, Zagreb, 2001.

[17] Penzar, B., Penzar, I., Orlić, M,: Periodičen promjena vjetra na Palaguži i uz obalu, Zbprnik Palagruža – jadranski dragulj, Hrvatska pomorsko meteorološka služba, Kaštela, 1996.

[18] Penzar, B., Penzar, I., Orlić, M,: Neke karakteristike cirkulacije zraka duž obalnog područja SR Hrvatske, X. Kongres o energiji, Opatija, 1988., 105-115

[19] Poje, D.: Neke značajke vjetrovnog režima u Splitu, Sunčeva energija 3, 213-220, 1981.

[20] Pomorski zakonik, NN, 118/2004.

[21] Popović, R., Kulović, M., Šore.: Meteorological warnings in the safety of navigation system, The 4th International Maritime Scinence Conference – IMSC 2012, Split

[22] Popović, R., Kulović, M.: Meteorological safety of navigation, 15th International Conference on Transport Science, 28th May 2012, Portorož, Slovenia

[23] Popović, R., Milković, J.: Pomorska meteorologija u sustavu državnog hidrometeorološkog zavoda hrvatske, Meteorološki izazovi, Zagreb,21.-22.11.2013.

[24] Popović, R.: Model studije vjetrovne klima za pomorske gradnje, The 3rd International Maritime Science Cobference – IMSC 2011, May, 21th, 2011

[25] Prpić-Oršić, J., Čorić, V.: Pomorstvenost plovnih objekata, Rijeka, 2006.

[26] Simović, A., Pomorska meteorologija, ŠK, 1978.

[27] SOLAS, Consolidated edition 2009, IMO, 2009

[28] Tabain, T.: Prijedlog standard stanja mora za Jadran, I. Simpozij Teorija I praksa brodogradnje, Brodogradnja, no.3/4, Zagreb, 1974.

[29] Tabain, T.: Standard Wind Wawe Spectrum for the Adriatic Sea Revisited (1977-1997), Brodogrradnja, vol. 45, no. 4, 1997.

[30] Vučetić, M., Vučetić, V.: Meteorologija za nautičare, Fabra, Zagreb, 2002.

[31] WMO, 1981. Manual on Marine Meteorological Services (MMS-558)

A MODEL OF DEPLOYMENT OF ANTI-COLLISION DEVICES FOR GLIDERS AND UNMANNED AERIAL VEHICLES IN SLOVENIAN UNCONTROLLED AIRSPACE

Gorazd Požgaj, B.Sc.
Republic of Slovenia
Ministry of Defense; Slovenian Armed Forces
Vojkova cesta 55, 1000 Ljubljana, Slovenia
gorazd.pozgaj@mors.si

ABSTRACT

In order to prevent aviation accidents and incidents, airspace security measures exist both in controlled and uncontrolled airspace. In controlled airspace, Air Traffic Control (ATC) provides air traffic control services aimed at preventing collisions. In uncontrolled airspace, a pilot must operate an aircraft according to Visual flight rules (VFR), a set of regulations that comprise visual control, navigation and separation from other aircraft. This is where we also find gliders[1], which fly by taking advantage of vertically rising air masses (thermal) and usually do not have any additional devices that would signal their presence to the others. A new category in the airspace that is gradually gaining importance is the unmanned aerial vehicle (UAV), an aircraft that can perform out-of-sight flights. Among all the categories, gliders and UAVs are most at risk when it comes to mid-air collision. Namely, gliders not only lack any technical equipment and engine, but they also depend on thermal lift. UVAs on the other hand are small and thus have a poorly visible silhouette, and, moreover, a final regulation for their use is yet to be adopted.

This paper focuses on the need to maintain airspace traffic in uncontrolled airspace secure. Before UAVs become widely employed, it is necessary to define the standards, the technical equipment and the regulations that will guarantee safe flying to all aircrafts. My aim is to present a model and examine the technical equipment, i.e. the anti-collision devices that can inform in due time gliders and UAVs about the presence of each other.

Key words: Unmanned aerial vehicle, UAV, gliders, uncontrolled airspace, anti-collision devices.

1 INTRODUCTION

The use of UAV for military purposes today is very diverse and massive, and has significantly increased in recent times, but the use for civil (commercial, entertainment and State) purposes has not been subject to these trends so far. By increasing the supply and affordability of high-tech components for the manufacture of UAV, they appear as robotic working devices in different industries and also as cheap flying toys.

This paper will present a cross-section of the current state of affairs in the field of anti-collision devices and what equipment the UAV and gliders should adopt in order to prevent any mutual collisions in the air, since currently this field has not yet been regulated. Some technical guidelines will be suggested, including equipment and recommendations on safety equipment, which should be taken into account when introducing an UAV, especially in the

[1]These include gliders (G), hang-gliders (HG) and para-gliders (PG).

uncontrolled airspace of class G. This is particularly important for the transitional period before a regulation comes into force. Both America and Europe are working towards a solution, but no changes are expected until 2018. Now it is up to individual Countries to regulate this area in accordance with existing regulations. UAVs are the future: they will be used for commercial, as well as for State purposes (border control, protection and rescue, etc.). If we want to keep up with the times, we need to allow their development and employment in our airspace, although with certain security restrictions.

2 AIRSPACE IN SLOVENIA

Airspace is part of the atmosphere, which is under the control of a particular country, and in which there are rules that should be followed by all aerial vehicles entering or flying into it. Each country has sovereignty over its own air space. This division and the associated flight rules were created because the number of aerial vehicles was rapidly increasing. Airspace in Slovenia, as well as in other countries is organized in accordance with the regulations of the International Civil Aviation Organization (ICAO). In accordance with a unified system of airspace division, the airspace can be roughly divided into a controlled and an uncontrolled part. According to the available services, the ICAO further divides it into seven classes (A, B, C, D, E, F and G). In Slovenia there only exist classes C, D and E (controlled) and class G (uncontrolled). Airspace classes A, B and F do not exist in Slovenia.

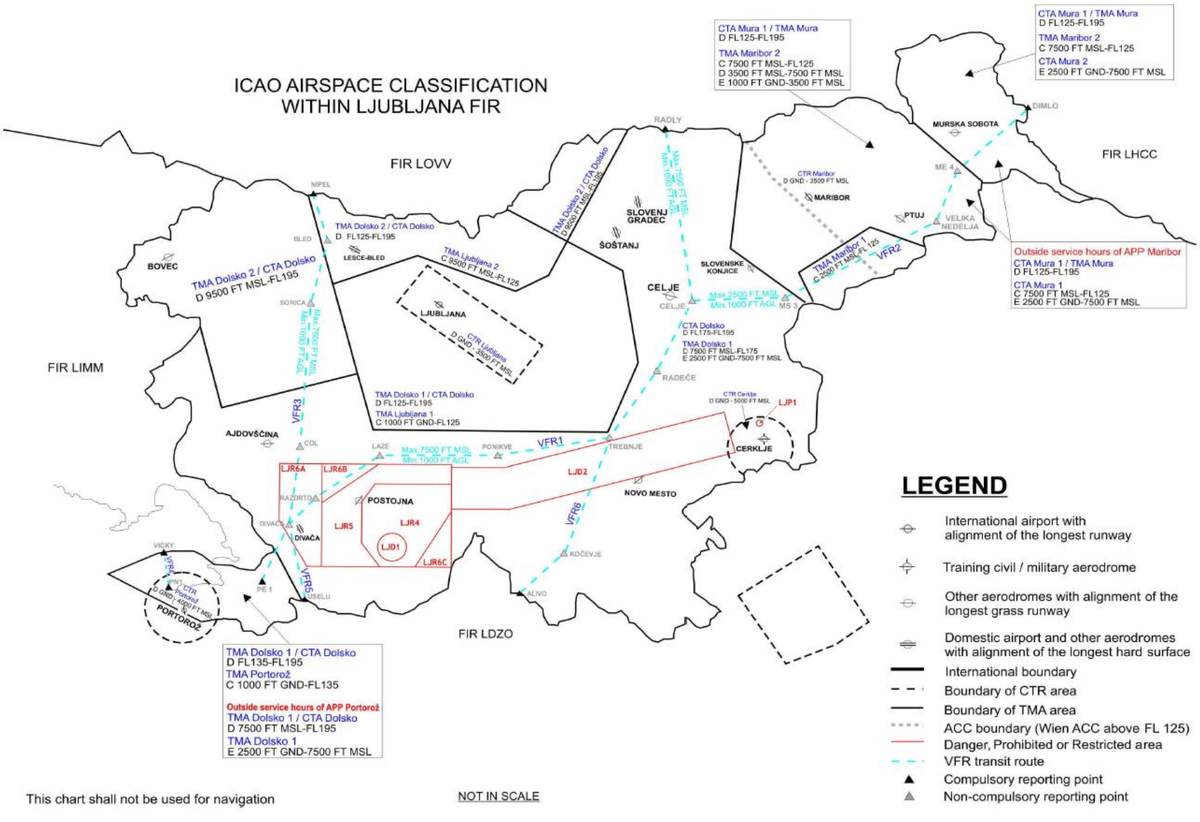


Figure 6: ICAO horizontal aerospace classification within Ljubljana FIR

Source: (http://www.sloveniacontrol.si/informacije/vfr-bilten)

In airspace class G all flights are permitted. It's the airspace of free flight. The separation between aircrafts by ATC is not assumed. Flying in this airspace also doesn't require any clearance (no need to submit the flight plan). In this space the radio communication is not required, except for IFR flights. Upon request, the Flight Information Service (FIS) gives information on the rest of the traffic and gives advice. In this class the speed is limited. The speed is limited to 250 knots of indicated air speed below 10,000 feet (10,000 ft) of altitude, except for military aerial vehicles. Minimum distance of the aerial vehicle in VFR flight, flying above or below the cloud or clouds, must be three hundred meters (300 m) or more. The lateral distance from clouds must be fifteen hundred meters (1500 m) or more. Minimum horizontal visibility to a height of ten thousand feet (10,000 ft) should be at least five kilometres (5 km) or more, and above the height of ten thousand feet (10,000 ft) eight kilometres (8 km) or more. Below a height of three thousand feet (3000 ft), however, it is sufficient to stay outside the cloud, while the terrain must visible (Figure 2). Users of class G airspace are all kinds of aerial vehicles, so it is necessary to remain visible to other users of this airspace. In airspace class G the UAV flight is also allowed. See and be seen, this is the main principle that must be obeyed by all airspace users.

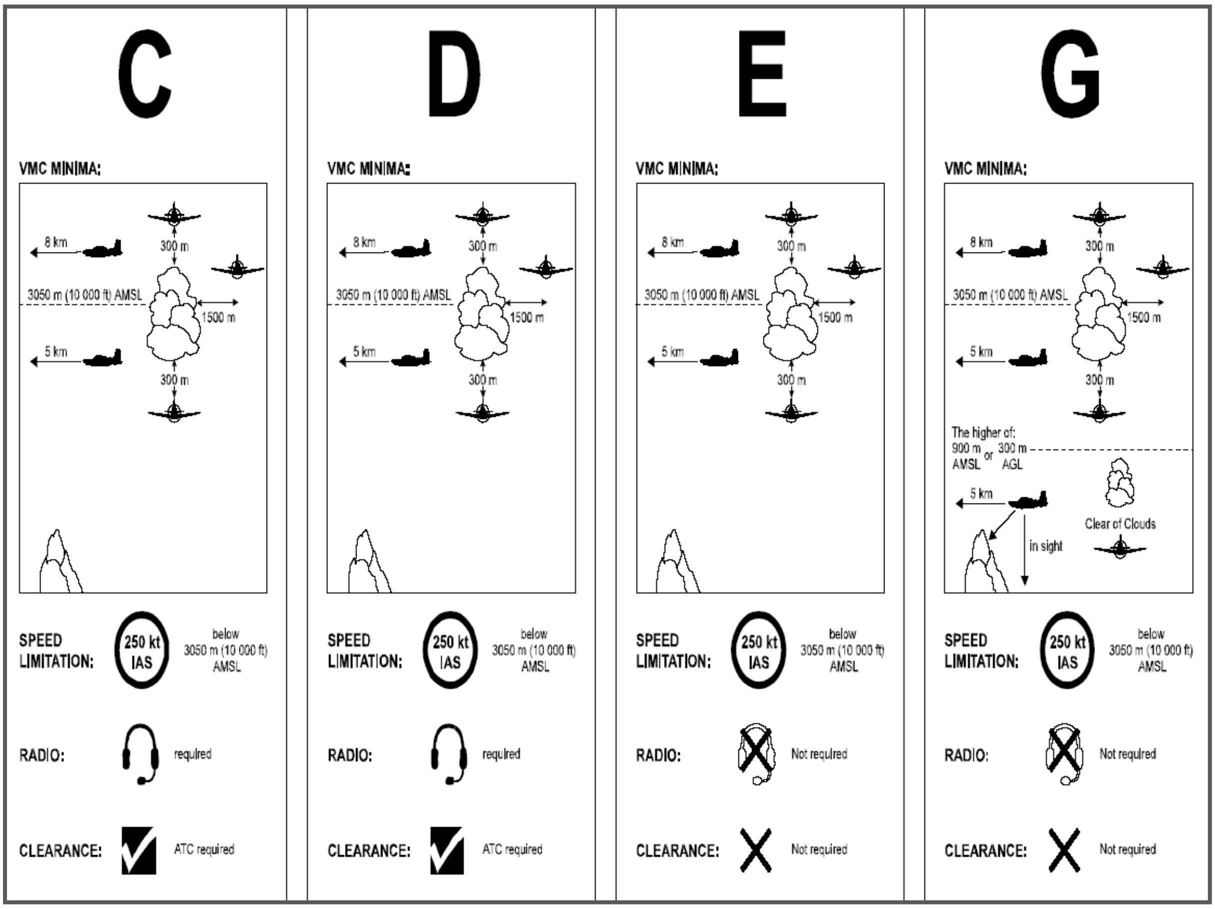


Figure 7: Airspace structure in Slovenia and flight conditions

Source: (http://www.sloveniacontrol.si/informacije/vfr-bilten)

2.1 Flight conditions

Depending on the conditions in which the flights are carried out, they may be divided in two categories according to the ICAO conditions :

- VFR (Visual Flight Rules),
- IFR (Instrument flight Rules).

VFR flights are carried out in accordance with visual flight rules based on visual control, navigation and separation between aerial vehicles. For a safe conduct of the flight under VFR, minimum meteorological conditions are set out (VMC, Visual Meteorological Conditions), which are shown in Figure 2.

When the weather conditions do not meet the VMC, the flight is carried out by Instrument Flight Rules (IFR), and the meteorological conditions are called instrument meteorological conditions (IMC). In flights undertaken by instrument flight rules, the navigation and control of the aircraft is based on instrument data of the aircraft. During IFR flights the crew must be in contact with air traffic control. These flights are allowed only in controlled airspace under prescribed procedures.

2.2 Management and control of air traffic in a controlled space

Loss of life and damage to property and aerial vehicles that occur when a collision happens, emphasize the need for Air Traffic Control. The principal activity of ATC is management and air traffic control. Equipment and features of ATC depend on the area of responsibility. VHF voice communications, transponder and telecommunications are standard tools of ATC services, while data connection is not yet implemented in general use. ATC is currently being implemented in two ways: in the traditional way and using devices to prevent collisions.

The traditional technique of air traffic control is implemented through the human factor (air traffic controller), observing a two-dimensional display of positions of the aerial vehicles obtained with the help of radar control. On the radar screens an image of the airspace is displayed, which is obtained through the primary surveillance radar.

If the aerial vehicle is equipped with an electronic device called a transponder, consisting of a receiver and a transmitter which transmits additional coded data, the data is displayed on a two-dimensional image of the radar screen near the point (lights), which shows the horizontal position of the aerial vehicle. This additional data is made of four digit octal codes, which are transmitted by the transponder to a computer on earth in order to identify the aerial vehicle; the four digit code is pre-allocated onto the aerial vehicle by an air traffic controller. Some transponders (Mode-C, Mode-S) also forward the height of the UAV, and this data is also displayed on the radar screen. An air traffic controller determines and sets, usually from the borders delineated on the radar screen, which aerial vehicles are within the geographical area of responsibility. Broadly speaking, there are two types of radars for aeronautical purposes: primary and secondary.

Primary radars record the echoes of radio signals from the surface of the aerial vehicle. With these radars we cannot determine the exact position of the UAV in the air. For a precise specifying of the UAV in the air space we need information about the altitude. For this purpose secondary radars are employed. A secondary surveillance radar operates on the principle of sensing response of the transponder, which is built in the aerial vehicle. The secondary radar casts the radio signal, which is answered by the device in the aerial vehicle called a transponder. The most important data returning to the radars from all UAVs in civil air traffic are the answers Mode-A and Mode-C. Mode-A is a four-digit octal code set by the pilot following the instructions of air traffic controller. Mode-C response is an indication of the altitude of the aircraft. Indication Mode-A uniquely identifies the UAV in the airspace and without it would be impossible to distinguish the aircrafts. Without the indication Mode-C we would not be able to accurately determine the position of the aircraft. The radar can determine the flying direction, the time of detection of the aerial vehicle, and the distance of the aircraft.

But it cannot tell the altitude on which the UAV is located without the value of Mode-C. However, as an indication of the altitude is received with a note from Mode-C, the position of the airplane is uniquely determined. Mode-S (Mode Select) radars are the newest generation of secondary radars, which can require through the unique 24-bit address of the aircraft a response only from this airplane and not from all who "hear" the request. Together with the appropriate aircraft equipment (Mode-S transponder) they are capable of obtaining much more information from airplanes, and not just the height and identification. A Mode-S radar can extract the contents of 56-bit registers from the aircraft, which contain different information. A complete list of registers is large and is listed in ICAO document Aeronautical Communications Annex 10 Volume III (ICAO, 1995).

Air traffic control also uses anti-collision systems which are located on board of the aerial vehicle and often receive help from the equipment on earth. Anti-collision systems will be described below.

2.3 Flying in an uncontrolled space

In uncontrolled airspace all flights for all aerial vehicles are permitted, so it is necessary to ensure that the aerial vehicles are easily visible. They fly under visual flight rules (VFR), which are based on visual control, navigation and separation between aerial vehicles, which should be provided by pilots themselves. The separation between aircrafts by ATC is not assumed. In order to fly in this airspace clearance is not required. In this space the radio communication is not required, except for the IFR flights. Upon request, the FIS gives information on the rest of the traffic and gives advice. In a non-controlled space we can also find gliders and UAV, which can also fly out of the visual field of the controller. In uncontrolled airspace the use of anti-collision equipment is not mandatory, but highly desirable.

3 DESCRIPTION OF THE CURRENT STATE OF SECURITY EQUIPMENT

3.1 Anti-collision equipment in controlled airspace

Today's security systems are mostly limited to the position lights and anti-collision lights. Lights are required to fly in controlled airspace. The aerial vehicle must be able to switch the lights on and off during the flight, although they are usually lit whenever the aerial vehicle moves along the manoeuvre area, and also in all of the flight phases. Also, the Traffic Collision Avoidance System (TCAS) is used, which is designed to prevent collisions between UAVs in the air. It is mostly used on airplanes, but also on other aircrafts. For the operation the aerial vehicles must be equipped with a suitable transponder (Mode-C, Mode-S), and it must be connected. ICAO requires the use of TCAS on board of any aircraft with a maximum take-off mass exceeding 5700 kg or more than 19 passengers. The TCAS-equipped are practically all passenger, freight and commercial aircrafts. It does usually not apply to sport aircrafts. TCAS greatly increases air traffic security. TCAS system is relatively expensive. Advanced TCAS II system provides a solution for the exchange of data between aircrafts and coordinated advice to both parties. The system T^2CAS (Terrain and Traffic Collision Avoidance System) has an additional ability to prevent a collision with the ground. All described systems require that the pilot reacts to a warning sign and are not directly related to the autopilot.

In the development phase are also the automatic systems to ensure separation (ASAS – Airborne Separation Assurance System) and collision avoidance in the airspace, and systems for monitoring and avoidance (ACAS – Airspace Collision Avoidance System) in active and passive versions. These systems will be able to identify the transport that will actively participate in the system, as well as those who will be passive, and they will be able to avoid them. ASAS / ACAS / TCAS operate using secondary radar and the transmitted signal of transponder, and operate independently of ground installations. The transponder must be Mode-C or Mode-S.

The above devices will never be useful for preventing collisions of gliders with other sport aerial vehicles, because the devices are too expensive, too big, the consumption of energy is too high, and they are not made for receiving the movement pattern of gliders and their density in a small space.

3.1.1 ADS-B

Automatic Dependent Surveillance-Broadcast (ADS-B) is a technology that is being developed and used for tracking the aerial vehicles and increasing air traffic safety. It will allow to monitor the traffic in the air and at airports by using this system alone or together with another one. It will complement or completely replace the current most common radar control manner. Aeroplanes and other aircraft periodically transmit information about their current location, which is determined by the system using Global Navigation Satellite System (GNSS) or the GPS, and is then broadcasted via radio transmitters to other UAVs, controllers, dispatchers and other users on the ground. The result is an image displayed on the screen, based on which the air traffic controllers guide and control the air traffic, and the pilots in the airplanes see and know where and what aircrafts are in the vicinity. ADS-B in aircrafts is able to capture and detect signals from sources which are very remote, so the standard TCAS system will be upgraded, which will allow the pilots to gain more information about the aircrafts in the area. When using the technology for secondary surveillance for obtaining data, it is necessary that the targets detected by the radar also respond appropriately. Unlike this manner, the ADS-B system in addition to a functioning transponder also depends on a functioning navigation system on the plane. Compared with radars, ADS-B receivers consume less electricity, the chance of damage is smaller, repairing them is less difficult, and the maintenance costs are lower; also, the installation is easier and more efficient. The ADS-B System is also cheaper, more accurate in most cases, and can be used where there are no radars, e.g. above the oceans. ADS-B will also be able to reduce separation between aircrafts and allow pilots to have better overview of the situation ("situational awareness") (ADS-B Tehnologies, 2015).

3.2 Anti-collision equipment in uncontrolled airspace

Security systems in uncontrolled airspace are mostly limited to the selection of the most visible colour of the dome or wings of para-gliders and hang gliders, and colouration of the wings and nose of the glider. Ultra-light and sport airplanes, which are often present in uncontrolled airspace, are equipped with integrated position lights and anti-collision lights.

In uncontrolled airspace the use of anti-collision equipment is not mandatory, but highly desirable. Since it is not mandatory, it does not have the prescribed standards and consequently the systems from different manufacturers are not mutually recognized. Currently, the most complete and mostly used is an electronic device FLARM.

3.2.1 FLARM

FLARM (Flight Alarm) is an electronic device which is used to prevent possible collisions between aerial vehicles. Formally, it is not an ADS-B, because the device is optimized for a specific use in small aerial vehicles such as gliders, ultra-light aircrafts and private airplanes, which often fly very close together without the risk of collision (for example in circulation of gliders in the same updraught), and is not designed to detect other aircrafts over large distances and interact with ATC. Precisely because of this, a TCAS system cannot be used on larger aircrafts, as it warns against all of the aircrafts in the vicinity, even if there is no danger of a collision between them. Compared to the transponder, the FLARM has low energy consumption and is relatively inexpensive to purchase and install.

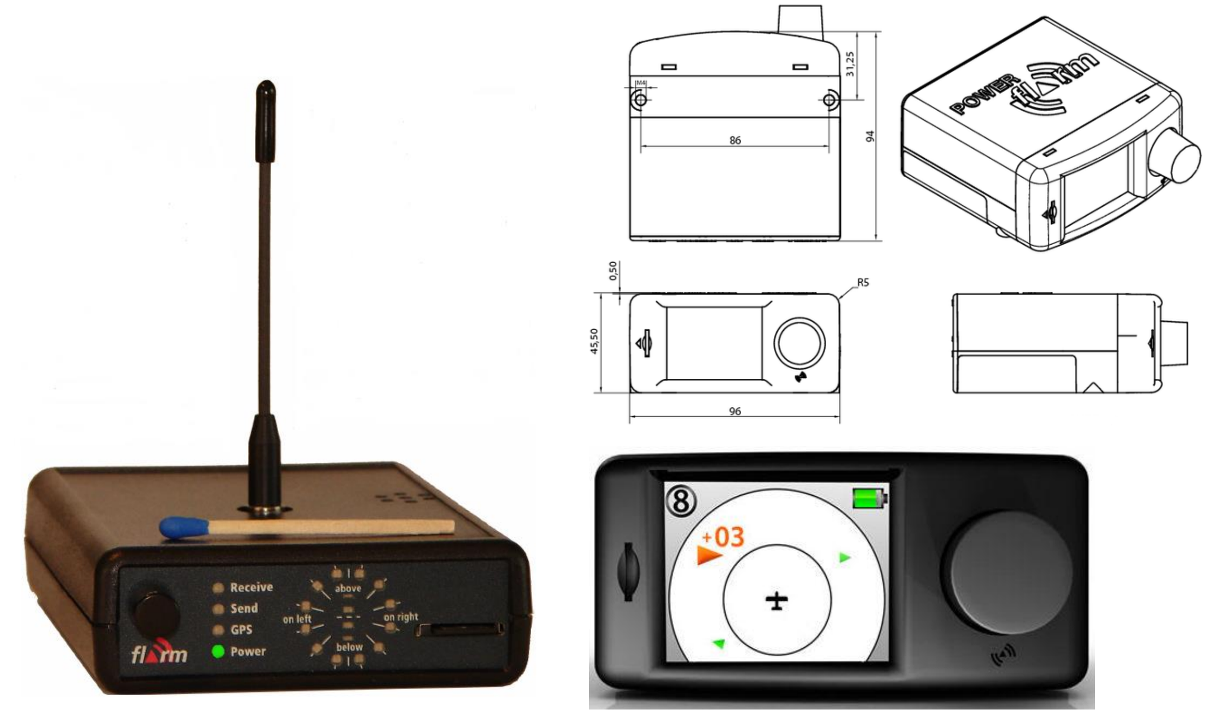


Figure 8: FLARM and PowerFLARM Portable devices

Source: (http://flarm.com/product/product_flyer_en.pdf, http://www.cumulus-soaring.com/flarm/PowerFLARM-2.jpg)

FLARM works to acquire/broadcast its GPS position and the change in barometric height by using the barometric sensor and predicted flight path calculated from these data, broadcasts its position to other aircrafts, and also receives the same information from other aircrafts equipped with this system. After receiving data from other systems, with their help and with the consideration of its own position, direction and height, FLARM calculates whether there is a possibility of a collision. A simple display shows the position of other aircrafts equipped with a FLARM system, and in case of danger it signals the danger of collision with light and sound signal to the pilot. The algorithm of the intended movement is able to process and transmit up to 50 signals. Based on the database with the positions of static obstacles (mountain cable-ways, power lines, etc.), stored in a single unit, the system is also capable of warning against a collision with these obstacles.

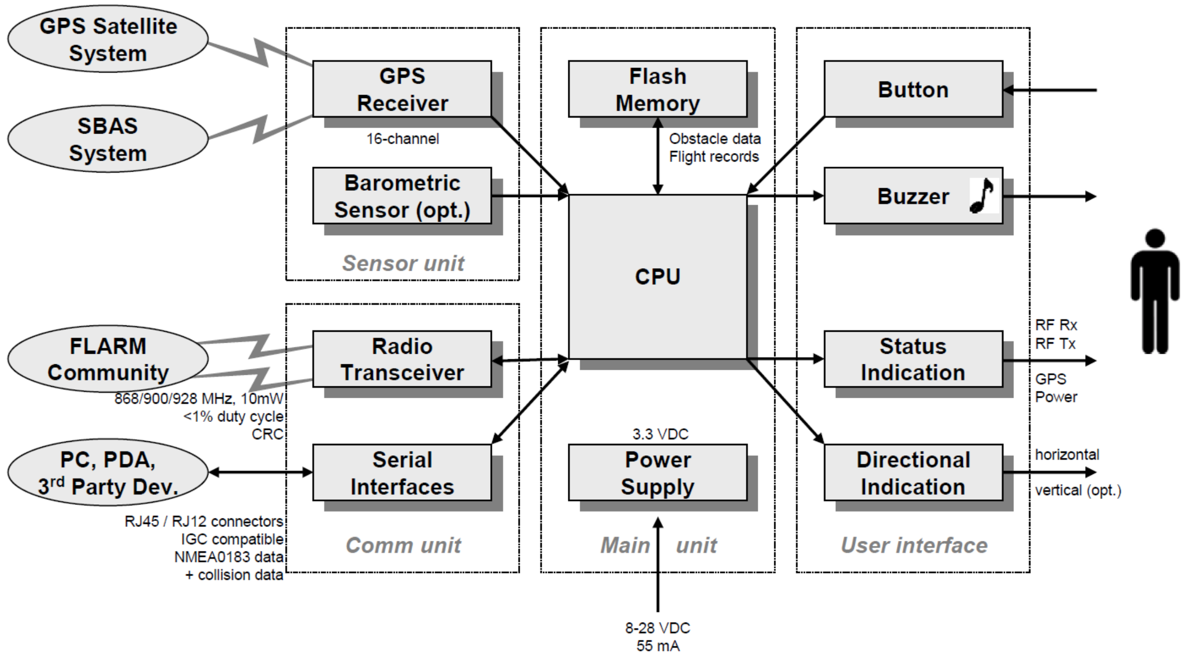


Figure 9: FLARM collision warning device hardware scheme

Source: (http://www.gliding.ch/manuels/flarm_afms_v1.00_en.pdf)

FLARM has lower power consumption than a conventional transponder. However, the FLARM signal has a relatively short range (3-5 km in the original derivatives), and therefore it cannot be used for passenger planes and other fast-flying aircrafts. There is also a new available version called the PowerFLARM which has a greater range (10 km). It enables the reception of data both from the transponder (Mode-A, the Mode-C and Mode-S) and from the ADS-B, and is approved by the EASA (PowerFLARM Portable Manual Version 6.00, March 2015).

The para-gliders and hang-gliders can use the FLARM, which is already built in the GPS navigation device (Flytec/Bräuniger); it is a simplified version with the range of 2-3 km and it delivers only the number of FLARM devices that are within range.

4 DISCUSSION

During the transitional period, before the adoption of the relevant legislation, which would govern the UAV flight in an uncontrolled airspace, it would be necessary to accept certain restrictions about the areas of flight, the allowed altitude, the maximum take-off weight of the UAV. Also, the flight should always be carried out in the pilot's field of vision.

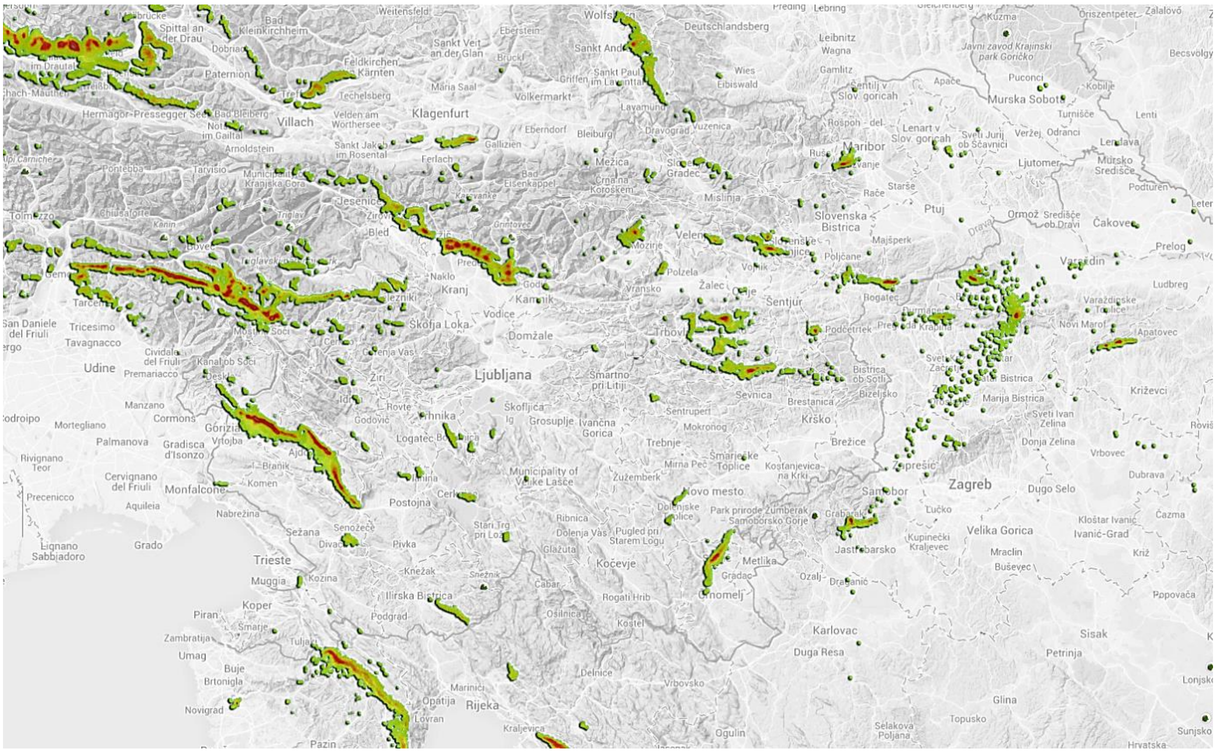


Figure 10: Map of Slovenia - activity of PG and HG

Source: (author; source IGC files form http://www.xcglobe.com/)

The map of Slovenia (Figure 5) shows that there are three areas (two on north Primorska, and one on Gorenjska) where the activity of para-gliders and hang-gliders is extremely high. In these areas, it would be necessary to restrict or prohibit the use of UAVs, respectively allowing the flight solely on the basis of a special permission to fly. I'd like to point out that a big responsibility lies especially on glider pilots, who will have to take care of their technical equipment for collision avoidance, and thus for their safety, so that they will be visible to the UAVs, which according to their complexity will certainly have a built-in airspace anti-collision system. A USA research study among glider pilots has shown that 40% of them were favourable to a safety regulation regarding the use of anti-collision devices on gliders (Conliffe, Rosenhammer & Walton, 2013).

5 CONCLUSION

I'd like to emphasize that among the aircraft categories the UAVs and the gliders are not the only ones that are dangerous to each other, but there are others, such as sport planes that fly in the Class G airspace, that are equally risky, so we need a comprehensive overview and solutions for all of them. Aircrafts flying in controlled airspace must have the appropriate technical equipment, the pilots must be properly trained and licensed for flight. To fly in controlled airspace they must have a built-in communication and a transponder, which allows controllers to see them on the radar screen, and provides the necessary information to help them carry out the separation of aircrafts. Some are also equipped with safety equipment that is designed to prevent collisions and increases safety. The devices transmit the signal to controllers and provide information about their current position to other aircraft. Much attention has been given to the new technology ADS-B, which will improve or even replace the use of conventional transponders. This technology works by using the built-in GPS, so that the data on the current position is periodically transmitted. Also FLARM, which (may) be used by smaller aircraft and gliders, operates using GPS to periodically transmit its current position. We can see that for all of these GPS devices, the key element for building and developing technology is that all aircrafts must be able to detect one another and avoid potential collisions. A newer version of this device, called PowerFLARM, is able to accept a signal also from the transponder (Mode-A, Mode-C, Mode-S) and ADS-B, which are built-in on aircrafts that fly in controlled airspace. We need to be aware that para-gliders and hang-gliders will never have built-in transponders, because their price is too high, they do not have a rigid structure which would allow the installation, the power consumption is too high, and a further obstacle is also the impact of radar radiation on health.

With the development of technology the UAVs have become interesting for the civilian area. Their technical characteristics do not fall behind classic aerial vehicles; in some areas they even exceed them. Their cost-effectiveness is attractive for both operators and users of services. The main problem from a safety point of view is that they fly where the user wants, and this is usually not over the unpopulated areas, where the uncontrolled airspace of class G is spread. In order to fly outside the area of the G Class the UAVs must meet the standards, requirements and rules as applied to the manned aerial vehicles. This sort of legislation does not exist for the UAVs.

Today's security systems on UAVs are mostly limited to the position lights and anti-collision lights, which are poorly visible during the day, so the pilot's visual perception and identification of unknown traffic in the area is almost impossible, especially when a UAV is in question. Anti-collision devices will be built-in primarily on civil UAVs, which will fly both over populated areas and in the airspace that is usually used by the rest of aircraft. Anti-collision devices are currently at an early stage of development, but depending on the degree of miniaturization and the required processing power it can be installed only in bigger UAVs (Moses, Rutherford, Kontitsis, Valavanis, 2011). The ACAS technology and the TCAS (Traffic Collision Avoidance System) derivative are thus not yet suitable for installation into small UAVs. We should take care of the miniaturization of the system, determine any restrictions about the concept of operations and improve the use of sensors and algorithms, which would ensure the safety in civilian operations for small UAVs. In the future it is likely that the UAVs will use a ACAS/ASAS system, which periodically transmits its position, altitude, speed and other parameters. This system will allow the pilot and the controller to access the accurate data on the aircraft. It will allow reliable solving of conflict situations with direct input of data into the autopilot system. By transfering information on air traffic, another system will also allow the detection of aircrafts that won't fit the above system.

Given the fact that most of the UAVs are equipped with a GPS module, the FLARM and PowerFLARM could be used as an anti-collision device during the transitional period. This one is also used by gliders. The device is small and light and has a low power consumption (55mA, 12 VDC). FLARM should be properly processed so that the UAVs could forward the obtained data to the operator, who would then obtain the information (direction and distance) via an external user interface (display and audio).

REFERENCES

[1] Conliffe M., Rosenhammer F. G. & Walton R. O. (2013). An analysis of anti-collision devices on gliders as a means to prevent mid-air collisions, Journal of business and behavioral sciences 25(Spring 2013), 158-166

[2] Moses A. A., Rutherford M. J., Kontitsis M., Valavanis K. P. (May 23, 2011). UAV-borne X-band radar for MAV collision avoidance, Proc. SPIE 8045, Unmanned Systems Technology XIII, 80450U. doi:10.1117/12.884150; http://dx.doi.org/10.1117/12.884150

[3] Sloveniacontrol (January 2015). http://www.sloveniacontrol.si/informacije/vfr-bilten

[4] FLARM collision warning Device (january 2015). http://www.gliding.ch/manuels/flarm_afms_v1.00_en.pdf

[5] PowerFLARM Portable Manual Version 6.00 (March 2015). http://flarm.com/wp-content/uploads/2015/03/PowerFLARM_Portable_Manual_6.00_EN.pdf

[6] Operating manual FLARM collision avoidance system status firmware version 6.00 (March 2015).

http://flarm.com/wp-content/uploads/2015/03/FLARM_OperatingManual_6.00_EN.pdf

[7] ADS-B Technologies (January 2015). http://www.ads-b.com/

CURRENT ISSUES ON THE ESTABLISHMENT OF EUROPEAN LIST OF SHIP RECYCLING FACILITIES

Željka Primorac, D.Sc
University of Split
Faculty of Law
Domovinskog rata 8, Split, Croatia
zeljka.primorac@pravst.hr

ABSTRACT

In November 2013, the European Parliament and the Council adopted the Regulation (EU) No 1257/2013 on ship recycling. According to article 6(2) of Regulation (EU) No 1257/2013, ship owners shall ensure that ships flying the flag of the EU, destined to be recycled, are only recycled at ship recycling facilities that are included in the European List of authorized ship recycling facilities. In this paper the author analyzes some of the factors of the controversial unilateral norms of the European List of ship recycling facilities with emphasis on the purpose of this Regulation – to direct ships flying the flag of the EU to ship recycling facilities that practice safe and environmentally sound methods of dismantling ships. This paper elaborates on requirements necessary for ship recycling facilities to be included in the European List especially on authorization of ship recycling facilities located in the EU and application for inclusion of ship recycling facilities located in third countries. Althought the EU ship recycling facilities meet high standards of occupational safety and environmental protection and the majority of coastal recycling facilities in South Asia work with minimal environmental and safety standards – all ship recycling facilities (in the EU or in third countries) which do not meet those minimum requirements should not be included in the European List. The purpose of this paper is to point to on the insufficient "clean" capacity and environmental standards in ship recycling facilities and problems in complying with the requirements set out in the European List of ship recycling facilities under Regulation (EU) No 1257/2013 particularly to the decreasing number of ships registered under EU flag (re-flagging the ship to a non-EU flag).

Key words: European List of ship recycling facilities.

1 INTRODUCTION

Clean and safe ship recycling is the most environmentally friendly way to dispose of ships at the end of their operational lives. It is true that the recycling industry eliminates obsolete and substandard ships, and therefore it is the key element of maritime safety, environmental protection and economic balance in the shipping markets.[1] Dismantling of ships at world level has increased by six times in the period from 2007 to 2009 becoming an economic phenomena – vital for the economies of certain countries. 2011 become the third biggest year ever for demolition with 41 m dwt,[2] 2012 was record year with 58.7 mill gt of recycled tonnage (in 2013 – 45.3).[3] The low-cost, ship-scrapping industry of India, Pakistan and

[1] Alexopoulos, A.B."Scrap Activities on the Coastal Zone: Dynamic Model for the Recycling of Ships", Journal of Shipping and Ocean Engineering, David Publishing Company, no.4, 2014, p. 29.
[2] McCarthy, L. "Ship recycling firmly on 2012 agenda", Lloyd's List, March 2012, p. 2.
[3] Gramann, H. "Hazardous times in Europe?", HANSA International Maritime Journal, no.8., 2014., p. 70.

Bangladesh is a multibillion-dollar business employing about a million workers,[4] and the three countries account for more than 70% of the global ship-recycling industry.[5] At the end of their operating life, most large[6] commercial seagoing vessels are being dismantled in facilities (operated in dangerous condition) using methods with significant environmental and health impacts.[7] While the majority of recycling facilities, located in South Asia, work with minimal pollution controls and environmental safety standards and approximately 35% of ships going for recycling have an EU flag or european ownership,[8] on 20 November 2013 the European Parliament and the Council adopted *Regulation (EU) No 1257/2013 on Ship Recycling*[9] to reduce disparities between operators in the EU and in relevant third countries in terms of health and safety at the workplace and environmental standards.[10] Regulation entered into force on the 30th of December 2013.[11]

[4] While labourers on demolition sites in Bangladesh and India earn 1-2 US$ day and employers' expenses for safety and health are negligible, the costs in Europe can be estimated at around 250 US$ day for a worker in the Netherlands and 13 US$ day in Bulgaria (Green Paper On better ship dismantling, Commission of the European Communities, 22 May 2007, COM(2007)269 final, available from http://www.minenv.gr/anakyklosi/v.menu/plia/00/GREEN%20PAPER.pdf, p. 6).

[5] Paris, C., Mukherji, B. "EU and South Asia Scrap Over Recycling Ships", p. 1. (available from http//online.wsj.com/article/SB10001424127887324423904578522982568438250.html, accessed 27 January 2015).

[6] More on annual recycling statistics for the world fleet of 500 GT and above from 1990 to 2006 see Mikelis, N. "A statistical overview of ship recycling", International Symposium on Maritime Safety, Security & Environmental Protection, Athens, September 2007, p. 3 (available from http://www.imo.org/blast/blastDataHelper.asp?data_id=23449&filename=shiprecycling.pdf, accessed 12 September 2014).

[7] Proposal for a Regulation of the European Parliament and of the Council on Ship Recycling, European Commission, Brussels, COM(2012) 118 final, 2012/0055(COD), 23 March 2012, p. 2. More on environmental risk assessment from metals contamination (heavy metals and organic carbon) in sediment of the Aliaga see Neşer, G., Kontas, A., Ünsalan, D., Uluturhan, E., Altay, O., Darilmaz, E., Küçüksezgin, F., Tekoğul, N., Yercan, F. "Heavy metals contamination leveles at the Coast of Aliağa (Turkey) ship recycling zone", Marine Pollution Bulletin, Elsevier Ltd., no. 64, 2012, p. 882-887. More on ship recycling and marine pollution see Chiang Chang,Y., Wang, N.; Sabri Durak, O. "Ship recycling and marine pollution", Marine Pollution Buletin, Elsevier Ltd., no. 60, 2010, pp. 1390-1396.

[8] More on owning and using ocean-going ships for their trade by developed countries and demolishing them in developing countries see Demaria, F. "Shipbreaking at Alang-Sosiya (India): An ecological distribution conflict", Ecological Economics, no. 70, 2010, Elsevier Ltd, pp. 250-260.

[9] Regulation (EU) No 1257/2013 of the European Parliament and of the Council of 20 November 2013 on ship recycling and amending Regulation (EC) No 1013/2006 and Directive 2009/16/EC – (Ship Recycling Regulation), Official Journal of the European Union, L 330/1-19, 10.12.2013. Ship recycling means activity of complete or partial dismantling of a ship at a ship recycling facility in order to recover components and materials for reprocessing, for preparation for re-use, while ensuring the management of hazardous and other materials, and includes associated operations such as storage and treatment of components and materials on site, but not their further processing or disposal in separate facilities (art.3(6) *Ship Recycling Regulation*).

[10] More on establishing mandatory requirements at global and regional level in order to ensure the solution of the ship recycling problem see Luttenberger, A. "Developing the environmental legislation on ship recycling, International Congress Energy and the Environment", Rijeka, 2008, pp. 207-214.

[11] *Ship Recycling Regulation* will apply to ships at the earliest 2 years and at the latest 5 years after its entry into force, depending on when the recycling capacity of facilities on the European List exceeds the 2.5 million light displacement tonnes threshold.

2 *SHIP RECYCLING REGULATION* AND REQUIREMENTS FOR SHIP RECYCLING FACILITIES

The purpose of the *Ship Recycling Regulation* is to prevent, reduce, minimize and, to the practicable, eliminate accidents, injuries and other adverse effects on human health and the environment caused by ship recycling.[12] The *Ship Recycling Regulation* affect the recycling market and the entire maritime industry because it directs ships flying the flag of an EU Member State[13] to worldwide EU approved ship recycling facilities[14] that practice safe and environmentally sound methods of dismantling ships.

Althought the *Ship Recycling Regulation* shall apply not earlier than 31 December 2015, and not later than 31 December 2018, in relation to the provisions of arts.13-16 (requirements for ship recycling facilities), the date of application is from 31 December 2014.[15] Once applicable, the *Ship Recycling Regulation* will only allow ships registered under the flag of an EU Member State to be dismantled in facilities that meet the requirements set out in the *Ship Recycling Regulation*.[16]

According to article 6 (2) of the *Ship Recycling Regulation*, ship owners shall ensure that ships[17] flying the flag of a Member State (EU), destined to be recycled, are only recycled at ship recycling facilities that are included in the European List of ship recycling facilities (European List).[18] If EU-flagged ships need to be broken up for scrap and recycled they have to go to EU approved ship recycling facilities that meet the requirements set out in the *Ship Recycling Regulation*. Ship recycling facilities (located in EU Member States – European facilities or outside the EU – facilities located outside the EU Member States, in third countries) wishing to recycle ships flying the flag of the EU Member Sates, must comply with a number of requirements enumerated in art. 13 to be included in the European List. In order to be included in the European List –any ship recycling facility irrespective of its location shall comply, according to art.13(1) of the *Ship Recycling Regulation*, with the following requirements: a) it is authorised by its competent authorities to conduct ship recycling operations; b) it is designed, constructed and operated in a safe and environmentally sound

---

[12] Art.1 Ship Recycling Regulation.
[13] Only ships sailing under the flag of an EU Member State will be covered by the *Ship Recycling Regulation*. These represent less than 10% of the world fleet.
[14] Ship recycling facilities means a defined area that is a yard or facility located in a Member State or in a third country and used for the recycling of ships (art.3(7) *Ship Recycling Regulation*).
[15] Art. 32(2,a) Ship Recycling Regulation.
[16] Jenssen, I. "Making Sure the New EU Ship Recycling Regulation Works", p. 2 (available from http://governmentgazette.eu/?=5822, accessed 10 July 2014).
[17] Ship means a vessel of any type whatsoever operating or having operated in the marine environment, and includes submersibles, floating crafts, floating platforms, self-elevating platforms, Floating Storage Units (FSUs), and Floating Production Storage and Offloading Units (FPSOs), as well as a stripped of equipment or being towed (art.3(1) *Ship Recycling Regulation*). Under art.2(2), *Ship Recycling Regulation* shall not apply to: a) any warships, naval auxiliary, or other ships owned or operated by a state and used, for the time being, only on government non-commercial service; b) ships less than 500 gross tonnage; c) ships operating throughout their life in waters subject to the sovereignty or jurisdiction of the Member State whose flag the ship is flying.
[18] The definition of the European List of ship recycling (European List) cannot be found in provisions of the *Ship Recycling Regulation*.

manner; c) it operates from built structures;[19] d) it establishes management and monitoring systems, procedures and techniques which have the purpose of preventing, reducing, minimising and to the extent practicable eliminating health risks to the workers[20] concerned and to the population in the vicinity of the ship recycling facility, and adverse effects on the environment[21] caused by ship recycling; e) it prepares a ship recycling facility plan;[22] f) it prevents adverse effects on human health and the environment, including the demonstration of the control of any leakage, in particular in intertidal zones; g) it ensures safe and environmentally sound management[23] and storage of hazardous materials and waste, including the containment of all hazardous materials present on board during the entire ship recycling process so as to prevent any release of those materials into the environment; and in addition, the handling of hazardous materials, and of waste generated during the ship recycling process, only on impermeable floors with effective drainage systems; that all waste generated from the ship recycling activity and their quantities are documented and are only transferred to waste management facilities, including waste recycling facilities, authorised to deal with their treatment without endangering human health and in an environmentally sound manner; h) it establishes and maintains an emergency preparedness and response plan; ensures rapid access for emergency response equipment, such as fire-fighting equipment and vehicles, ambulances and cranes, to the ship and all areas of the ship recycling facility; i) it provides for worker safety and training, including ensuring the use of personal protective equipment for operations requiring such use; j) it establishes records on incidents, accidents, occupational disease and chronic effects and, if requested by its competent authorities, reports any incidents, accidents, occupational diseases or chronic effects causing, or with the potential for causing, risks to workers' safety, human health and the environment;[24] k) it agrees to

---

[19] Niejenhuis-Rensen, N. "European Regulation on Ship Recycling", Thesis, Erasmus Universiteit Rotterdam, 2014, pp. 40-41: Ship recycling facilities must operate from built structures, beaching is practically prohibited since in general no such structures are used at a beach.

[20] Worker means any person who performs work, either regularly or temporarily, in context of an employment relationship, including the personnel working for contractors and subcontractors (art.3(2, c) *Ship Recycling Regulation*).

[21] Green Paper On better ship dismantling, *op.cit*., p. 2: From the ships scrapped between 2006 and 2015 an estimated 5.5 million tonnes of materials of potential environmental concern will end up in dismantling yards (in particular oil sludge, oils, paints, PVC and asbestos).

[22] Ship recycling facility plan is a plan prepared by the operator of the ship recycling facility and adopted by the board or the appropriate governing body of the ship recycling company that describes the operational processes and procedures involved in ship recycling at the ship recycling facility and that covers in particular workers' safety and training, protection of human health and the environment, roles and responsibilities of personnel, emergency preparedness and response, and systems for monitoring, reporting and record-keeping, taking into account the relevant IMO guidelines and resolutions (art.1(17) *Ship Recycling Regulation*).

[23] Environmentally sound management means taking all practicable steps to ensure that waste and hazardous materials are managed in a manner which protects human health and the environment against the adverse effects which may result from such materials and waste (art.3(2,d) *Ship Recycling Regulation)*.

[24] Green Paper On better ship dismantling, *op.cit*., pp.2, 8: In Bangladesh some 200 ship breaking workers died in accidents between 1998 and 2003. There is a high risk of dangerous accidents, particularly because of the lack of heavy machinery (cranes) and safety equipment for workers. According to a 2004 government report in India, there were 434 incidents at the Alang yards between 1996 and 2003, killing 209 labourers. According to a medical report to the Indian Supreme Court in September 2006, 16% of the workforce handling asbestos in Alang were found to be suffering from asbestosis and thus at serious risk of mesothelioma. As is known from medical research, the incidence of this form of lung cancer reaches its peak only several decades after exposure. For workers in Bangladesh and India can be said that most workers come from the poorest regions of the country

comply with the following requirements: sending ship recycling plan to the ship owner and the administration or a recognised organization authorised by it; reporting to the administartion that the ship recycling facility is ready in every respect to start the recycling of the ship; sending a statement of completion to the administration which issued the ready for recycling certificate[25] for the ship - within 14 days of the date of the total or partial recycling).

In order to conduct ship recycling, all ship recycling facilities will have to comply with the requirements set out in art. 13 of the Regulation, which generally mirror[26] the relevant provisions of the *Hong Kong International Convention for the safe and Environmentally Sound Recycling of Ships, 2009*[27] which establish standards that are safe for workers and are environmentally sound.[28] Additional requirements were also included in art. 13 of the *Ship Recycling Regulation* to exempt certain yards in South Asia who scrap on beaches (and in particular yards in India, Bangladesh and Pakistan)[29] from being included on the European List.[30] Such a decision by the European Commission would block EU flagged ships from accessing all of South Asia's ship recycling yards, in other words more than 70% of the world's recycling capacity.[31]

It would be possible for recycling facilities to obtain the authorisation to be included in the European List provided for by the Regulation already from 31 December 2014,[32] when the relevant provisions will become applicable.[33] New season is opening for yards that will start with the setting up of a European List of authorised recycling facilities, which will be managed by the European Commission, via the web,[34] by 31 December 2016.[35]

---

and are usually unskilled. They work without contracts and health or accident insurance and are not allowed to form trade unions.

[25] Ready for recycling certificate is a ship-specific certificate that is issued to ships flying the flag of a Member State and that is supplemented by an inventory of hazardous materials and the approved ship recycling plan art.1(22) *Ship Recycling Regulation*.

[26] See more Gramann, H., *op.cit*., p. 70.

[27] *The Hong Kong International Convention for the safe and Environmentally Sound Recycling of Ships, 2009 (HKC)* adopted on 15 May 2009 has not yet entered into force. Until 6 January 2015, contracting states of the *HKC* are Congo, France and Norway (see more Status of multilateral Conventions and instruments in respect of which the International Maritime Organization or its Secretary-General performs depositary or other functions, IMO, available from: http://www.imo.org/About/Conventions/StatusOfConnventions/Documents/Status%20-%201015.pdf, accessed 27 January 2015). Text on HKC available from http://ec.europa.eu/environment/waste/ships/pdf/Convention.pdf, accessed 27 January 2015).

[28] Weijburg, B. “The European Ship Recycling Regulation comes into force”, Green Shipping Bulletin, March 2014 (available from http://www.hfw.com/downloads/HFW-Green-Shipping-Bulletin-March-2014.pdf), p. 2.

[29] A ban will havea much more regrettable effect on the EU and its efforts towards clean and safe ship recycling especially on influence whatsoever in the countries where this influence is most needed (Mikelis, N. “Ship Recycling markets and the impact of the Hong Kong Convention”, International Conference on Ship Recyclinng, Malmo, 2013 (available from http./www.imo.org/Knowledge Centre/PapersAndArticlesByIMOStaff/DocumentsSHIPREC%202013%Int.., p. 13.). More about good reasons while *HKC* has not banned any type of recycling methods see Gramann, H., *op.cit*., p. 71.

[30] Weijburg, B., *op.cit*., p. 2.

[31] Mikelis, N. “Regulatory, social and commercial considerations on ship recycling”, HANSA International Maritime Journal, 2014, no.9., p. 117.

[32] See art.32 (2,a) Ship Recycling Regulation.

[33] Cavagnaro, L. “Ship dismantling industry and the new European regulations: an occasion of development or a mere burden on shipowners' costs?”, Shipping and Transport Bulletin, February-March 2014., p. 7.

[34] The European List shall be published in the Official Journal of the European Union and on the website of the Commission not later than 31 December 2016 (art.16(2) *Ship Recycling Regulation*).

According to art. 16(1) of the *Ship Recycling Regulation*, the Commission shall adopt implementing acts to establish a European List of ship recycling facilities which: a) are located in the EU and have been notified by the Member State in accordance with art. 14(3); b) are located in a third country and whose inclusion is based on an assessment of the information and supporting evidence provided or gathered in accordance with art. 15. The Commission shall adopt implementing acts to regularly update the European List, in order to include a ship recycling facility in the European List or remove a ship recycling facility from the European List – art.16(4) *Ship Recycling Regulation*.[36] The European List of ship recycling facilities located in Member States and the ship recycling facilities located in a third country shall be published in the *Official Journal of the European Union* and on the website of the Commission not later than 31 December 2016 (art.16(2) *Ship Recycling Regulation*). The European List shall include all of the following information about the ship recycling facility: a) the method of recycling; b) the type and size of ships that can be recycled; c) any limitation and conditions under which the ship recycling facility operates, including as regards hazardous waste management; d) details on the explicit or tacit procedure, as referred to in art. 7(3) of the *Ship Recycling Regulation*, for the approval of the ship recycling plan by the competent authority; e) the maximum annual ship recycling output – art. 16(2) *Ship Recycling Regulation*. The European List shall indicate the data of expiry of the inclusion of the ship recycling facility. An inclusion shall be valid for a maximum period of five years and shall be renewable – art. 16(3) *Ship Recycling Regulation*.

The establishment of a European List represents green light to recycle EU flagged vessels but maritime lobby groups have a very strong resistance to the European List using the argument that this "unilateral" action by the EU creates unnecessary bureaucracy and will drive ship-owners to a re-flagging in favour of non-European flags of convenience.[37] The *Ship Recycling Regulation* does not prevent shipowners from circumventing the Regulation by changing the registration of their ships to non-EU flags before ships are sent to be recycled.[38] To ensure that the *Ship Recycling Regulation* has a positive impact on improving ship recycling practices globally the EU needs: a) to make sure that the listed facilities are properly audited and certified to guarantee Environmentally Sound Management of the Hazardous Waste (ESM); b) to issue technical guidelines for ship recycling facilities, including guidelines for a robust mandatory certification and auditing scheme.[39] Guidance on the requirements as outlined in article 13 of the *Ship Recycling Regulation* should therefore at least include clarity

---

[35] Cavagnaro, L., *op.cit.*, p. 7.

[36] In establishing and updating the European List, the Commission shall act in accordance with the principles enshrined in the Treaties and with the international obligations of the Union – art. 16(5) *Ship Recycling Regulation*.

[37] Ormond, T. "Hong Kong Convention and EU Ship Recycling Regulation: Can they change bad industrial practices soon"?, Environmental Law Network International, Elni Review, no. 2, 2012, p. 58.

[38] Weijburg, B., *op.cit.*, p. 3.

[39] NGO Shipbreaking Platform "A principled & practical approach, Making sure the EU Ship Recycling Regulation will be a driver for change", September 2013 (available from http://www.shipbreakingplatform.org/shipbre_wp2011/wp-content/uploads/2014/02/Policy-Paper-EU-September, accessed 10 July 2014): Without an auditing scheme and guidance it will be impossible for the Commission to ensure that the recycling facilities included on the EU list indeed operate in an safe and environmentally sound manner.

in that the EU will only list facilities that meet these European standards and clarity that the shipbreaking facilities employing the beaching method will fail to meet approval.[40]

2.1 Additional requirements for ship recycling facilities located in the EU

Althought european ship recycling facilities[41] meet high standards of occupational safety and environmental protection, according to UNCTAD reports, a tonnage of between 6 and 30 million dwt have been sold for breaking per year between 2000 and 2005, while approx. 23% of the world merchant fleet fly the flags of EU Member States.[42]The *Ship Recycling Regulation* sets out a number of requirements for ship recycling facilities willing to recycle European ships.

According to art.14(1) of the *Ship Recycling Regulation* competent authorities[43] shall authorise ship recycling facilities located in EU Member State territory, if they comply with the requirements set out in art. 13, to conduct ship recycling. Facilities located in EU Member States will have to be authorised before they are included on the European List.[44] The EU Member States shall inform the Commission about the authorisation without delay.[45] EU Member States shall establish and update a list of the ship recycling facilities that they have authorised and this list shall be communicated to the Commission without delay not later than 31 March 2015.[46] If the ship recycling facility ceases to comply with the requirements set out in art. 13 – the EU Member State where that ship recycling facility is located shall suspend or withdraw the authorisation given to it or require corrective actions by the ship recycling company[47] concerned and shall inform the Commission thereof without delay.[48] Finally, concerns have been raised that not all ship recycling facilities in the EU operate according to existing requirements and that there are unacceptable variations in which laws are implemented for ship recycling activities amongst, and also within, certain Member States.[49]

[40] Respone submitted jointly by the European Environmental Bureau (EEB) and NGO Shipbreaking Platform to the European Commission questionnaire on the interpretation of requirements found in Regulation 1257/2013 (Ship Recycling Regulation), NGO Shipbreaking Platform, May 2014 (available from http://www.shipbreakingplatform.org/shipbre_wp2011/wp_content/uploads/2014, accessed 16 December 2014), p. 2.

[41] More about European ship recycling facilities (Van Heyghen Recycling S.A.; Scheepssloperij Nederland B. V.; Harland and Wolff, etc. see Ship recycling Practice and regulation today, Lloyd's Register, June 2011 (available from http://www.er.org/en/images/213-35820-ShipRecycling-040711-tem155-223320.pdf, accessed 17 November 2014).

[42] Green Paper On better ship dismantling, *op.cit.*, p. 7.

[43] Competent authority means a governmental authority or authorities designated by a Member State or a third country as responsible for ship recycling facilities, within a specified geographical area or an area of expertise, relating to all operations within the jurisdiction of that state (art. 1(11) *Ship Recycling Regulation*).

[44] Weijburg, B., *op.cit.*, p. 2.

[45] Art. 14(5) *Ship Recycling Regulation*. See more Mikelis, N. " An analysis of the European Regulation on ship recycling", *op.cit.*, p. 4.

[46] Art. 14(2 and 3) Ship Recycling Regulation.

[47] Ship recycling company means the owner of the ship recycling facility or any other organization or person who has assumed the responsibility for the operation of the ship recycling activity from the owner of the ship recycling facility (art. 1(8) of the *Ship Recycling Regulation*).

[48] Art. 14(4) Ship Recycling Regulation.

[49] Response submitted jointly by the European Environmental Bureau (EEB) and NGO Shipbreaking Platform to the European Commission questionnaire on the interpretation of requirements found in Regulation 1257/2013 (*Ship Recycling Regulation*), *op.cit.*, p. 2.

2.2 Additional requirements for ship recycling facilities located outside of the EU

In 2013, more than half of 1 213 vessels were sold to substandard beaching facilities in India, Pakistan and Bangladesh which do not operate to international safety and environmental standards. Many ships which were sent for breaking to South Asia contain in their structure hazardous materials that are potentially harmful to human health[50] and the environment.[51] Consequently, South Asia has become a preferred dumping ground for end-of-life ships as environmental, safety and labour rights standards are poorly enforced there.[52] Ship recycling in India, Pakistan and Bangladesh (developing countries) represents major problems due to the lack of facilities for dealing with heavily polluted and toxic waste in a responsible way. The governments of the South East Asian states refuse to tackle these practices because they consider ship recycling to be an important economic activity[53] in which they should interfere as little as possible.[54]

The *Ship Recycling Regulation* has effectively disqualified the beaching method for EU-flagged ships. A big challenge for the developing countries' ship recycling facilities represents lies in with requirements and procedures under the *Ship Recycling Regulation*. Article 15 of the *Ship Recycling Regulation* states that recycling facilities located in a third county (non-EU Member States) may be placed on a European List if they meet the requirements set by the EU for responsible scrapping,[55] i.e. acceptable human health safety and environmental standards equivalent to that in the EU. Shipbreaking yards in South Asia will clearly not appear on the EU list of approved facilities.[56]

A ship recycling company[57] owning a ship recycling facility located in a third country (outside of the EU) and intending to recycle ships flying the flag of an EU Member State shall submit an application[58] to the Commission for inclusion of that ship recycling facility in the

[50] According to reports from Pakistan, more than 400 shipbreaking workers were killed in that county between 1986 and 2006 and 6 000 were seriously injured. Most workers come from the poorest regions, have no qualifications, employment contracts or sickness and accident insurance and are not allowed to organize in trade unions (Opinion of the European Economic and Social Committee on the "Proposal for a Regulation of the European Parliament and of the Council on ship recycling", COM(2012) 118 final – 2012/0055 (COD), Official Journal of the European Union, C 299/158-164, 4 October 2012, p. 160.).

[51] On environmental risks in ship recycling facilities in India see Srinivasa, R. M., Basha, S., Joshi, H.V.; Ramachandraiah, G."Seasonal distribution and contamination levels of total PAHs and heavy metals in coastal waters of the Alang-Sosiya ship scrapping yard, Gulf of Cambay, India", Chemosphere, vol.61, no.11, 2005, pp. 1587-1593.

[52] Jenssen, I., *op.cit*., p. 2.

[53] According to Lloyd's List, Asian scrap yards generated 6.3 billion US$ from beaching in 2012 (Paris, C., Mukherji, B., *op.cit*., p. 3).

[54] Opinion of the European Economic and Social Committee on the "Proposal for a Regulation of the European Parliament and of the Council on ship recycling", *op.cit*., p. 160: A 2004 study by the Commission estimated the amount of hazardous waste at 1 000 to 3 000 tonnes of asbestos, 170 to 540 tonnes of PCBs, 6 000 to 20 000 tonnes of hazardous paints and 400 000 to 1.3 million tonnes of sludge oil per year up to 2015.

[55] *Ibidem*, p. 162.

[56] Jenssen, I., *op.cit*., p. 2.

[57] Ship recycling company means, the owner of the ship recycling facility or any other organisation or person who has assumed the responsibility for the operation of the ship recycling activity from the owner of the ship recycling facility (art.13.3(8) of the *Ship Recycling Regulation*).

[58] Facilities located in third countries will have to apply individually to the Commission for their inclusion in the European List (Mikelis, N. "An analysis of the European Regulation on ship recycling", *op.cit*., p. 4.)

European List (art. 15(1) *Ship Recycling Regulation*).[59] The ship recycling facility located in a third country shall, in particular: a) identify the permit, license or authorisation granted by its competent authorities to conduct the ship recycling and, where relevant, the permit, license or authorisation granted by the competent authorities to all its contractors and sub-contractors directly involved in the process of ship recycling and specify all information referred to in art. 16(2) of the *Ship Recycling Regulation*; b) indicate whether the ship recycling plan will be approved by the competent authority through a tacit or explicit procedure, specifying the review period relating to tacit approval, in accordance with national requirements, where applicable; c) confirm that it will only accept a ship flying the flag of a Member State for recycling in accordance with this Regulation; d) provide evidence that the ship recycling facility is capable of establishing, maintaining and monitoring of the safe-for-hot work[60] and safe-for-entry[61] criteria throughout the ship recycling process (to prevent explosions and accidents amongst workers in ship recycling facilities); e) attach a map of the boundary of the ship recycling facility and the location of the ship recycling operations within it; f) for each hazardous material (asbestos, ozone-depleting substances, polychlorinated biphenyls, perfluorooctane sulfonic acid, anti-fouling compounds and systems)[62] and additional hazardous material which might be part of the structure of a ship, specify: whether the ship recycling facility is authorised to carry out the removal of the hazardous material – where it is so authorised , the relevant personnel authorised to carry out the removal shall be identified and evidence of their competence shall be provided; g) confirm that the company adopted a ship recycling facility plan, talking into account the relevant IMO guidelines; h) provide the information necessary to identify the ship recycling facility.[63] In order to be included in the European List, compliance by ship recycling facilities located in third countries with the requirements set out in art. 13 shall be certified following a site inspection[64] by an independent verifier with appropriate qualifications – art.15(4) of the *Ship Recycling Regulation*. Furthermore, by applying for inclusion in the European List, ship recycling companies accept the possibility of the ship recycling facility concerned being subject to site inspections by the Commission or agents acting on its behalf prior to or after their inclusion in the European List in order to verify compliance with the requirements set out in art. 13 and art. 15(4) of the *Ship Recycling Regulation*.

---

[59] The application shall be accompanied by evidence that the ship recycling facility concerned complies with the requirements set out in art. 13 (art.15(2) *Ship Recycling Regulation)*. See more Weijburg, B., *op.cit*., p. 2.
[60] Safe-for-hot-work means a space in which all of the following criteria are met: a) safe, non-explosive conditions, including gas-free status, exist for the use of electric arc or gas welding equipments, cutting or burning equipment or other forms of naked flame, as well as heating, grinding, or spark-generating operations; b) the safe-for-entry criteria are met; c) existing atmospheric conditions do not change as a result of the hot work; d) all adjacent spaces have been cleaned, rendered inert or treated sufficiently to prevent the start or spread of fire (art.3(1, 19) of the *Ship Recycling Regulation)*.
[61] Safe-for-entry means a space that meets all of the following criteria: a) the oxygen content of the atmosphere and the concentration of flammable vapours are within safe limits; b) any toxic materials in the atmosphere are within permissible concentrations; c) any resideus or materials associated with the work authorised by the competent person will not produce uncontrolled release of toxic materials or an unsafe concentration of flammable vapours under existing atmospheric conditions while maintained as directed (art.3(1,18) *Ship Recycling Regulation)*.
[62] Annex 1 – Control of hazardous materials, p. 18 *Ship Recycling Regulation*.
[63] Art. 15(2) Ship Recycling Regulation.
[64] Site inspections means an inspection of the ship recycling facility assessing whether the conditions on site are consistent with those described in any relevant documentation provided (art.3(2, b) *Ship Recycling Regulation*.

Due to the fact that the whole process of scrapping involves the use of a large workforce instead of heavy machinery and the conditions on a tidal beach make it virtually impossible to employ cranes or scaffolding or to contain oil spills, as a rule, South Asian shipbreaking yards still have no or only rudimentary facilities to deal with the incoming hazardous wastes, in line with the generally poor infrastructure for waste management in the region.[65]

3 CONCLUSIONS

Ships contain many hazardous materials that can have adverse effects on human health, environment and maritime safety. Responsible ship recycling is a global issue of public interest that is environmentally beneficial especially because 90% of world trade is carried by the international shipping industry. The purpose of the *Ship Recycling Regulation* is to direct ships flying the flag of the EU to ship recycling facilities that practice safe and environmentally sound methods of ship dismantling, i.e., facilities that are safe for workers and environmentally sound. Althought the EU ship recycling facilities meet high standards of occupational safety and environmental protection and the majority of coastal recycling facilities in South Asia work with minimal environmental and safety standards causing significant environmental pollution, all ship recycling facilities (in the EU or in third countries) willing to recycle EU flagged ships, which do not meet requirements under the *Ship Recycling Regulation* - should not be included in the European List of approved ship recycling facilities.

The European *Ship Recycling Regulation*, based on and mostly a copy of *HKC*, has some differences which make it stricter. This refers to demanding that ships, flying the flag of an EU Member State, only be recycled in ship recycling facilities that are included in the European List. To be included in the European List, ship recycling facilities must operate from built structures; demonstrate the control of any leakage in order to prevent adverse effects on human health and the environment; handle hazardous materials, and waste generated during the ship recycling process – only on impermeable floors with effective drainage system.[66] Special requirements are demanded of the ship recycling facilities located in a third country (non EU Member States) which want to recycle EU flagged ships and be included in the European List. These ship recycling facilities must comply with additional requirements according to art.15(2) of the *Ship Recycling Regulation*.

The *Ship Recycling Regulation* excludes all ship-breaking yards that rely on the beaching method from the European List. Such a solution can constitute a problem to world's largest market for shipbreaking in South Asia - more than 70% of the global ship recycling industry – which uses the beaching method of ship recycling and is unable to support safety measures (heavy lifting or emergency response equipment). In this case, what has been brought into focus is the insufficient “clean” capacity and environmental standards in world's ship recycling facilities and the fact that the *Ship Recycling Regulation* could have significant effect on decreasing the number of ships registered under EU flag (re-flagging the ship to a non-EU flag).The *Ship Recycling Regulation* has not yet established any measures to prevent ship owners from re-flagging their ships to a non-EU flag prior to sending them for demolition. We can say that the *Ship Recycling Regulation* allows easy circumvention of its

[65] Ormond, T., *op.cit*., p. 54.
[66] See more Gramann, H., *op.cit*., p. 70.

rules, so the questions are: how many ships will the *Ship Recycling Regulation* finally apply to and what is the possibility that *Ship Recycling Regulation* could significantly accelerate the date when the *HKC* becomes the global standard for the recycling of ships.[67] Equally, even though *Ship Recycling Regulation* puts an end to the scrapping of EU flagged ships on South Asia beaches it is questionable how safe and environmentally sound ship recycling capacity is according to the *Ship Recycling Regulation* for ship recycling facilities in the EU and the third countries, and if there is a possibility of them working without causing unnecessary economic hardship. It will also be significant to see how the European Commission will ensure that the ship recycling facilities included in the European List operate in a safe and environmentally sound manner. On the subject of modern ship recycling industry – ship recycling activities must have effective measures which ensure that the ship recycling facilities comply with the *Ship Recycling* – the priority is to clarify the requirements related to the ship recycling facilities and required financial incentives closely related with European List. Finally, the international nature of shipping as the safest and most environmentally benign form of commercial transport and green ship recycling industry require international uniformity of maritime safety and environmentally clean ship recycling regulations.

REFERENCES

[1] Alexopoulos, A.B.”Scrap Activities on the Coastal Zone: Dynamic Model for the Recycling of Ships”, Journal of Shipping and Ocean Engineering, David Publishing Company, no.4, 2014, p. 29.

[2] Cavagnaro, L. “Ship dismantling industry and the new European regulations: an occasion of development or a mere burden on shipowners costs?”, Shipping and Transport Bulletin, February-March 2014, p. 7.

[3] Chiang Chang,Y., Wang, N.; Sabri Durak, O. “Ship recycling and marine pollution”, Marine Pollution Buletin, Elsevier Ltd., no. 60, 2010, pp. 1390-1396.

[4] Demaria, F. “Shipbreaking at Alang-Sosiya (India): An ecological distribution conflict”, Ecological Economics, no. 70, 2010, Elsevier Ltd, pp. 250-260.

[5] Gramann, H. “Hazardous times in Europe?”, HANSA International Maritime Journal, no.8, 2014, pp.70, 71.

[6] Green Paper On better ship dismantling, Commission of the European Communities, 22 May 2007, COM(2007)269 final, available from http://www.minenv.gr/anakyklosi/v.menu/plia/00/GREEN%20PAPER.pdf, pp. 2, 6.-8.

[7] Jenssen, I. “Making Sure the New EU Ship Recycling Regulation Works”, p. 2. (available from http://governmentgazette.eu/?=5822, accessed 10 July 2014).

[8] Luttenberger, A. “Developing the environmental legislation on ship recycling, International Congress Energy and the Environment”, Rijeka, 2008, pp. 207-214.

[9] McCarthy, L. “Ship recycling firmly on 2012 agenda”, Lloyd's List, March 2012, p. 2.

---

[67] According Mikelis, N. “An analysis of the European Regulation on ship recycling”, MIKELIS, N.: An analysis of the European Regulation on ship recycling, p. 1. (available from http://www.gmsinc.net/gims/pdf/2013-11-18_GMS_Tokyo_Conf/The_EU_Regulation_on_ship_recycling.pdf, accessed 3 April 2014): It is very possible that the Ship Recycling Regulation could significantly accelerate the date when the HKC becomes the global standard for regulating the recycling of ships.

[10] Mikelis, N. “A statistical overview of ship recycling”, International Symposium on Maritime Safety, Security & Environmental Protection, Athens, September 2007, pp. 3,4 (available from http://www.imo.org/blast/blastDataHelper.asp?data_id=23449&filename=shiprecycling.pdf, accessed 12 September 2014).

[11] Mikelis, N. “An analysis of the European Regulation on ship recycling”, p. 1. (available from http://www.gmsinc.net/gims/pdf/2013-11-18_GMS_Tokyo_Conf/The_EU_Regulation_on_ship_recycling.pdf, accessed 3 April 2014)

[12] Mikelis, N. “Regulatory, social and commercial considerations on ship recycling”, HANSA International Maritime Journal, 2014., no.9, p. 117.

[13] Mikelis, N. “Ship Recycling markets and the impact of the Hong Kong Convention”, International Conference on Ship Recyclinng, Malmo, 2013, p. 13 (available from http.//www.imo.org/Knowledge Centre/PapersAndArticlesByIMOStaff/DocumentsSHIPREC%202013%Int..).

[14] Neşer, G., Kontas, A., Ünsalan, D., Uluturhan, E., Altay, O., Darilmaz, E., Küçüksezgin, F., Tekoğul, N., Yercan, F. “Heavy metals contamination leveles at the Coast of Aliağa (Turkey) ship recycling zone”, Marine Pollution Bulletin, Elsevier Ltd., no. 64, 2012, pp. 882-887.

[15] Niejenhuis-Rensen, N. “European Regulation on Ship Recycling”, Thesis, Erasmus Universiteit Rotterdam, 2014, pp. 40-41.

[16] NGO Shipbreaking Platform “A principled & practical approach, Making sure the EU Ship Recycling Regulation will be a driver for change”, September 2013 (available from http://www.shipbreakingplatform.org/shipbre_wp2011/wp-content/uploads/2014/02/Policy-Paper-EU-September, accessed 10 July 2014)

[17] Opinion of the European Economic and Social Committee on the “Proposal for a Regulation of the European Parliament and of the Council on ship recycling”, COM(2012) 118 final – 2012/0055 (COD), Official Journal of the European Union, C 299/158-164, 4 October 2012, pp. 160,162.

[18] Ormond, T. “Hong Kong Convention and EU Ship Recycling Regulation: Can they change bad industrial practices soon”?, Environmental Law Network International, Elni Review, no.2, 2012, pp. 54,58.

[19] Paris, C., Mukherji, B. “EU and South Asia Scrap Over Recycling Ships”, pp. 1, 3 (available from http//online.wsj.com/article/SB10001424127887324423904578522982568438250.html, accessed 27 January 2015).

[20] Proposal for a Regulation of the European Parliament and of the Council on Ship Recycling, European Commission, Brussels, COM(2012) 118 final, 2012/0055(COD), 23 March 2012, p. 2.

[21] Regulation (EU) No 1257/2013 of the European Parliament and of the Council of 20 November 2013 on ship recycling and amending Regulation (EC) No 1013/2006 and Directive 2009/16/EC – (Ship Recycling Regulation), Official Journal of the European Union, L 330/1-19, 10.12.2013.

[22] Response submitted jointly by the European Environmental Bureau (EEB) and NGO Shipbreaking Platform to the European Commission questionnaire on the interpretation of requirements found in Regulation 1257/2013 (Ship Recycling Regulation), NGO Shipbreaking Platform, May 2014 (available from

http://www.shipbreakingplatform.org/shipbre_wp2011/wp_content/uploads/2014, accessed 16 December 2014), p. 2.

[23] Ship recycling Practice and regulation today, Lloyd's Register, June 2011 (available from http://www.er.org/en/images/213-35820-ShipRecycling-040711-tem155-223320.pdf, accessed 17 November 2014).

[24] Srinivasa, R. M., Basha, S., Joshi, H.V.; Ramachandraiah, G.”Seasonal distribution and contamination levels of total PAHs and heavy metals in coastal waters of the Alang-Sosiya ship scrapping yard, Gulf of Cambay, India”, Chemosphere, vol.61, no.11, 2005, pp. 1587-1593.

[25] Status of multilateral Conventions and instruments in respect of which the International Maritime Organization or its Secretary-General performs depositary or other functions, IMO, available from: http://www.imo.org/About/Conventions/StatusOfConnventions/Documents/Status%20-%201015.pdf,

[26] The Hong Kong International Convention for the safe and Environmentally Sound Recycling of Ships, 2009 (HKC), available from http://ec.europa.eu/environment/waste/ships/pdf/Convention.pdf, accessed 27 January 2015.

[27] Weijburg, B. “The European Ship Recycling Regulation comes into force”, Green Shipping Bulletin, March 2014 (available from http://www.hfw.com/downloads/HFW-Green-Shipping-Bulletin-March-2014.pdf), p. 2, 3.

THE BETINSKA GAJETA – SUCCESSFUL MULTI-PURPOSE DESIGN SINCE 1745

Tomislav Skračić, MA
University of Split
Faculty of Maritime Studies
Zrinsko-Frankopanska 38, Split, Croatia
tomislav@pfst.hr

ABSTRACT

The paper provides a qualitative and comparative study of the *betinska gajeta*, a Croatian traditional working sailboat. In order to comprehend the boat's essential features, advantages and its role in Croatia's maritime heritage, the analysis embraces an inter-disciplinary approach, taking into consideration the maritime, historical, sociological, and economic aspects that have intensely shaped the design of this vessel. The betinska gajeta, a 6-8 m long half-decked one-masted wooden workboat, is a multi-purpose vessel whose basic form was developed in Betina on Murter Island in 1750s and was modified over the centuries to respond to a number of requirements and challenges. Seaworthy and capable of sailing in any weather, heavy but easy to handle, robust but streamlined, having considerable transport capacity but a shallow draft enabling the approach to any coastal configuration, the betinska gajeta has been used for transport, fishing, recreation and other services, eventually becoming a multi-purpose boat, a recognizable symbol of the identity of Murter Island people and their traditional activities and skills, one of the rare Croatia's traditional boats that is still regularly commissioned and built in the yards of Betina and Murter. Within the context of boatbuilding technique in general, the betinska gajeta presents a universal concept of a sustainable design: in addition to seaworthiness and quality construction, a successful hull design should be multi-functional, adaptable, driven by alternative means of propulsion, truly meeting the needs of the users and broader requirements, including prevailing meteorological and geomorphological features of the sailing area, tradition and socio-economic environment.

Key words: Betinska gajeta, hull design, multi-purpose boat, Croatia's traditional boatbuilding.

1 INTRODUCTION

Betina on Murter Island remains one of the strongholds of Croatia's traditional boatbuilding that has flourished there since 1745 when Paško Filipi came from Korčula Island and, together with his sons, set up a family business and a boatbuilder association. The year of 1745 should be taken as a milestone and not as the year of invention because, at the time, the residents of Betina and Murter had already owned or leased the lands on the surrounding islets and on the mainland, which could be accessed only by sea. Therefore, it would probably be correct to assume that they had boats and mastered sailing technique before the arrival of the Filipis. The features of these vessels remain unknown. It is also not clear which elements of the existing models, which elements of the know-how previously gained in Korčula, and which innovations the Filipi family combined – and to what extent – to create the betinska gajeta, but they eventually managed to produce the design that was exceptionally successful in meeting the diverse requirements and in facing the economic, social, demographic and other changes. As the population of the neighboring islands and coastal towns had similar requirements and needs, the descendants of the Filipi family and their apprentices soon established yards in Šibenik, Biograd, Sukošan, Ugljan and Dugi Otok.

2 HULL DESIGN AND RIGGING

The *betinska gajeta* is typically 6-8 m long, 2-3 m wide, with 1-1.3 m high freeboard and a draft rarely passing half a meter. The boat is constructed and manufactured according to traditional "plank-on-frame" carvel technique.[1] The ribs and keel are made from oak and the planking from oak and pine boards. Her hull is ample and rounded and she has a sharp fore and aft (but not as sharp as in the *guc*), with a flared bow to shed spray. As in other traditional round-bottom vessels, the keel is extremely strong to preserve stability, with a rather broad rudder reaching under it and with the fore stempost extending high over the deck.

Figures 1 and 2: Structural elements of the betinska gajeta

Source: www.fsb.unizg

The boat is designed to sail both in shallow waters and open seas. The forward draft is reduced and the rudder can be lifted to the upper position so that any configuration of shoreline can be approached. The fine under body allows the boat to ride high on the waterline when not carrying cargo, which enables relatively easy rowing and fast sailing – up to 6 knots.[2] When the boat is loaded, it becomes stable and squats onto a wide beam that allows heavy loading without any issues. The entire construction is very robust and able to carry several tons of cargo. The boat is half-decked, with a large open hold amidships and narrow decked corridors running along the sides for easier embarking / disembarking or loading / unloading when berthed alongside, and allowing fast movement of the crew from stern to bow when sailing or fishing. The hold can also be decked with hatch covers if necessary. Originally, the boat carries one mast and one sail with simple standing and running rigging.[3] The lateen rigged sail allows sailing downwind, reaching and sailing close to the

[1] Plank-on-frame construction is, globally, the most traditional method of building wooden boats. Find more about carvel planking method in Birmingham, R.: *Boat Building Techniques*, Adlard Coles Nautical, London, 2005, pp. 62-64, or at http://www.sailfeed.com/2013/01/wood-boat-construction-practical-and-traditional.

[2] As these vessels usually do not carry any instruments showing their speed or position, the speed was assessed empirically by the author of this paper. See also: Skračić, V.: *Kornati s krme od gajete*, Tetrakis, Biblioteka Nautilus, Zagreb, 2005, p. 19; also: http://adriatic-maritime.org/the-kornati-endeavor-agriculture-and-maritime-skills-in-a-remote-archipelago/ (accessed: 2015-01-17)

[3] See detailed description and layout of the betinska gajeta's hull form, construction and rigging in: Bobanac, N.; Salamon, V.: The Betinska Gajeta between the Past and the Future, in *Brodogradnja*, 46/1, Zagreb, 1998, pp. 62-65.

wind. Four fir or beech oars are used as propulsion in port, when the vessel is dismasted or when winds fail.

3 PURPOSE

There is a large family of wooden workboats called *gajeta* that have been used by Croatia's insular and coastal communities, namely *korčulanska gajeta*, *betinska gajeta*, *rapska gajeta*, *gajeta falkuša*, etc., and these vessels are quite often labeled as "fishing" boats.[4] However, such definitions require great care and justice. For instance, the definition serves well the *gajeta falkuša* from Komiža on Vis Island. The falkuša was a special version of the gajeta, a streamlined and fast boat (up to 8 knots) used for long-distance fishing around Vis, Palagruža and other offshore islands. The boat was fitted with *falke*, a special structure running from stem to stern on each side up to half a meter high. When the removable side planking was taken away, the falkuša regained her ordinary form of a long, low vessel with strikingly prolonged fore and aft posts. She was about 8.8-9.8 m long, about 2.5 m wide and could hold about 5.4 tons (90 barrels) of salted fish.[5] Still, since there are no natural havens at the offshore islands, the falkuša's design had to be light and slender enough to allow hauling the boat ashore.

Figure 3: Port of Betina – early 20th century

Source: www.latinskoidro.hr

On the other hand, the betinska gajeta was not a fishing boat – initially, it was a transport boat. By the time Paško Filipi and his four sons moved from Korčula and established boatyards in Betina on the island of Murter, the fields of the island had already become

[4] See for example http://www.enciklopedija.hr (sub voce *gajeta*).
[5] See: Kozličić, M.: *Hrvatsko brodovlje*, Književni krug Split and AGM Zagreb, 1993, pp. 209-211.

insufficient to feed the population and the colonization of the neighboring lands had already started.[6] Residents of Murter and Betina first became owners of Modrave, Makirina and the nearby islands and islets, the so-called Murterski Škoji. As all these properties, whether on the islands or the mainland, could be reached only by sea, the demand for boats was tremendous. For the Filipi family, this might have been the very motive for choosing Betina for developing boatbuilding business. As it has been already pointed out, the Filipis managed to respond to the demands of the time: they designed a boat able to transport workforce and tools to cultivate the newly acquired lands and to bring crops back home.

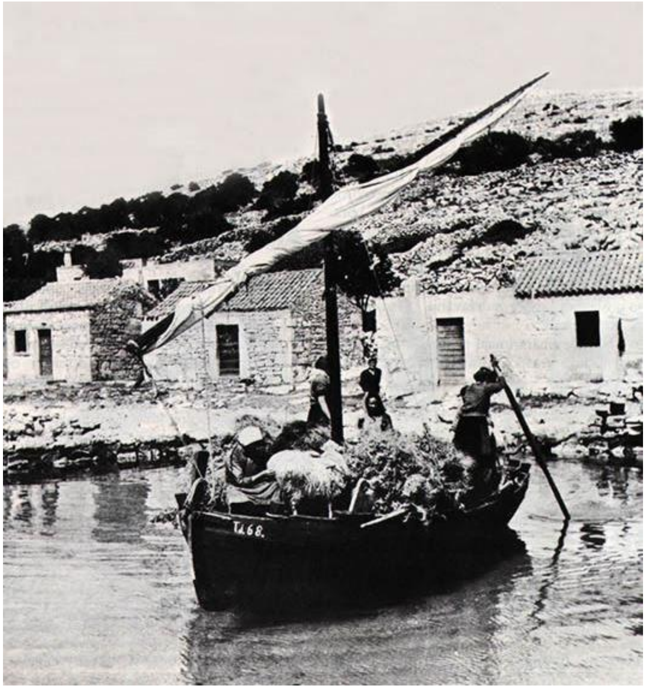


Figure 4: A loaded gajeta at Kornati Islands – early 20th century

Source: www.latinskoidro.hr

Over the next hundred years the betinska gajeta had to meet even more challenging requirements as the residents of the town of Murter and (to a lesser extent) Betina became present in the Kornati archipelago, first as laborers, then leaseholders, and eventually the owners of Kornati Islands.[7] These properties were far away from their home island. The distance ranged from 8 NM (Island of Smokvica) to over 20 NM (Port of Lučica, Island of Kornat) and the boats had to pass the 7 NM wide Murtersko More (the Murter Sea). While this is not a huge distance, like the remoteness of Palagruža, it is an open sea, and can get quite rough for passage. It was, and still is, a hazardous sailing area that does not provide any shelter during summer storms or in the prevailing NE and SE winds during winter. Clearly,

---

[6] 60 residents of the town of Murter died of hunger in just one year in the 18th century. Skračić, V: Glosar, in *Biseri Jadrana – Kornati* (M. Majnarić, ed.), Fabra, Zagreb, 2004, p. 29.

[7] More about the overseas land acquisition in: Juran, K.: Kupnje i diobe, in *Biseri Jadrana – Kornati* (M. Majnarić, ed.), Fabra, Zagreb, 2004, p. 14; Skračić, V.: *Kornati s krme od gajete*, Tetrakis, Biblioteka Nautilus, Zagreb, 2005, p. 16; Ferić, S.: *Murterski otočni brevijar*, Nacionalni park Kornati, Murter, 1999, p. 20.

the boats had to be seaworthy enough to make the passage. Rounded hull and pronounced keel proved to be a valuable asset in terms of stability and safety.[8]

While the betinska gajeta design had to be modified under new circumstances, her basic purpose remained the same – transportation. There are documents confirming this. A list drawn up in 1792 specified the number of fishing boats in the area: 76 in Zlarin, 79 in Prvić, 15 in Betina, only 9 in Murter.[9] Another document, dated 1840, just before the purchase of Kornati Islands, affirmed that fishery in the town of Murter (no records for Betina) was poorly developed and that 138 gajetas owned by the residents were not engaged in fishing.[10] As Murter had around 1100 inhabitants at the time, and given the size of the families, it appears that almost every family had a boat capable of transporting heavy load – people, sheep, goats, donkeys, olives, grapes, figs, sand, stone and other building material – to and from Kornati.[11] But not a fishing boat.

However, the situation changed when the residents of Murter and Betina became owners of all Kornati Islands. Long stays in the remote properties, large families and nutritional value of fish and seafood, forced the new landowners into going fishing and – consequently – into adapting their boats for fishing activities. In addition, the boat had to provide enough space for the fishermen or family members to sleep and rest when necessary. She was also used for leisure and recreation activities. The betinska gajeta became a truly multi-purpose vessel.[12]

4 THE GAJETA, THE BATEL, THE LEUT…

Why was this design dominant in the Šibenik-Zadar archipelago for more than 250 years? The people of inhabited islands in northern Dalmatia – Zlarin, Prvić, Murter, Dugi Otok, Pašman, Ugljan and a dozen others – shared the same issues and needs. Residents of each home island had overseas properties on the neighboring islands and islets. One activity was not enough for survival. Fishing, farming and maintaining overseas lands were not possible without boats. Multi-functional people required multi-functional vessels. Local boatyards responded by producing a series of designs. The *batel*, the *kaić* and the *guc* were easy to handle and ideal for fishing and transport, but were not seaworthy enough to make long passages and cope with heavy seas. A family having only a kaić or a guc had to borrow a gajeta, and this was done reluctantly. The *leut* – a larger, decked version of the gajeta – was perfect for making safe passage across the Murtersko More, and was commonly used for professional fishing, transport, and upkeep of the remote overseas properties, but only wealthy families were able

[8] It is well known that the rounded hull of good design is treated much more kindly by the sea. For this reason naval architects often characterize such hulls as "sea kindly". As John Gardner states, "there is nothing flat or square for surging seas to grab or slam against. Like the seasoned boxer, they "roll with the punches" [...] Only a boat which responds freely, lightly, quickly, and easily to the motion of water can be considered safe. The sea is much too powerful to fight." Gardner, J.: *Building Classic Small Craft*, International Marine / McGraw-Hill, 2004, pp. 2-3.

[9] *Popis ribarskih lađa / List of fishing boats*, 1792. Županović, Š. *Ribarstvo šibenskog područja*, Jadranski institut JAZU, Vol. 6, Zagreb, 1963. Cited in: Skračić, V.: Kurnaska gajeta – sveti brod, in *Čakavska rič* XXXI, No. 1-2, Split, 2003.

[10] Ibid. The document Operato dell'estimo censuario di commune di Morter, dated 22 June 1840.

[11] http://www.betinskagajeta1740.hr (accessed: 2015-01-15)

[12] The designation "multi-purpose" is considered more appropriate than "all-purpose". As John Gardner points out, there is no such thing as the superior, all-purpose boat, "just as there is no such animal as the superior, all-purpose dog." Gardner, *op. cit.*, p. 3.

to afford it. Just around 2 m longer, the leut was almost twice as expensive as the gajeta.[13] Being larger, the leut also required more workforce. If a family was not able to provide the crew, various partnership deals were made. In addition to the leut, wealthy families usually had another boat for small-scale fishing, e.g. a 4-5 m batel.[14] On the other side, the gajeta was robust enough to perform almost all transport tasks and light enough to be used for fishing. Most importantly, it was light enough to be handled – at all times and in any weather – by family crew. Unlike the leut or the falkuša (with its magnificent rigs and complex sail arrangement), the betinska gajeta could be handled by one fit person assisted by one more family member: a child, an old person, a woman. It should be pointed out that women from Murter made excellent deckhands and navigators. Unlike others, people of Murter had no prejudice against women on board. In the times of need, any help was most welcome. Murter women often sailed without their husbands and they did it successfully.[15] All of these are reasons why the gajetas have remained popular in Murter area up to the present time – this design is still dominant in the variety of modern-day activities: transport (cargo, tourists…), fishing, recreation, lateen sail regattas,[16] and the like.

Figure 5: Lateen Sail Regatta – demonstration of seamanship and promotion of maritime heritage

Source: Andrejka Velikonja Skračić

[13] It is tempting to think that a 9 m boat is only 20-30% more expensive than a 7 m boat. “But boats are three dimensional”, forewarns Richard Birmingham, “and an increase in length produces an increase in work (and expense) proportional to the cube of the lengths.” According to his calculation, the ratio would not be 9:7 but $9^3:7^3$ or 729:343. Cf. Birmingham, R.: *Boat Building Techniques*, Adlard Coles Nautical, London, 2005, p. 1.
[14] Skračić, V.: Glosar, in *Biseri Jadrana – Kornati* (M. Majnarić, ed.), Fabra, Zagreb, 2004, p. 23
[15] See a detailed account of the seamanship of Murter women in: Skračić, T., Od sunca do sunca, in *Biseri Jadrana – Kornati* (M. Majnarić, ed.), Fabra, Zagreb, 2004, pp. 182-183; also: Skračić, V.: *Kornati s krme od gajete*, Tetrakis, Biblioteka Nautilus, Zagreb, 2005, p. 40.
[16] http://www.latinskoidro.hr (accessed: 2015-01-21)

5 MODERN CHALLENGES, DILEMMAS AND COMPETITION

Today, the pace of life is fast on Murter Island, many people have steady jobs ashore and do not depend on farming and fishing. Accordingly, boats are less used than before. Modern versions of the traditional designs (gajeta, leut, kaić…) tend to be less ample and more streamlined. They are fitted with 10-20 kW engines and diverse equipment. Many of them are dismasted and some of them carry cabins, even small galleys with a stove and refrigerator.[17] Despite various refinements, the basic design has remained the same. While two oars are kept as standard equipment, the lateen sail is rarely rigged. Still, these alternative means of propulsion are not entirely abandoned – they are precious assets in case of engine failure or lack of fuel. Some aspects of life have not changed much. People of Murter keep on going fishing, for professional or recreational reasons; they still own Modrave, Kornati and other properties. Indeed, certain traditional activities have been largely abandoned (wine production, tending sheep…), but some of less time-consuming activities have survived (olive groves), and new ones have appeared over the past several decades (tourism). And Murtersko More still presents a challenge.

Consequently, unlike the *falkuša*, *bracera* and some other old-style designs, the boats traditionally produced in Murter and Betina, especially the gajetas, have survived. They are regularly commissioned, built and used. True, the betinska gajeta is no longer the pivot around which the family life and economic relationships used to be structured, but she has endured the test of time and has become the keystone of identity and the synonym for material and non-material maritime heritage.[18]

At the same time, new designs have been developed with the aim of responding to the demands of the modern-day men. Over the last several decades, a number of boatbuilders, both along the Croatia's coast and in the hinterland, have produced fiberglass 6-8 m boats with excellent characteristics. Galeb 675, for instance, has probably been the most successful fiberglass workboat over the past thirty years; popular boats include Betina 700, Nerezine 630, along with dozens of others.[19] As is the case with traditional wooden designs, most of them are designed and advertised as multi-purpose vessels, suitable for fishing, recreation, family trips and transfer of tourists. Most of them have powerful propulsion units (30 to 120 kW) and semi-displacement hulls, allowing them to make up to 7 knots in displacement mode and around 15 knots in planing mode. This represents a huge advantage. The 20 NM distance from Murter to the most remote properties can be now reached in 90 minutes instead of 3-4 hours. In addition to saving time, this means that shorter periods of fair weather can be used

[17] http://www.betinskagajeta1740.hr (accessed: 2015-01-15)

[18] In addition to family and socio-economic relationships, the gajeta and other traditional designs heavily affected the development of arts and crafts, employment and demographic stability, as well as the infrastructure of Murter and Kornati ports. See: Skračić, V.: "Kurnaska gajeta – sveti brod", in: Čakavska rič XXXI, No. 1-2, Split, 2003. As for identity and preservation of maritime heritage, Murter primary school now owns a 6.5 m gajeta named *Kurnatarica* for education purposes and participation in regattas and maritime heritage festivals. Meticulously researched by scholars and built in Betina by Ante Fržop, the boat represents a historically accurate prototype of the betinska gajeta. The Murter Lateen Sail Regatta has been held since 1998. Each September, over 70 gajetas, leuts and other boats fitted with lateen sails take part in this event that has fostered cultural awareness across the local population and has attracted enthusiasts from all over the Croatian Adriatic.

[19] Galeb 675 (hull length: 6.75 m) is produced by Arausa Nova d.o.o. Vodice (http://www.gull.hr/proizvod.htm), Betina 700 (hull length: 7.08 m) is produced by Manikela d.o.o. Split (http://www.manikela.hr), Nerezine 630 (hull length: 6.25 m) is produced by Yacht service Milenović in Mali Lošinj (http://www.nerezineplovila.com).

for sailing, e.g. around noon when the gusts of the NE bura are less strong. Needless to say, this is very important for modern-day boaters who are expected to be at work on Monday morning and for the transfer of tourists who rent cottages, advertised as "fishermen's houses", at Kornati National Park. There are over a hundred of cottages for rent and the transfers from and to Kornati must be completed on Saturdays, when the tourists arrive and leave, which means that a boat has to sail across the Murtersko More at least twice a day. To make the passage safe and comfortable, it is equipped with lights and instruments for navigation at night. Also, such a boat is usually fitted with heads, a galley and two or three berths under the cabin which provides not only comfort but also shelter from spray and rain. Standard equipment includes double commands (in the cabin and at the stern), electric windlass, stainless steel rails, grab-rails, stern platform, etc. Compared to the gajeta, the modern fully-equipped boat is less dependent on weather conditions and can be exploited throughout the day and throughout the year.

On the other side, these fiberglass workboats have a number of shortcomings, especially when taking into consideration the requirements of the people in Murter area and Zadar-Šibenik archipelago. Here are some of them:

- reduced transport capacity: the capacity is limited to 6-8 persons, i.e. 800-1000 kg;
- reduced working space, the superstructure and general layout make these boats useless in some forms of fishing (nets, pots) that are important in this area;
- reduced maneuverability: light structure, less pronounced keel and smaller rudder result in steering difficulties, especially in beam and following seas (yawing), in confined waters such as ports, or when going astern. Also, air resistance of the superstructure causes significant leeway;
- without sails and oars, these boats are helpless in the event of engine failure, unless they carry an auxiliary outboard engine;
- the price of a fully-equipped semi-displacement boat ranges from 30,000 to 50,000 euro, whereas a new fully-equipped gajeta can be commissioned for less than 25,000 euro to be paid in installments, as agreed with the boatbuilder (the above figures do not include VAT).

Having considered basic advantages and disadvantages of competitive modern designs, it is obvious that they do not represent a threat to boat-building tradition in Murter and Betina.[20] A typical present-day resident of Murter – or any other island in the Zadar-Šibenik area – is usually engaged in modern and traditional activities and combines new and old ways, as both are essential for his/her survival and identity. The structure of his/her socio-economic life is very complex and such a situation requires a boat which is truly multi-functional, reliable, easy to handle, fast and affordable. Clearly, it will take some time to harmonize these requirements and produce an optimum vessel that would be competitive with traditional designs.

[20] The ratio of residents to vessels shows a considerable dependence and demand for traditional and modern vessels of all types in Murter-Betina area: according to the Harbormaster's Office Šibenik – branch office Murter, there were 957 boats (213 fishing boats and 744 other boats) registered in Murter and Betina in 1999. In 2001, according to the Croatian Bureau of Statistics, there were 2,842 permanent residents in these two towns on Murter Island (2,068 in Murter and 774 in Betina). Hence the ratio is approximately 3 persons / 1 boat.

6 CONCLUSION

The purpose of this inter-disciplinary study has been to examine the maritime, historical, sociological, and economic background that explains why the betinska gajeta has been one of the most successful designs in Croatia's history of boatbuilding. The analysis has also underlined the gajeta's essential comparative advantages over the other traditional and modern boats. Generally speaking, the betinska gajeta provides a concept to be carefully explored by anyone aspiring to create a successful multi-purpose craft.

Along with the leut, the guc, the kaić, and the batel, the betinska gajeta is a representative of art and craftsmanship of the traditional boatbuilding that has flourished on the island of Murter since 18th century. The betinska gajeta is a round-bottom vessel made of oak, typically 6-8 m in length, half-decked, originally fitted with one mast, one lateen rigged sail, and four oars. Seaworthy enough to sail long distance in almost all weathers, heavy but easy to handle, robust but streamlined, having considerable transport capacity but a shallow draft enabling the approach to any coastal configuration, the betinska gajeta has been used for transport, fishing, recreation and other services, eventually becoming a multi-functional vessel, a brand, a recognizable symbol of the identity of Murter Island people and their traditional activities and skills. Over the time her basic design and layout has remained the same, but the boat has been constantly enhanced and adapted to the circumstances that have affected the activities, priorities, needs, standard and life-style of the residents of Murter Island. The betinska gajeta is one of the rare Croatia's traditional boats that is still regularly commissioned and built, despite modern challenges, abandonment of traditional activities, development of new activities such as tourism, introduction of new materials and technologies, global crisis, and fiberglass competition.

Within the context of boatbuilding technique in general, the betinska gajeta presents a universal concept of a sustainable design. Any boatbuilder, wishing to create a successful modern wooden or fiberglass multi-purpose workboat that would endure the test of time, should approach the project in a multi-disciplinary way and take into consideration a number of maritime and anthropological aspects: such a boat should be seaworthy, reliable, adaptable, affordable, driven by alternative means of propulsion, truly meeting the needs and priorities of the users, as well as fulfilling broader requirements, such as prevailing meteorological and geomorphological features of the sailing area, tradition and socio-economic environment.

Figure 6: *Kurnatarica* – prototype of the betinska gajeta built for education and raising awareness of the importance of tradition and identity

Source: Author

REFERENCES

[1] Birmingham, R. (2005). *Boat Building Techniques*, London: Adlard Coles Nautical.

[2] Bobanac, N., & Salamon, V. (1998). The Betinska Gajeta between the Past and the Future. *Brodogradnja*, 46/1, Zagreb, Croatia, 62-65.

[3] Ferić, S. (1999). Murterski otočni brevijar / Murter's insular breviary. Murter: Nacionalni park Kornati.

[4] Gardner, J. (2004). *Building Classic Small Craft*, International Marine / McGraw-Hill.

[5] Juran, K. (2004). Kupnje i diobe / Acquisitions and divisions. In M. Majnarić (Ed.), *Biseri Jadrana – Kornati / Pearls of the Adriatic – the Kornati Islands* (No. 6/II, pp. 12-17). Zagreb: Fabra.

[6] Kozličić, M. (1993). *Hrvatsko brodovlje / Croatian Shipping.* Književni krug Split and AGM Zagreb (pp. 209-213).

[7] Skračić, T. (2004). Od sunca do sunca / From sunrise to sunrise. In M. Majnarić (Ed.), *Biseri Jadrana – Kornati / Pearls of the Adriatic – the Kornati Islands* (No. 6/II, pp. 180-184). Zagreb: Fabra.

[8] Skračić, V. (2003). Kurnaska gajeta – sveti brod / The Kornati Gajeta – A Holy Boat. *Čakavska rič*, Vol. XXXI, No. 1-2, Split, Croatia.

[9] Skračić, V. (2004). Glosar / Glossary. In M. Majnarić (Ed.), *Biseri Jadrana – Kornati / Pearls of the Adriatic – the Kornati Islands* (No. 6/II, pp. 19-42). Zagreb: Fabra.

[10] Skračić, V. & Bašić, N. (2004). Kolonija Kornati / The colony of Kornati. *Murterski godišnjak*, No. 1, 89-133.

[11] Skračić, V. (2005). Kornati s krme od gajete / Kornati Islands from the gajeta's stern. Zagreb: Tetrakis, Biblioteka Nautilus.

[12] Županović, Š. (1963). Ribarstvo šibenskog područja / Fishery in Šibenik area. Zagreb: Jadranski institut JAZU (Vol. 6).

[13] Bender, J. (2014). The Kornati Endeavor – Agriculture and Maritime Skills in a Remote Archipelago, Adriatic Maritime Institute. At http://adriatic-maritime.org/the-kornati-endeavor-agriculture-and-maritime-skills-in-a-remote-archipelago/ (accessed: 2015-01-17).

[14] www.betinskagajeta1740.hr (2014-11-15)

[15] www.gull.hr/proizvod.htm (2015-01-17)

[16] www.latinskoidro.hr (2015-01-21)

[17] www.manikela.hr (2015-01-17)

[18] www.nerezineplovila.com (2015-01-17)

[19] www.sailfeed.com/2013/01/wood-boat-construction-practical-and-traditional (2015-04-04)

IMPORTANCE OF PORT, FLOATING AND SHIP CRANES IN MARITIME TRANSPORTATION

Tatjana Stanivuk, PhD
University of Split
Faculty of Maritime Studies
Zrinsko-Frankopanska 38, Split, Croatia
stanivu@pfst.hr

Ivana Zore, MEng
Milan Simić
Brodosplit Shipyard
Put Supavla 21, Split, Croatia
ivana.zore@brodosplit.hr, milan.simic@brodosplit.hr

ABSTRACT

Loading capacity of cranes determines the efficiency of each port. Due to the lifting capacity as well as the time necessary for loading and unloading of cargo in port, commercial aspect of cargo transport is defined. The paper discusses three main types of cranes used in maritime transport: port cranes, floating cranes and ship cranes. The first part of the paper presents the main characteristics of port and floating cranes, including comparison with regard to their capacity and type of cargo for several major European ports. Afterward, vessel cargo cranes with specific focus on regulations for lifting appliances by classification societies will be explained. In conclusion, the comparison of all three types of cranes from the aspects of loading, transportation time and costs will be presented.

Key words: Port cranes, floating cranes, ship cranes, maritime transportation, port transport.

1 INTRODUCTION

This paper discusses general features of port cranes, with particular attention paid to their operative capacities and their role in the efficiency of ports. With regard to their mobility, the stationary and floating port cranes are discussed separately. The construction characteristics are described considering the two most common types of handled cargo – containers and bulk cargo. The examples and comparisons are presented with reference to major European ports and their trends: the sources of information include the port statistics of the three largest European ports – Rotterdam, Antwerp and Hamburg – for the period 2005-2013.

The first part of the paper focuses on stationary port cranes, providing essential characteristics and categorization regarding two types of cargo: bulk cargo and containers. Construction features are described using the example of “Grande Tukan 3000”, the crane that was built and delivered by the shipyard Brodosplit, Croatia, in 2014. This class of crane has been used for presenting the multi-purpose application of port cranes. The discussion also includes a brief account of large gantry container cranes intended exclusively for handling containers at container terminals, along with the description of basic characteristics of the very terminals.

The second part of the paper deals with technical and technological capacities of floating cranes. In addition to general categorization with reference to their purpose, two basic floating crane concepts have been described: fundamental features and operation concept of the floating cranes specially designed for unloading containers, i.e. floating gantry cranes, and mobile cranes available on today's market, variations of their use and operation range. Given the increasing trend of cargo containerization, particularly in European ports, there is a need of faster transshipment in the future. The introduction of floating cranes employed in these services implies an increase in transportation cost-effectiveness and greater port capacities, because the turn-round and cargo-handling time is reduced, as is reduced the load on quayside cranes at the same time.

The last part of the paper discusses the heavy-lift vessels. Indeed, their primary function is transportation and secondary function is cargo handling. The primary section is lost without secondary section. Considering the risk involved in these operations, the paper presents an overview of requirements laid out by the classification societies for cargo handling operations performed by such vessels, as well as requirements for the accommodation and transport of this type of cargo. Finally, the comparative advantages and optimal use of all three crane types are presented in the conclusion.

2 PORT CRANES

Cranes are mobile or static facilities designed to lift, lower and carry cargo. There are a number of crane types (construction, harbor, floating, self-erecting, overhead, jib, gantry, crawler cranes etc.). Regarding the type of cargo they handle, this paper is particularly focused on container cranes and bulk cargo cranes, whereas with regard to their mobility, the following chapters discuss stationary, mobile and floating cranes.

2.1 Stationary port cranes

2.1.1 Features of the bulk handling port cranes and their trends

Bulk cargo terminals are defined by their transport capacity, surrounding infrastructure, capacities of warehouses and storage yards, depending on a terminal's purpose. Characteristics of cranes and warehouses mainly depend on the type of cargo that a terminal handles: coal, iron ore, phosphates, cement, corn or other bulk goods. Here it is important to point out that terminals may be either loading or discharging and are rarely designed to have the double function, handling both operations. This considerably affects the type and technical features of their cranes and transportation facilities.

Loading of bulk cargo on a ship is most often carried out by conveyor belts, grabs and various funnel equipment. On the other hand, discharging of ships is performed by mobile port cranes, mainly low-capacity slewing-platform grabbers.

Figure 1: Bulk handling harbor crane

Source: LHM Mobile Harbor Crane brochure [8]

Mobile slewing cranes (Figure 1) are primarily used in small ports, whereas large ports are equipped with gantry cranes with grabbers having a capacity of 1600 t/h and with ship unloaders whose capacity ranges up to 3000 t/h. [1,8]

Basic characteristics of portal slewing port cranes can be illustrated by “Grande Tukan 3000”, built by the shipyard Brodosplit (Split, Croatia) in 2014 for the Ukrainian port of Yuzhny [5]. The characteristics of this crane are as follows:

- Lifting speed at full load: 64 m/min (1);
- Lifting speed without load: 90 m/min (1);
- Boom lifting (luffing) speed: 40 m/min and 60 m/min (2);
- Slewing speed: 1.0 rpm – 1.6 rpm (3);
- Crane travel speed: 20 m/min and 40 m/min (4).

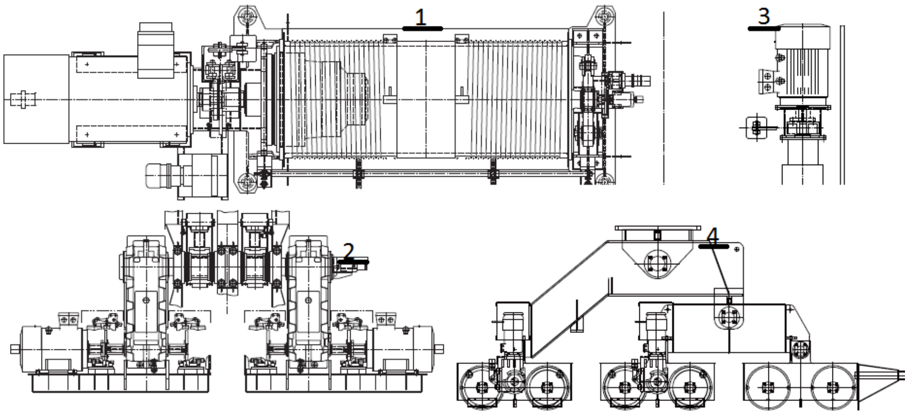


Figure 2: Drive components of the crane “Grande Tukan 3000”

Source: Ardelte technical description [6]

The crane has a maximum capacity of 63 t and a maximum outreach of 50 m. It consists of the steel travelling gear, portal slewing gear, large-diameter tubular tower with hoisting gear, and associated components including staircase, elevator, cabin and adequate installations.

The crane can handle bulk cargo and containers. When grabbing bulk cargo, it is possible to perform lifting, slewing and travelling simultaneously, which results in high efficiency of the facility. Grabs are controlled by the crane operator and sensors in order to avoid overload. Fuel consumption has been reduced to a minimum due to advanced hydraulic system. The damper system reduces and almost entirely absorbs the shocks occurring due to slewing or swaying during grabbing operation.

Cranes of the Tukan series are multi-purpose cranes suitable for handling bulk goods with all types of grabs, for general cargo handling using load hooks and special load attachment equipment such as coil or slab tongs, magnets, and for container transshipment by means of spreaders. [6]

Table 1: Capabilities of the Grande Tukan series when unloading bulk cargo

BULK CARRIER	ship size [dwt]	ship width [m]	hatch width [m]	Required outreach [m]	CRANE TYPE
SAIMAX	2,000 – 4,000	12,6	5,7	9,1	750 - 27
HANDYSIZE	15,000 – 35,000	27	12,1	19,5	750 - 27
SEAWAYMAX	40,000 – 50,000	24	10,8	17,4	750 - 27
HANDYMAX	50,000 – 60,000	30	13,5	21,8	1500 - 32
PANAMAX	60,000 – 75,000	32,3	14,5	23,4	1500 - 35
POST-PANAMAX	75,000 – 85,000	38	17,1	27,6	1500 - 40
POST-PANAMAX	75,000 – 85,000	38	17,1	27,6	1500 - 40
POST-PANAMAX	75,000 – 85,000	38	17,1	27,6	1500 - 40
JAPANMAX	80,000 – 85,000	50	22,5	36,3	3000 - 50
					3000 - 63

Source: Ardelte Technical description [6]

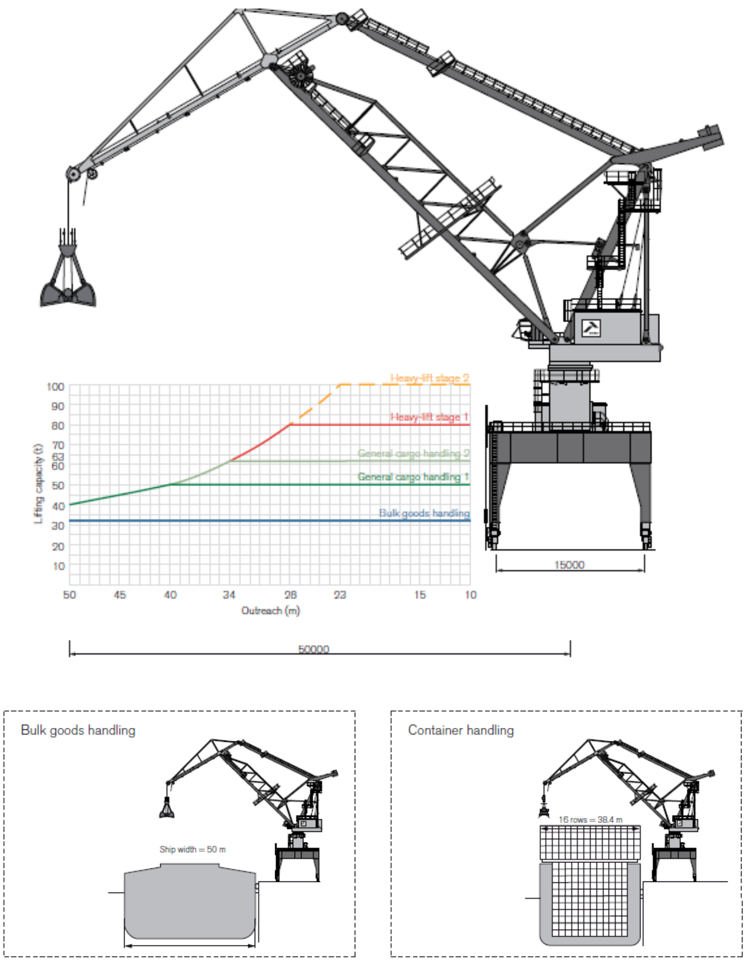


Figure 3: Outreach, lifting height and capacity of the "Grande Tukan 3000"

Source: Ardelte technical description [6]

Bulk carriers dominate the world merchant fleet with a share of almost 42% dwt. The trend is likely to continue, given the fact that 57% of all new commissioned ships belong to this category. The greatest exporters of bulk goods include Australia and Brazil, while the greatest importers are China and Europe. Large amounts of coal are transported from Australia, mainly to China, and iron ore is mostly exported by Brazil and imported by European countries. These operations clearly require efficient port infrastructure, capable of accommodation and transshipment of these goods. Figure 4 shows the volume of bulk cargo transport by type of goods in one of Europe's largest ports – Antwerp. [4]

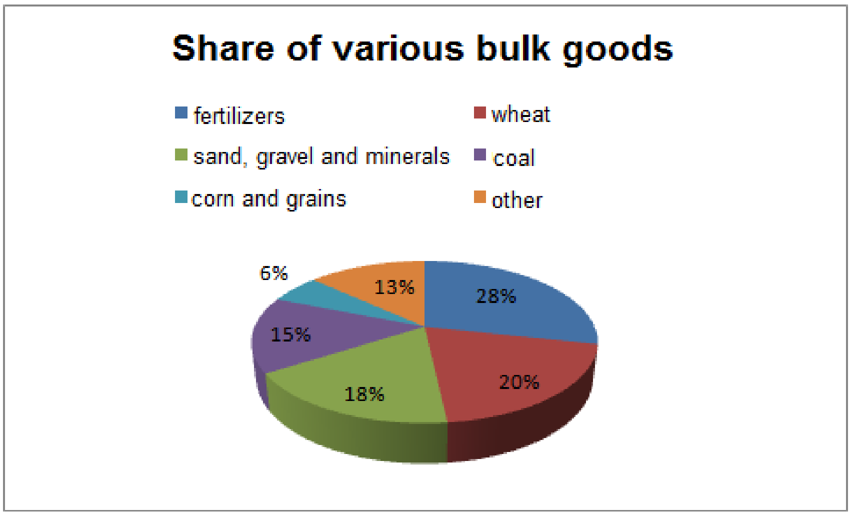


Figure 4: Share of various bulk goods in 2013 – Port of Antwerp

Source: Port statistics [4]

2.1.2 Characteristics of container handling port cranes and their trends

The container terminal is a part of the port dedicated for loading and unloading containers, as well as for storing containers in the event of change of transportation mode. Intensive containerization started in the 1950s and has been on the increase ever since, due to cost-effectiveness of this type of transportation. As the volume of the containerized cargo increases, ports and vessels follow the general trend. The demand for containers ships has been steadily growing over the decades and so have the investments in the port infrastructure. [4]

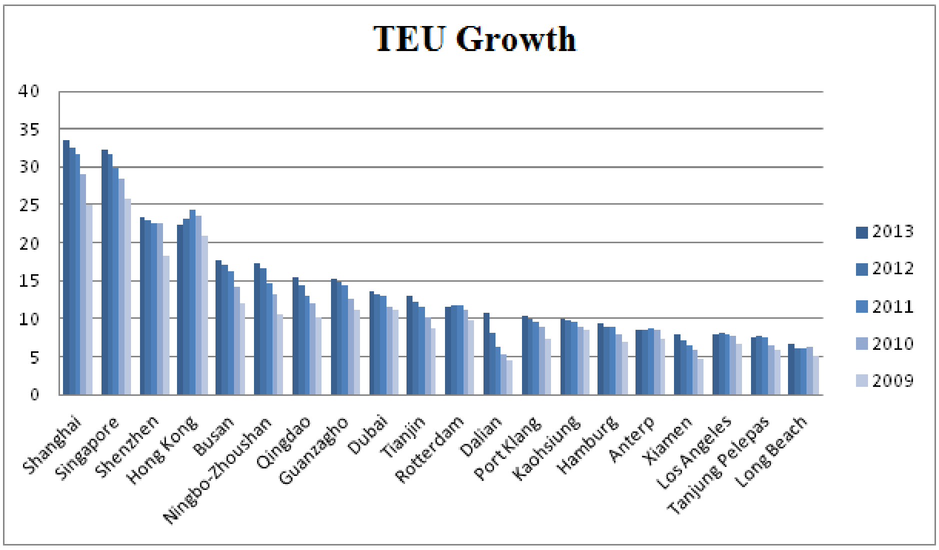


Figure 5: Growth of container transport from 2009 to 2013

Source: (http://europe.nxtbook.com/nxteu/informa/ci_top100ports2014/#/6)

Apart from the position, which is not a variable factor, the efficiency of a port predominantly depends on the cargo handling speed and this is directly related to the port's cargo handling capacities, including cranes. Figure 6 presents a scheme of the terminal for loading and discharging containers in the port of Busan in South Korea, showing how the terminal functions. The terminal features a two-way accommodation area (loading or unloading), a yard for storing containers, and the outlet which is also a two-way facility, serving maritime and land transport modes.

Cargo handling consists of several basic operations that employ various cargo handling equipment, depending on the means of transport. The equipment may include:

- Specialized container cranes (portainers);
- Transtainers;
- Wide reach portal carriers;
- Floating cranes.

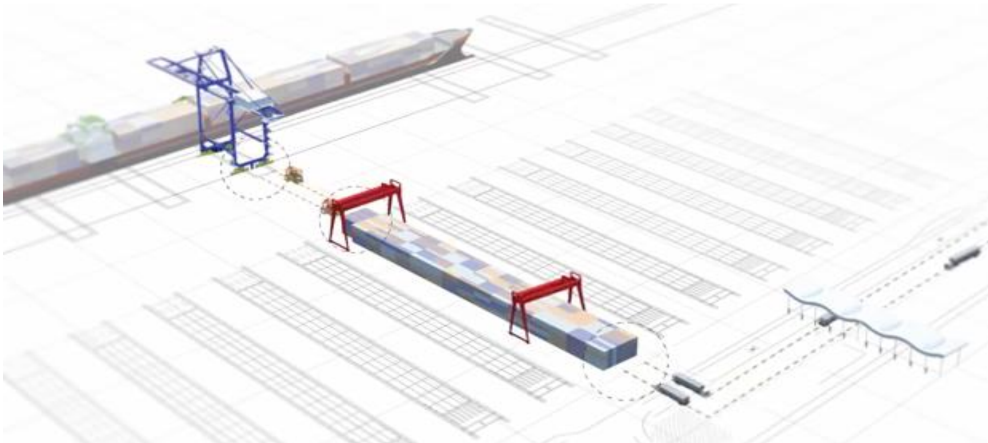


Figure 6: Layout of the container transshipment terminal in Busan, South Korea

Source: Busan Port Authority

Container cranes belong to the group of gantry cranes. Gantry cranes, also referred to as bridge cranes, have a robust construction consisted of strong girders supporting the framework that can travel along the quay on wheels or a rail track, and are able to carry containers as well as cargoes having large weight and size. A classic container crane has a console inside the frame (between the girders) featuring jibs or booms – horizontal components overhanging the crane that extend the hoisting systems as far out as possible, over the full beam of a ship and, on the opposite side, over the quay and a part of the storage yard. The hoisting system is a device moving along the jib, which uses cables, winches and pulleys to lift and move containers. Instead of a grab or a hook, the hoisting system is fitted with a spreader that can be lowered on the top of a container and locked onto the container's four locking points, using a twist-lock mechanism. Cranes normally transport a single container at a time, but some newer cranes are able to handle two to four TEU (20-foot) containers at once. As it has been pointed out above, the entire construction moves along the running track, on rails or on tires, serving the full length of a ship (and a part of the quay).

Figure 7: Super-Post-Panamax cranes in the Port of Rotterdam

Source: Rotterdam Port Authority [5]

Figure 7 shows a typical container handling gantry crane. Serving the container terminal in Rotterdam, the crane has an overhang of 50 m, reaching over 22 rows of containers. This type of crane is exclusively designed to handle containers and is suitable only for container terminals. All major ports accommodating a large number of container ships are equipped with these cranes that enable fast transshipment of cargo. These cranes are not cost-effective in smaller ports where containers are handled by portal slewing cranes which are multi-functional but slower. [1, 5]

2.2 Floating port cranes

Floating cranes have a wide range of applicability. They are commonly used to handle cargo in ports but can also be used for installing offshore structures. Transport operations of floating cranes can be divided into these areas:

- Port and port waters (ship/ship and ship/shore);
- Rivers (serving barges);
- Offshore and inshore (supply of ships at anchor).

Floating cranes have been increasingly used when transferring cargo from one vessel to another. In this mode of transport, they most frequently unload cargo from a ship and load it onto barges. Costs of cargo handling operation are considerably reduced as the ship's berth dues, harbor dues and demurrage are reduced. The transshipment from vessel to vessel is fast and it is well known that the barge transport is one of the cheapest modes of transport.

The role of floating cranes is essential in places where port cranes are overloaded, as well as in harbors and coastal waters with limited or inexistent port infrastructure. The following chapter discusses the most frequent operations where floating cranes are engaged.

2.2.1 Transshipment of cargo using floating cranes

Transshipment of cargo may heavily depend on floating cranes. Cargo is discharged from large merchant ships – usually bulk carriers or container ships – directly into barges or other vessels, and is conveyed further on, without having any direct contact with the quay. Naturally, cargo may move in the opposite direction: barges may carry coal or iron ore via inland waterways and rivers. Upon reaching a seaport, floating cranes are used to transfer cargo onto a bulk carrier. The ship resumes her voyage without using port cranes. [8]

As there are more and more container ships in the world merchant fleet, the use of floating cranes becomes increasingly important in container handling operations. Given the growth of the containerized transport, the trend is to serve as many ships as possible, as fast as possible. The existing port capacities often do not allow that, i.e. ships spend too much time in port, thus increasing operation costs considerably. Currently, floating cranes are used to transfer containers onto the terminal. However, in the long run, there will be a need for the full use of floating cranes in container unloading operations. The concept of the interim discharge of containers from ships to barges-terminals, using floating cranes, has been under consideration. In this way, port capacities would be relieved and port dues would be decreased (Figure 8).

In the ports having limited or busy port crane capacities, floating cranes are used to unload cargo onto the shore. They are also used in places where port cranes do not have sufficient outreach or where shallow waters impede berthing. [8,9]

Floating cranes can work even far out on the open sea, as far as 30 km off the coast, at wind speeds of up to 24 m/s and wave heights of up to 2.5 m. This is rather important when handling cargo from the ship onto barges. The ship does not have to enter the port and use port cranes. Even if the ship is only partially unloaded, floating cranes considerably relieve port facilities by handling part of the cargo while the ship is at anchor. Finally, as it has been mentioned above, floating cranes can be used in inshore waters for mounting and equipping offshore structures. [8]

Figure 8: Floating cranes handle cargo in ports with few quay facilities

Source: Terex Gottwald floating cranes

2.2.2 Technical characteristics of floating cranes

If floating cranes are used for dealing with the increased containerized cargo traffic and for relieving the stationary port cranes, it is necessary to define the requirements in the design stage. A floating crane capable of serving a container ship has to meet the following requirements:

- Outreach of the boom over the full beam of the ship;
- Draft that allows performance in port waters;
- Own propulsion system and ability of positioning alongside the ship;
- Particular requirements, such as the union purchase system when serving two barges, or the automated operation, etc.

2.2.3 Floating cranes designed to handle containers

Floating cranes that are designed to handle containers consist of:

- Deep-sea gantry crane;
- Barge crane;
- Pedestal;
- Pontoon / barge with propulsion and mooring systems.

The design of the gantry part of the container handling crane is similar to any other type of the shore-based bridge crane intended for handling containers. The only difference concerns the pedestal on which the gantry crane is mounted and the reduced span between girders. The pedestal is an essential element of the construction. It is modified to serve this specific purpose. Floating cranes require good maneuvering performance that allows them to operate between ships and barges. Therefore, they are equipped with a number of propellers, i.e. thrusters. Each pontoon is fitted with a thruster, enabling the crane to come alongside a ship or a barge and to be moored and moved as required by means of warping winches. The facility is equipped with an automation system which controls the draft, stability and load of the crane. [8, 9]

These days it is possible to find modular designs of floating cranes that can be mounted on the pontoons and barges, as well as on the quayside wheels or rails. These cranes are suitable for various transport operations:

- ship-to-ship handling,
- ship-to-shore handling,
- transport on rivers (up to 30 km inland),
- transport operations in ports, rivers and confined waters,
- transport operations in coastal and offshore waters,
- handling bulk goods, containers and general cargo.

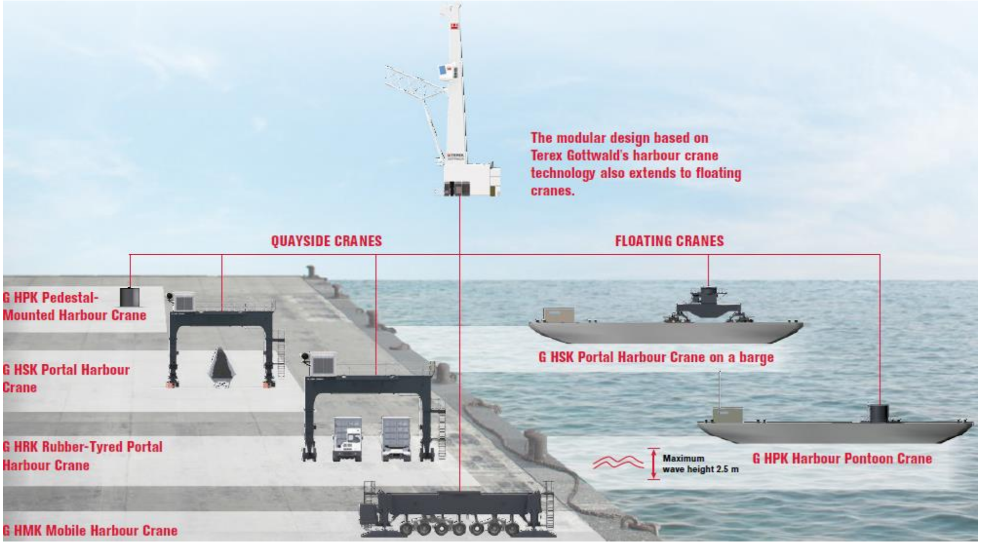


Figure 9: Mobile portal cranes can be mounted on barges and pontoons

Source: Terex Gottwald floating cranes

In the short term, the introduction of such a crane would be quite costly, due to inevitable modification of rails, quay and investment in barges. Yet, in the long run, the crane would prove to be a cost-effective solution as it enables a wide range of operations and includes a variety of vessels and terminals the crane can serve. Such cranes are particularly cost-effective in smaller ports, i.e. in ports and terminals that are not specialized for one trade or one type of vessels.

Given the growing containerization of goods, it is expected that the demand for container ships will grow too. Accordingly, ports and terminals will have to adjust in order to efficiently handle the increasing fleet of container ships. A large share of containerized cargo is handled by European ports, especially by the three largest ports: Rotterdam, Antwerp and Hamburg. It is expected that these ports will experience even greater workload in the near future. [4,5]

There have been a number of studies dealing with enhancing the efficiency of container terminals. It has been concluded that the transport is cheapest if a terminal or a port is in the vicinity of a river or an inland waterway so that containers can resume their voyage on barges. However, the problem of the ship’s turn-round time remains, as the cargo has to be transferred from or onto the barges. Port infrastructure has to be adjusted to withstand increased loads, i.e. it is necessary to make considerable investment in portainers and transtainers in order to reduce the ship’s stay in the port. Floating cranes that handle ship-barge-ship operations can increase port efficiency, allowing the port’s stationary cranes and quay infrastructure to deal with the remaining cargo handling tasks.

Table 2: Port statistics for 2005

	ANTWERP	ROTTERDAM
TRANSPORT	6.488.029 TEU	9.286.756 TEU
Road	60%	60%
River	33%	31%
Railway	7%	9%

Source: Port statistics of Antwerp & Rotterdam [4,5]

When unloading containers from ships, the goal is to reduce the number of crane operations. In the above mentioned large ports, unloading is performed simultaneously by a number of cranes, with due attention paid to the ship's stability. In spite of using several cranes at the same time, there are container rows that may remain out of reach. If this is the case, containers can be conveniently reached by floating cranes from the other side of the ship. Calculations made by Delft University (Floating cranes for container handling, October 2008), have proved that floating cranes can reduce the ship's unloading time by up to 12%, or they can relieve the load on stationary quayside cranes by up to 12%, depending on the size of containers and the outreach of the quayside cranes. Here it is important to point out that this reduction cannot be accomplished by adding more quayside cranes as this is not possible in terms of available space and functionality. Cargo handling efficiency can be only improved by investing in larger stationary cranes, which is undoubtedly a more expensive solution and represents an investment that is more risky than purchasing and maintaining floating cranes. Therefore it can be concluded that combined operation of floating and quayside cranes, that handle the flow of containers between ships and barges, is the most cost-effective solution for the ports situated at the mouth of a river or at the entrance to the waterways.

3 SHIP CRANES

Ship cranes mostly refer to barge cranes and heavy-lift vessels. As the barge cranes have been already discussed within the context of floating cranes, this chapter focuses on heavy-lift vessels, their types and specific characteristics and essential regulations laid out by the classification societies with regard to heavy cargo operations. The transport of heavy cargo refers to cargo units over 10.000 kN. They include voluminous and massive cargoes such as oil rigs and their elements, port cranes, ship engines, various steel constructions etc. It is worth noting that, unlike cranes which operate within port areas, these special-purpose vessels are employed both for transport and handling the cargo. [2]

Heavy-lift ships are sophisticated vessels. To begin with, the construction of such vessels is a very demanding process because these vessels are exposed to extreme loads and risks. They have heavy-lift cranes and hulls, decks and holds able to withstand high loads. They also feature large deck area for accommodating cargo, vertically adjustable freeboard, advanced maneuverability (DP system), high-capacity ballast pumps, anti-heeling system, pontoon stabilizing system, etc. [2]

Considering the way they load cargo, there are three options:

- RO/RO (Roll on/Roll off);
- FLO/FLO (Float on/Float off);
- LO/LO (Lift on/Lift off). [2]

The first heavy-lift ships were LO/LO vessels. These days, they are mainly employed for transporting and installing offshore structures. They carry two cranes on each side and are equipped with the system of double stabilization while lifting their cargo: the anti-heeling system and pontoon stabilization system. The largest companies engaged in heavy-load LO/LO operations include SAL, Hansa and Jumbo Shipping. The shipyard Brodosplit from Croatia delivered a heavy-lift ship to Jumbo Shipping Company in 2014 (Figure 10). The vessel's characteristics are shown in Table 3.

Table 3: The Jumbo Kinetic, principal dimensions and characteristics [5]

LOA = 152.60 m
LBP = 141.70 m
B = 27.40 m
T = 8.10 m
Volume of holds = 21.000 m^3
Main deck hatches 9 PCS
Twin deck hatches 13 PCS
Lifting capacity = 9600 t at T = 7.0 m
Cranes: HLMC (Heavy Lift Mast Cranes) HUISMAN 1300 MT at the outreach of 25.0 m

Source: Brodosplit Technical Specification NB 473 [7]

The vessel is fitted with the anti-heeling system having the capacity of 3700 t/h. The main propulsion system consists of two 4500 kW at 750 rpm main engines, two CPP propellers, one 1500 kW bow thruster and a possibility of installing another thruster in the event of switching to DP2. [7]

When making a transportation deal, it is necessary to perform several actions beforehand, the most important being the calculation of risk, designing the loading procedure and the safety assessment. [2]

Figure 10: Mounting of cranes on the Jumbo Kinetic

Source: Brodosplit Shipyard Ltd.

With regard to the type of cargo, classification societies divide heavy cargoes into eight categories. They differ in the ways the cargo is packed and the availability of eyes or rings for transport. Shifting of weight results in the change in stability, especially when lifting the cargo vertically. Then the weight of the cargo may overpass the top of the crane. As the center of gravity of the cargo changes, so does the center of the gravity of the vessel and she heels. Unless the loading operation is accurately calculated, the vessel may capsize due to loss of stability. When inspecting the cranes and the supporting equipment, the classification societies make sure that the system is in compliance with:

- Safety Of Life At Sea (SOLAS) 1974;
- International Maritime Organization (IMO) LSA Code;
- IMO Maritime Safety Committee (MCS);

- Individual requirements of the state whose flag the vessel flies. [3]

Generally speaking, inspections carried out by classification societies are related to granting specific certificates and classification. The classification is obligatory and includes the classification of an entire heavy-lift vessel, crane barges, etc.

During the annual inspection, it is necessary to produce the register of the lifting equipment and devices, certificates for the rigging and the associated equipment, comments made after the previous inspection, maintenance book, plan of the replacement of individual components, as well as the general plan, block diagram and waybill. The inspection of ship cranes includes the examination of loose gear, ropes, protection and limitation devices, winches, brakes and drums, built-in sheave units, hydraulic cylinders and pins, jibs, jib heel pins, slewing columns and machinery deck, slew bearings and bolts, pedestal and foundations. [3]

4 CONCLUSION

The operation principles and the characteristics of two basic types of marine cranes are essential in maritime transportation: the primary purpose of port cranes is to handle cargo within port areas, whereas the ship cranes are engaged in accommodating cargo to be transported by the ship and in performing offshore installation tasks. The chapter dealing with port cranes discusses two basic sub-types: stationary (or quayside) port cranes and mobile floating cranes. When analyzing general technical features and capacities of these cranes, it can be concluded that:

According to the data gathered from three major European ports – Rotterdam, Antwerp and Hamburg for the period 2005-2013 – the transport of containerized cargo has been growing and there is an increased demand for specialized cranes for handling containers. When taking large ports into consideration, large specialized container gantry cranes appear to be the most cost-efficient option. These cranes are specifically intended for unloading containers. However, given the forecasts for the next 20 years, present capacities are not sufficient and the existing container terminals require modernization and improvement. One of the possible solutions is the introduction of specialized floating cranes for unloading containers onto barges that would take the cargo further inland or serve as a temporary storage area for containers. The basic concept and features of these facilities have been discussed in the chapter dealing with floating cranes.

In smaller European ports, the transport of bulk cargo is still the most common type of cargo operation. Conventional portal slewing cranes remain the ideal solution for handling bulk cargo. One of such cranes was built in Brodosplit shipyard and delivered to the Ukrainian port of Yuzhny in 2014. It is a classic example of a multi-purpose portal crane. Its basic technical characteristics and range has been presented above in this paper. Bulk cargo can be also handled by floating cranes. However, this is not economical except in special circumstances when, for instance, a ship does not enter the port but waits for the floating crane to meet her at anchor to unload cargo into barges.

As for ship cranes that include crane barges, it is perhaps best to discuss them along with floating cranes. Therefore, the last chapter of this paper rather focuses on the exploitation and essential features of heavy-lift ships. These vessels are not used to handle cargo within port areas but to transport heavy units. The Jumbo Kinetic has served as an example. The ship was built by Brodosplit shipyard and delivered to the Dutch shipping company Jumbo Shipping in 2014. Due to the weight of the cargo and the complexity of operation, the heavy-lift ship lifts, positions and carries her cargo by herself. This type of transportation belongs to the class of risky and complex maritime operations, so that the requirements of classification societies, flag states and other auditors are exceptionally complex and thorough.

REFERENCES

[1] House, D. J. (2005). Cargo Work for Maritime Operations. 7th Edition.

[2] Voorn, F. V. (1970). Semi-submersible Heavy-lift ships in operation Langhaar.

[3] LR (November 2011). Survey and Examination of Ships' Lifting Appliances – available at: http://www.webstore.lr.org/products/293-pocket-guide-no2-survey-and-examination-of-ships-lifting-appliances.aspx

[4] Antwerp port Authorty (February 2015) Maritime cargo turnover - 2000 – 2014

[5] Port of Rotterdam (June 2014) Port statistics 2011 – 2012 – 2013

[6] Brodosplit Shipyard (2014). Technical Specification Ardelte Crane,

[7] Brodosplit Shipyard (2013). Technical Specification NB 473

[8] Terexportsolution (August 2014). Technical specification – mobile cranes

[9] Liebher Floating Cranes (2014). Chatalog of producer available at http://www.liebherr.com/MCM/en-GB/products_mcm.wfw/id-11556-0

TECHNOLOGICALLY ADVANCED EVACUATION MODELS AND THEIR INFLUENCE ON THE RISK ANALYSES DURING ACCIDENTS IN LNG TERMINAL

Goran Stanković, PhD Student
Stojan Petelin, D.Sc.
University of Ljubljana
Faculty for Maritime Studies and Transport
Pot pomorščakov 4, 6320 Portorož, Slovenia
gstankovicg@yahoo.com

ABSTRACT

The evacuation of people located in different safety zones of an LNG terminal is a complex problem considering that the accidents involving LNG are very hazardous and post the biggest threat to the safety of the people located near the LNG leakage. The safety risk criteria define the parameters which one LNG terminal should meet in terms of safety. Those criteria also contain an evacuation as an evasive action with the objective to mitigate the influence of the LNG accident on the people at risk. Till date, not a lot of attention has been paid to technologically advanced evacuations intended for LNG terminals. Creating the technologically advanced evacuation influences directly on the decrease of the probability of fatalities $P_{f,i}$, thus influencing the calculation of the individual risk as well as the societal risk which results in the positioning of the F-N curve in the acceptable part of the ALARP zone. The aim of the paper is to present the technologically advanced evacuation model and the difference between the safety analyses in cases when conservative data for $P_{f,i}$ is being used while calculating the risk, and in cases when real data for $P_{f,i}$ is been used.

Key words: Evacuation model, LNG terminal, risk analysis.

1 INTRODUCTION

With the ever increasing need of energy in the world, the use of LNG is also increasing. The potential LNG accident with a terminal is potentially very hazardous event. The on time evacuation of people is such situations, despite the complexity of such operation, is of crucial importance and significance. Due to this, the safety analyses include the evacuation as a factor for mitigation of the consequences from the accident. Vanem [1] have made analyses of accidents with LNG tankers where the risk models include evacuation and success levels of the evacuation. Tanabe and Miyake [2] have focused their research on the influences on the risk reduction concept on the basis of design criteria for emergency systems for LNG plants. The need for development of structural measures for disaster risk reduction, which also includes the evacuation, indicates that special attention should be paid to this type of evasive actions which was not the case so far in terms of the LNG terminals. The multi-year progress of the hazard warning systems is described by Sorensen [3] indicating the lack of researches of evacuations to safe harbours as protective action. The creation of safety evacuation route which is active at the moment of the accident and the fast dissemination to the people for evacuation is essential for eliminating the consequences.

Through the following considerations, we want to present and give significance to the advanced evacuation models, during their incorporation into the safety analyses.

2 EVACUATION

The conservative approach during the application of the risk analyses in case of an accident involving LNG leakage and dispersion of the gas, provides a certain assumption that the consequences on the people nearby the accident may be different i.e. smaller that previously presumed. This is not just due to the uncertainties in modelling incident outcomes or modelling limitations that may lead to conservative assumptions and results, but also due to certain factors such as topography, physical obstruction, but especially die to the evasive actions taken by people.

Some of the possible evasive actions are evacuation, escape, sheltering, heroic medical treatment. Evacuation is a way of increasing the distance between the population and a hazard, and is the counter measure to toxic chemical releases. The term evacuation also describes the extraction of persons from a specific area because of a real or anticipated threat or hazard.

In the last decade the warning process and response, organizational response, behaviour in evacuations, evacuation planning and management has been more in focus than had been the case in the past. The stress has been on the quality of information, the timing of message delivery and the compliance with warnings.

While analysing the evasive actions, when an LNG accident is in question, a conclusion was reached that the evacuations managed by advanced technology at the same time influence the escape as an evasive action. Due to this, the terms evacuation and escape in this case may be merged and titled as escape with technologically advanced evacuation.

Due to the issue with the inability to select i.e. identify an escape direction to safe harbor, the probability of escape, during a sudden release of LNG from a LNG vessel, is very low. Prugh, (1985) [4] shows the effectiveness of the evacuation obtained as a function of the warning time, area to be evacuated, and the density of population. This chart may be used to identify the efficiency of the evacuation for various large scale releases, including LNG releases, where sheltering at the location is less desirable. Escape with technologically advanced evacuation was developed during our previous research [4]. The same uses QRA (Quantitative risk analysis to create a database and to obtain experiences for the specific LNG terminal and its environment, with the objective to set the logic used by the managing computer device which uses Fuzzy logic in the process of determination (in real time) of the fastest and safest evacuation route for an individual. This model of advanced evacuation which falls under the previously indicated escape with technologically advanced evacuation, plays a certain part in the successfulness of the evacuation, expressed through the decrease of the percentage of individuals which have not been evacuated i.e. increase of the percentage of successful escapes. This directly reflects on $P^{f,i}$ (Probability of fatality) resulting in its decrease.

3 PROBABILITY OF FATALITY

With the objective to simplify the process of calculation of the individual and social risk, the value referring to the Probability of fatality, is set at 0 or 1. In reality, the Probability of fatality, being graphically presented, is in a form of a curve. For comparison, it is shown in the following Figure 1. If we are to exclude the conservative approach of determination of the Probability of fatality, the same varies depending on the remoteness of the accident and its influence, with a value ranging between 0 and 1. Probability of fatality in a situation where we have technologically advanced evacuation model, is in direct correlation with the difference between the time needed for the individual to reach the safety zone and the time needed for the impact of the accident to reach the final foreseen limit or point. The greater the difference is, the greater the probability for the individual to reach the safety zone, without being impacted by the accident. Adequately, the value of the Probability of fatality is decreasing. Figure 2 shows the location of the accident with the LNG leakage, the standardized location of work of the employees in the terminal as well as a safe area in which the impact of the accident is brought to a zero.

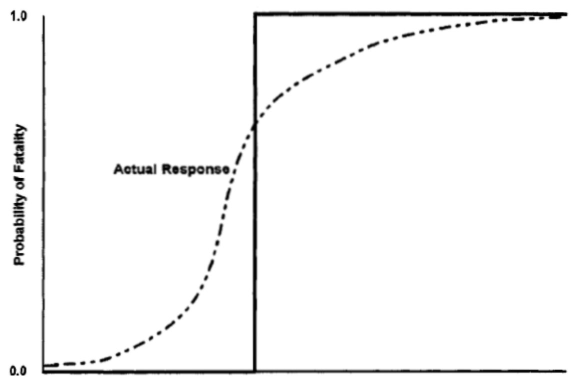


Figure 1: Probability of fatality

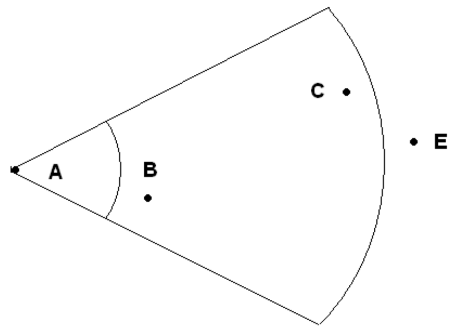


Figure 2: Accident, Employees and Safe area

Point A represents the location of the accident. Probability of fatality in the zone of Point A has a value of 1. Points B and C represent accurately determined locations of the employees in the LNG terminal, where the value for the Probability of fatality for these two points would ranges between 0 and 1 (under a conservative approach of determination of the Probability of fatality, the zone in which are located points B and C would have a value of 1). Point E represents the target or the objective to be reached and the same is located in an area where the impact of the accident equals 0. The individuals located in Point B are at a distance of 550 meters from the accident, while from Point E, the individuals are at a distance of 1200 meters. The individuals located in Point C are at a distance of 1300 meters from the accident i.e. 450 meters from Point E. After the accident occurs and the alarm goes off, the employees in the terminal as well as the automatic safety systems perform all emergency safety measures and the Escape begins with technologically advanced evacuation. The individual located at Point B is to cover 1200 meters in order to reach the safety area in Point E. The usual travelling speed of an individual is 4 meters/s. Having in mind the previous, in approximately 300 seconds the individual will reach Point E. On the other hand, the impact of the accident is nearing the Point B. In compliance with the previously executed QRA, it was concluded that in approximately 200 seconds Point B will be affected. The individual travelling from Point B will reach the safe zone in a total of 300 seconds, while the impact of the accident will reach the final point of around 1600 meters in a total of 500 seconds. Considering this, the calculation shows that the individual has a safe time of around 200 seconds. The greater this safe time is, the smaller the value for Probability of fatality. For comparison, the individuals from Point C will reach Point E in approximately 120 seconds. Compared with the time for the accident impact to reach 1600 meters which is 500 seconds, the calculation indicates 380 seconds of safe time. Also, the Probability of fatality will have smaller value in reference to the individuals located at Point B. This dependency of the Probability of fatality on the safe time as an example is shown in Figure 3. This manner of determining the Probability of fatality enables identification of a more realistic value of the Probability of fatality, in reference to the conservative principle, having the values 0 or 1.

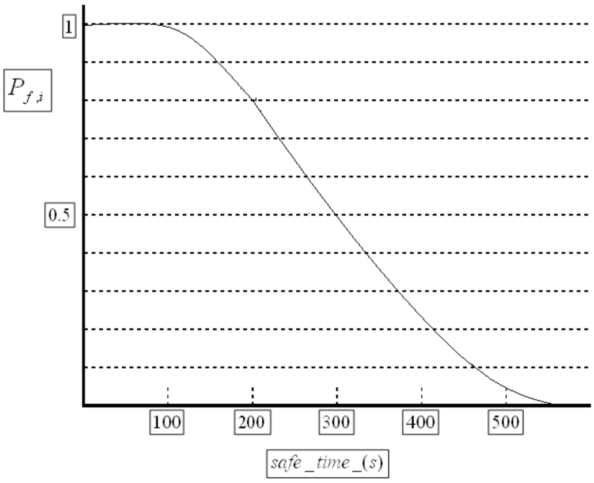


Figure 3: Dependency of the Probability of fatality on the safe time

The use of technologically advanced evacuation model represents a guarantee that these time calculations and differences are applicable in real/actual cases. This will influence the previously stated time difference i.e. the decrease of the Probability of fatality. Consequently, all of this will also influence the Individual Risk but also the Societal Risk by causing the F-N curve to have a more acceptable positioning in the ALARP zone.

All of this enables the technologically advanced evacuation model to be widely accepted as an Evasive action i.e. to be used with the objective of mitigation of the consequences from the accidents.

4 RISK CALCULATION

The objective of conducting the QRA is to identify the potential impact of the LNG leakage accident on the workers in the terminal as well as on the population near the terminal. Risk calculations include calculations of Individual Risk and Societal Risk.

4.1 Individual risk

Individual risk is the frequency at which an individual may be expected to sustain a given level of harm from exposure to specified hazards. The calculation of IR at a location near a LNG plant, or inside the LNG plant assumes that the contribution of all incident outcome cases are additive. The total IR at each point is equal to the sum of the individual risks at that point, of all incident outcome cases associated with the plant [5] (CPQRA, 4.4 risk calculation).

$$IR_{x,y} = \sum_{i=1}^{n} IR_{x,y,i} \tag{1}$$

where $$IR_{x,y,i} = f_i \cdot P_{f,i} \tag{2}$$

(f_i - Frequency of incident outcome case i)
($P_{f,i}$ - Probability of fatality for case i)

4.2 Societal risk

Societal risk is the relationship between the frequency and the number of people suffering from a specified level of harm in a given population from the exposure to specified hazards. A common form of Societal risk is an F-N curve (frequency – number), and it is a plot of cumulative frequency versus number of fatalities [5] (CPQRA, 4.4 risk calculation).

$$N_i = \sum_{x,y} P_{x,y} \cdot P_{f,i} \tag{3}$$

(N_i - Number of fatalities resulting from incident outcome)
($P_{x,y}$ - Number of people at the location x, y)
($P_{f,i}$ - Probability of fatality)

$$F_N = \sum_i F_i \tag{4}$$

for all incidents outcome case i for which $N_i \geq N$

(F_n - Frequency of all incident outcome cases affecting N or more people)
(F_i - Frequency of incident outcome case i)

5 EXAMPLE RISK CALCULATION PROBLEM

We shall review the model of LNG terminal, in a situation of accident on a moored LNG tanker with leakage of LNG over the water. The LNG leakage accident is considered to be a consequence of intentional breach.

The area around the accident according to SANDIA [6], may be divided in three impact zones: Zone 1 is a distance up to 500m from the accident in which the Probability of fatality for all present individuals is 1. Zone 2 is a distance ranging from 500 to 1600 from the accident. In this case we will review two options for interpretation of the Probability of fatality (Case I – 1 or 0; Case II – values between 0 and 1). Zone 3 is a distance greater than 1600 m from the center of the accident, where the Probability of fatality will be set with a value of 0.

The risk calculation will be applied to a very simple example, with the goal to make the calculations easily comparable, and we will present a calculation of IR and SR under the simplest scenario in which the evacuation is not incorporated into the calculations. We will also present a calculation of the IR and SR with incorporated advanced evacuation with real/actual approach of determination of $P_{f,i}$.

5.1 Case I – The evacuation is not included in the calculation

The following simple problem illustrates the risk calculation techniques, using highly simplified frequency and consequence data. It should be emphasized that the risk assessment is been conducted for a LNG terminal at a time of an accident on an LNG carrier during a process of offloading. We shall use highly simplified results for frequency, probability, and consequence and effect estimation.

This example calculation applies the following conditions:

- All hazards originate at a single point;
- The atmospheric stability class and wind speed are always the same. Half of the time wind blows from the south and half of the time from the north;
- The people are located inside the LNG terminal. Their locations will be presented later in the example;
- The probability of fatality from a hazardous incident at a particular location is: for Case I (either 0 or 1).

The incident outcome from the accident of the LNG carrier is release of the LNG onto the water. We are using the Event tree logic model to determine additional possible outcomes (Figure 4). For this example, only two outcomes are assumed to occur. If the formed vapour cloud from the released LNG ignites, there is a Pool fire. If the formed vapour cloud does not ignite, the result is a vapour cloud downwind dispersion from the release point.

Very simple impact zone (Figure 5) estimates for the identified incident outcome cases will be defined:

- Incident outcome case IA (pool fire) - the pool fire is centred at the centre point of the LNG carrier. All persons within 500 metres of the pool fire centre are killed (probability of fatality = 1). All persons beyond this distance are unaffected (probability of fatality = 0).
- Incident outcome cases IB1 and IB2 (LNG vapour cloud dispersion) – all persons in pie shaped (90 degrees) segment of radius of 1600 metres downwind are killed (probability of fatality = 1). All persons outside this area are unaffected (probability of fatality = 0).

5.1.1 Frequency analysis

For this example, it is assumed that the frequency for the Incident is $3*10^{-5}$ events per year and the ignition probability is around 33%. Previously, we have mentioned that 50% of the time the wind blows towards north, while 50% of the time the wind blows towards the south. Figure 4 shows the Frequency estimates for the example incident.

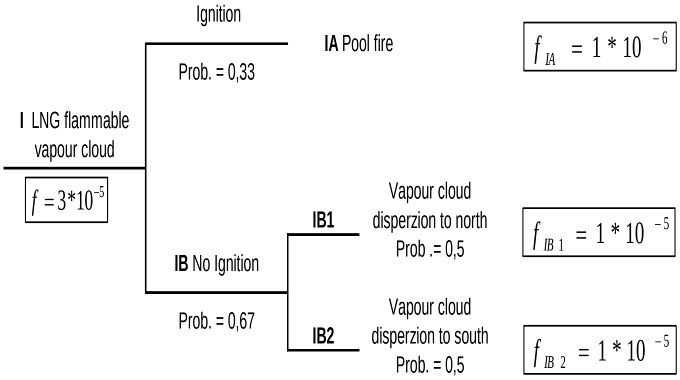


Figure 4: Event tree and Frequency estimates for the example incident.

5.1.2 Individual risk estimation

The example that we are processing is set in a way to provide simple calculations. Hence, in the zones where $P_{f,i}=1$, $IR_{x,y,i}$ equals the frequency of that incident outcome case. Outside the impact zone, $IR_{x,y,i}$ is zero. Figure 5 shows the impact zones from the incident. Figure 6 shows the number and location of people in the area surrounding the LNG terminal. The total individual risk of fatality at each geographical area is determined by adding the IR from all incident outcome case impact zones that impact that area (Table 1).

Table 1: Individual risk of fatality (Case I)

Area	Incident outcome case	fi (per year)	Pfi	IRi (per year)
A	IA IB1	$1*10^{-6}$ $1*10^{-5}$	1 1	$1*10^{-6}$ $1*10^{-5}$ $\sum IR_i = 1.1*10^{-5}$
B	IA IB2	$1*10^{-6}$ $1*10^{-5}$	1 1	$1*10^{-6}$ $1*10^{-5}$ $\sum IR_i = 1.1*10^{-5}$
C	IB1	$1*10^{-5}$	1	$1*10^{-5}$ $\sum IR_i = 1*10^{-5}$
D	IB2	$1*10^{-5}$	1	$1*10^{-5}$ $\sum IR_i = 1*10^{-5}$
E	IA	$1*10^{-6}$	1	$1*10^{-6}$ $\sum IR_i = 1*10^{-6}$
F	IA	$1*10^{-6}$	1	$1*10^{-6}$ $\sum IR_i = 1*10^{-6}$

Table 4: Individual risk of fatality (Case II)

Area	Incident outcome case	fi (per year)	Pfi	IRi (per year)
A	IA IB1	$1*10^{-6}$ $1*10^{-5}$	1 0,57	$1*10^{-6}$ $5.7*10^{-6}$ $\sum IR_i = 6.7*10^{-6}$
B	IA IB2	$1*10^{-6}$ $1*10^{-5}$	1 0,6	$1*10^{-6}$ $6*10^{-6}$ $\sum IR_i = 7*10^{-6}$
C	IB1	$1*10^{-5}$	0,57	$5.7*10^{-6}$ $\sum IR_i = 5.7*10^{-6}$
D	IB2	$1*10^{-5}$	0,6	$6*10^{-6}$ $\sum IR_i = 6*10^{-6}$
E	IA	$1*10^{-6}$	1	$1*10^{-6}$ $\sum IR_i = 1*10^{-6}$
F	IA	$1*10^{-6}$	1	$1*10^{-6}$ $\sum IR_i = 1*10^{-6}$

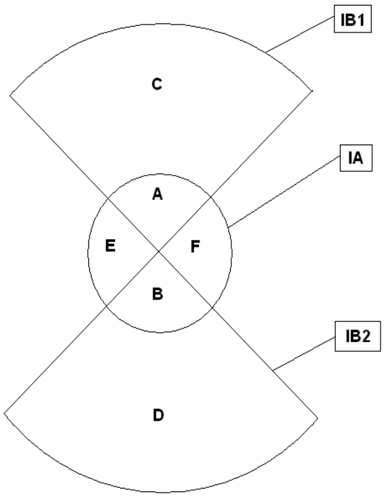


Figure 5: Impact zones

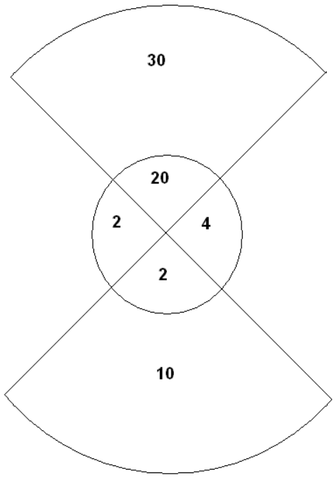


Figure 6: Num. and location of people Case I

The maximum IR is the highest value of IR at any geographical area.

5.1.3 Societal risk estimation

The first step while generating the F-H curve is to calculate the number of fatalities as a result of every incident outcome case (Table 2). The next (Table 3) summarizes the cumulative frequency results. Those data are plotted to obtain the societal risk F-N curve (Figure 7).

Table 2: Estimated number of fatalities

Incident outcome case	Frequency per year	Estimaten number of fatalities
IA	$\boxed{1*10^{-6}}$	28
IB1	$\boxed{1*10^{-5}}$	50
IB2	$\boxed{1*10^{-5}}$	12

Table 3: Cumulative frequency results

Estimaten number of fatalities	Incident outcome case	Total frequency per year
12+	IA, IB1, IB2	$\boxed{2.1*10^{-5}}$
28+	IA, IB1	$\boxed{1.1*10^{-5}}$
50+	IB1	$\boxed{1*10^{-5}}$
>50+	none	0

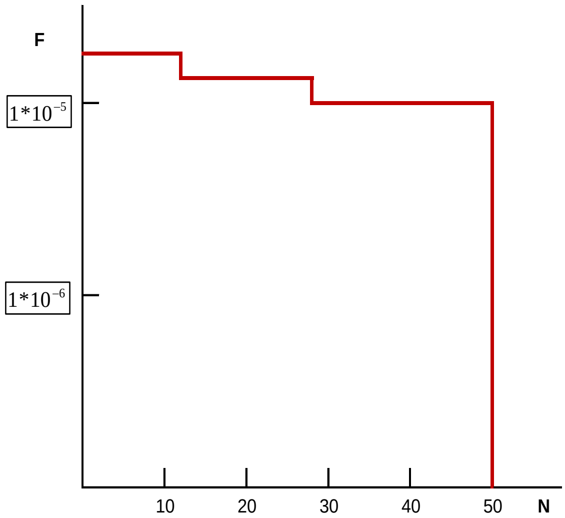


Figure 7: F-N curve for Case I

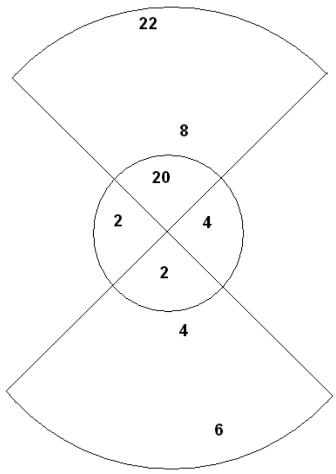


Figure 8: Num. and location of people Case II

5.2 Case II – Advanced evacuation with actual access of determination of $P_{f,i}$.

In Case II we use the same sample problem as in Case I and apply the same conditions, with a note that for the probability of fatality from a hazardous incident at a particular location we will use data for Case II (between 0 and 1).

We are using the same Event tree logic model to determine additional possible outcomes (Figure 4).

Very simple impact zone (Figure 5) estimates for the identified incident outcome cases will be defined:

- Incident outcome case IA (pool fire) - the pool fire is centred at the centre point of the LNG carrier. All persons within 500 metres of the pool fire centre are killed (probability of fatality = 1). All persons beyond this distance are unaffected (probability of fatality = 0).
- Incident outcome cases IB1 and IB2 (LNG vapour cloud dispersion) – all persons in pies shaped (90 degrees) segment of radius 1600 metres downwind are killed (probability of fatality = between 0 and 1). All persons outside this area are unaffected (probability of fatality = 0).

The Frequency analysis remains the same (Figure 4).

5.2.1 Individual risk estimation

The total individual risk of fatality at each geographical area is determined by adding the IR from all incident outcome case impact zones that impact that area (Table 4). Figure 8 shows the number and location of people in the area surrounding the LNG terminal.

The maximum IR is the highest value of IR at any geographical area. The final value of the Probability of fatality for IB1 is obtained as mid value of the Probability of fatality for all locations from IB1 where people are located. The individual Probability of fatality for the people in IB1 and IB2 are determined in Figure 3.

5.2.2 Societal risk estimation

While generating the F-H curve, we calculate the number of fatalities as a result of every incident outcome case (Table 5), and summarizes the cumulative frequency results (Table 6). Those data are plotted to obtain the societal risk F-N curve (Figure 9)

Table 5: Estimated number of fatalities

Incident outcome case	Frequency per year	Estimaten number of fatalities
IA	$1*10^{-6}$	28
IB1	$1*10^{-5}$	37
IB2	$1*10^{-5}$	8

Table 6: Cumulative frequency results

Estimaten number of fatalities	Incident outcome case	Total frequency per year
8+	IA, IB1, IB2	$2.1*10^{-5}$
28+	IA, IB1	$1.1*10^{-5}$
37+	IB1	$1*10^{-5}$
>37+	none	0

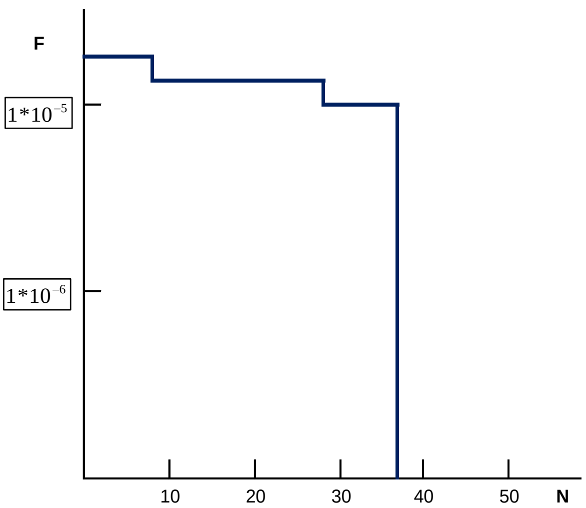


Figure 9: F-N curve for Case II

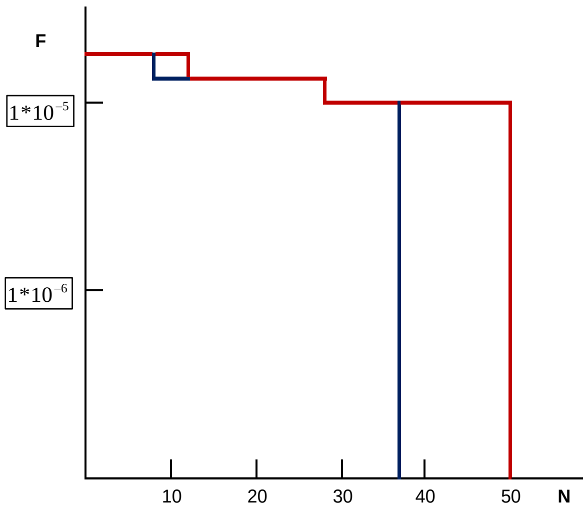


Figure 10: F-N curves for Case I and Case II

The objective of the development and the use of the technologically advanced evacuation model is the dislocation of the people from hazardous areas to safe harbors. The successful dislocation is expressed through presentation of the realistic or actual value of the Probability of fatality (between 0 and 1). The influence on the F-N curve can be seen in Figure 10 (F-N curves for Case I and Case II), where the F-N curve for Case II has more acceptable positioning in the F-N area than in Case I.

6 CONCLUSION

The development of the technologically advanced evacuation model aimed for people in and outside the LNG terminals, which could be used in situations of LNG leakage accidents, provides the possibility to eliminate the potential errors during the selection of the evacuation routes by an individual or a group of people. In addition, the creation of the evacuation route which is considered the shortest and the safest one, at the same time influences the decrease of the Probability of fatality, which additionally influences the decrease of IR and SR. The difference during the use of the Probability of fatality with a conservative approach during the determination of the value (0 or 1) and on the other hand the conservative but sufficiently realistic selection of the value for the Probability of fatality (between 0 and 1) is quite evident and we are presenting the same through a simple example. Quality developed and accurately defined technologically advanced evacuation model represents a guarantee for elimination of the underestimation of the value of Probability of fatality, as well as a guarantee that this approach of execution of the risk analyses will provide conservative but at the same time more realistic values.

REFERENCES

[1] Eric Vanem, A. Pedro, I. Ostvik, F. Del Castillo de Comas, (2008) Analysing the risk of LNG carrier operations, *Reliability Engineering & System Safety*, Volume 93, Issue 9, September 2008, Pages 1328-1344.

[2] Tanabe, M., Miyake, A., (2011) Risk reduction concept to provide design criteria for Emergency Systems for onshore LNG plants, *Journal of Loss Prevention in the Process Industries*, 24, 383-390.

[3] John H. Sorensen , May, 2000 HAZARD WARNING SYSTEMS: REVIEW OF 20 YEARS OF PROGRESS, *Natural Hazards Review*, Vol. 1, No. 2

[4] Goran Stanković, Stojan Petelin, Peter Vidmar, Marko Perkovič, (2014) Advanced evacuation model managed through fuzzy logic during an accident in LNG terminal, *Mechanical Engineering – Scientific Journal*, Vol. **32,** No. 1, pp. 71–79 (2014)

[5] *Guidelines for Chemical Process Quantitative Risk Analysis, Second edition*, Center for chemical process safety of the American Institute of chemical engineers, 2000

[6] Mike Hightower, Louis Gritzo, Anay Luketa-Hanlin, John Covan, Sheldon Tieszen, Gerry Wellman, Mike Irwin, Mike Kaneshige, Brian Melof, Charles Morrow, Don Ragland, (2004) *Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water*, *SANDIA REPORT*, SAND2004-6258, Unlimited Release, Printed December 2004.

AIR TRANSPORT CONNECTIVITY SCENARIO OF REGIONAL DEVELOPMENT

Sanja Steiner, PhD
University of Zagreb
Faculty of Transport and Traffic Sciences
Vukelićeva 4, 10000 Zagreb, Croatia
ssteiner@fpz.hr

Ana Šimecki, PhD
South East Europe Transport Observatory (SEETO)
Omladinskih Brigada 1, 11198 Belgrade, Serbia
asimecki@seetoint.org

Srđan Ljubojević, MSc
University of Defence
Pavla Jurišića Šturma 1, 11000 Belgrade, Serbia

ABSTRACT

Scientific problem elaborated in the paper refers to insufficient development of inland transport infrastructure and of air transport connections within the South East European region which hinders citizens' mobility as well as economic progress of the region. Targeted research has been done in 2012 and 2013 on sample SEETO[1] network, which encompassed seven regional participants, including Croatia prior to accession to the European Union. The paper presents developed Air Transport Connectivity Model based on comparison criteria for transport mode options on the route samples by applying method of multi-criteria decision. Establishment of identified air transport connections would contribute to strategic objective of the regional transport system efficiency. Implementing scenario of Air Transport Connectivity Model in the South East Europe would support development of regional air transport on the line of European transport policy and White Paper 2011.

Key words: Air Transport, connectivity modeling, regional development, South East Europe.

1 INTRODUCTION

Transport is a key factor in development of international trade, regional integration and national and regional economy where insufficiently developed transport system hampers physical access to the market and thus prevents exchange of commodities and passenger mobility. As a prerequisite for further integration into European Union (EU) networks and market, it is necessary to establish appropriate connectivity within the South East European (SEE) region and connect internal regional market.

[1] SEETO – South East Europe Transport Observatory

The main output of joint cooperation between seven Regional Participants[2] and the European Commission was the signing of the Memorandum of Understanding (MoU) for the Development of the Core Regional Transport Network in 2004. The multimodal Core Regional Transport Network i.e. SEETO Comprehensive Network (SCN) defined under the MoU represents a commonly agreed main and ancillary transport infrastructure in the SEE, which is the base for the implementation of transport related investments programs. Seventeen international airports in seven Regional Participants, with highest importance in the SEE region, constitute air transport infrastructure as a part of the SEETO Comprehensive Network.

When focusing on air transport connectivity in the South East Europe, the factors such as economic characteristics of the region as well as the level of social development should be taken into account together with technical parameters of air transport system [1]. Scientific research in the field of air transport connectivity differentiates spatial and temporal approach in the definition of air transport connectivity. Spatial approach theory is elaborated in the context of air transport network analysis by application of existing models such as graph theory, modeling locations of potential node airports and implementation of the concentration and dispersion measures [2]. Temporal approach is a modern approach used in air transport connectivity analysis that emerged in response to increasing complexity of the air traffic system. Temporal approach in the definition of air transport connectivity is highly used for evaluation of connectivity within European air transport networks due to its high complexity and large number of transfer flight on a daily basis [3].

In order to comprise both spatial and temporal variables it is necessary to define basic configuration of the network according to the level of spatial and temporal airport concentration [4]. Figure 1 shows existing air transport network structures with several prototypes of nodal and linear structures included.

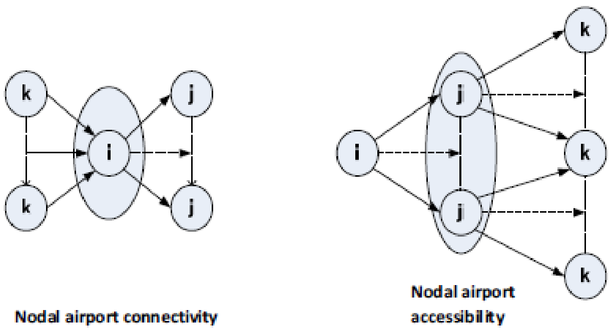


Figure 1: Graphical view of nodal airport connectivity and accessibility [5]

Summarizing above stated air transport connectivity models, it is perceivable that basic condition for their usage is fully developed air transport network and its purpose is further optimization for improvement of accessibility and connectivity within the existing network.

However, those models are not applicable in the evaluation of intraregional air transport network in the SEE because their precondition is to establish complex and integrated hub and spoke network with high number of daily flights. Until now there is no established regional

[2]Regional Participants – Albania, Bosnia and Herzegovina, Croatia, the former Yugoslav Republic of Macedonia, Montenegro, Serbia and Kosovo

hub in the SEE being the basis for modeling networks on a temporal approach and it highlight the need for targeted air traffic connectivity model development. Aforementioned approach presents directions that can be evaluated in future research on air transport connectivity in the SEE when the basic conditions will be fulfilled [1].

2 CRITERIA SET FOR DEVELOPMENT OF AIR TRANSPORT CONNECTIVITY MODEL IN THE SOUTH EAST EUROPE

The Air Transport Connectivity Model processed 136 air transport connections among seventeen SEETO Comprehensive Network international airports in the South East Europe. By its very nature, the problem of air transport connectivity underdevelopment in the SEE can be observed as a problem of multi-criteria ranking of air transport connections alternatives in the network among the SCN airports.

Given the current state of air transport in the SEE region - underdevelopment of overall transport network; insufficient number of studies that focused on economic character of identified research problem; unavailability of precise data on origin-destination passenger transport and uncertainty in estimation of required parameters, it was not possible to use common, explicit economic criteria pertaining to profitability, efficiency and economic viability of the air transport connection as the main criteria for evaluation of air transport connections importance. Instead of these criteria, ranking of air transport connection alternatives is made according to the criteria which value can be determined or estimated from the available data with a high degree of reliability. Accordingly, problem of generating air transport connections in the SEE is perceived in terms of aspects between the need for establishment of air transport connections and the general principles of relative effectiveness of different transport modes. Therefore, only primary network of direct connections among the SCN airports were considered for model input.

The decision which network configuration type would provide the highest benefits for the regional air transport development is brought based on research results of the survey conducted on the SCN airport representatives.

Survey confirmed that current operations in the SEE are performed under “point to point” network configuration while regarding possible implementation of “hub and spoke” network, airports Zagreb, Belgrade, Skopje and Pristina tend to apply this operation model. Thus, the model is based on a “point to point” network configuration which outcome should provide guidelines for the establishment of fully connected “point to point” network in the SEE.

Three main criteria and six sub-criteria are determined as main model input parameters. First criteria “Technical specifications of air transport connection” in this case presents a combination of two possible priorities differentiation and comparison when establishing air transport connection among the SEETO Comprehensive Network airports which are a) length of the observed air transport connection and b) concerned airports technical specifications.

Second criteria “Regional importance of air transport connection” evaluates market demand, respectively social and economic justification of operations establishment on observed air transport connections. Accordingly, the air transport connections are evaluated through aspects of socio-demographic importance and economic importance.

“Competitiveness of air transport connection” is a third criterion that describes air transport connection competitiveness among the SEETO Comprehensive Network airports. It is evaluated by assessing other transport modes available services on the observed air transport connection. Differentiation of air transport connection alternatives according to this criterion provides comparative advantage to those air transport connections that do not have competitive operating service provided by other transport modes between observed airport pairs. In this respect, the existence and the level of service of inland transport connections between the SCN airports is evaluated.

3 AIR TRANSPORT CONNECTIVITY MODEL IN THE SOUTH EAST EUROPE

3.1 Connectivity Modeling

In accordance with defined ranking and selection criteria for the air transport connections among the SEETO Comprehensive Network airports, due to its complexity, it is very important to structure the problem hierarchically in order to retain possibility for further decomposing. In accordance with that, fuzzy interpretation of AHP[3] method is used for air transport connection alternatives evaluation, as it enables elimination of uncertainties which may arose where data assumptions are used. In fuzzy AHP approach, triangular fuzzy numbers are used:

$$n = (n_l, n_m, n_u) \tag{1}$$

where is:
n_l - lower value,
n_m - medium value,
n_u- upper value of fuzzy number,

and where the affiliation number is defined as:

$$\mu n(x) = \begin{cases} \frac{1}{m-l}\,x - \frac{1}{m-l}, & x \in [l,m] \\ \frac{1}{m-u}\,x - \frac{1}{m-u}, & x \in [m,u] \end{cases} \tag{2}$$

All basic mathematical operations in fuzzy environment are used in accordance with commonly accepted operations of triangular fuzzy numbers:

$$n_1 + n_2 = (n_{1l} + n_{2l}\,, n_{1m} + n_{2m}\,, n_{1u} + n_{2u}) \tag{3}$$

to sum triangular fuzzy numbers,

$$n_1 \times n_2 = (n_{1l} \times n_{2l}\,, n_{1m} \times n_{2m}\,, n_{1u} \times n_{2u}) \tag{4}$$

to multiply triangular fuzzy numbers,

$$1/n_1 = (1/n_{1u}\,, 1/n_{1m}\,, 1/n_{1l}) \tag{5}$$

to divide triangular fuzzy numbers,

$$-n_1 = (-n_{1u}, -n_{1m}, -n_{1l}) \tag{6}$$

to negate triangular fuzzy numbers.

[3] AHP - Analytic Hierarchy Process

In order to apply fuzzy AHP method on ranking and selection of air transport connections, the problem has been hierarchically structured in four levels (Figure 2).

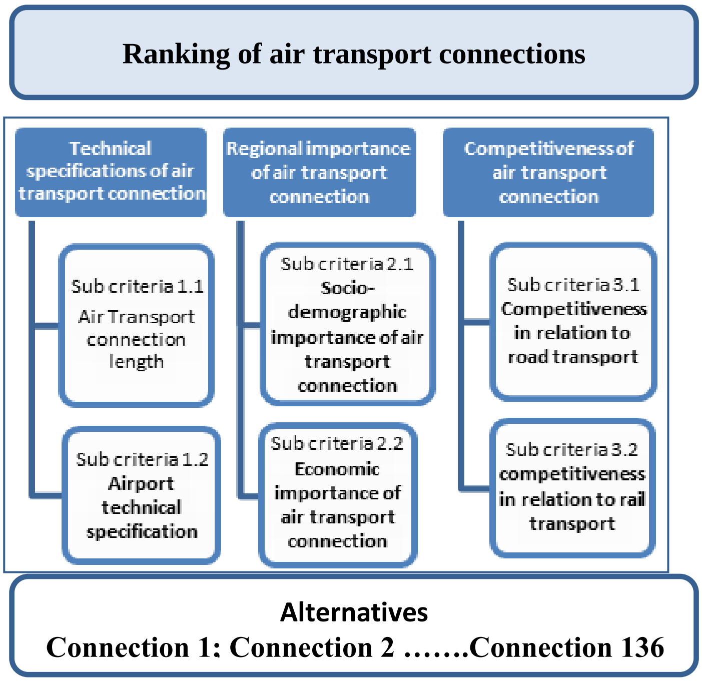


Figure 2: Hierarchy structure of the air transport connections ranking

In defined criteria set and in established hierarchy structure of air transport connections ranking and selection problem, when applying fuzzy AHP method, each criteria is possible to be further decomposed and analyzed in compliance with available data or on the basis of the assumptions when the data is not available.

Following the results of the research published in scientific paper “Design and Development of Decision Making System Using Fuzzy Analytic Hierarchy Process” [6], standard Saaty scale for pairwise comparison is fuzzyficated and applied in fuzzy AHP method according to defined linguistic expression [7].

In order to define relevant weighting factors which are crucial input for Air Transport Connectivity Model in the SEE development, the experts’ opinion inquiry was realized through online questionnaires. Two groups of experts were interviewed where “primary” expert’s group answers were used for model tightening factors defining and the other “control” expert’s group answers were used for model results validation.

Interviewed primary expert group was consisted of 38 air transport experts who provided their opinion on the importa

nce of each criteria and sub criteria, and their degree of dominance in relation to each other (for each pair of criteria) by choosing appropriate term on a scale of linguistic expressions (Table 1) and assign it to observed criteria and sub criteria.

Table 1: Standard and fuzzyficated Satty scale for pairwise comparison

Standard value	Definition (linguistic expression)	Fuzzyficated values $A = (a_l, a_m, a_u)$[4]
1	Same Significance (SS)	(1, 1, 1) if the comparison is done with themselves (1, 1, 3) in all other cases
3	Weak Dominance (WD)	(2, 3, 4)
5	Strong Dominance (SD)	(4, 5, 6)
7	Very Strong Dominance (VSD)	(6, 7, 8)
9	Absolute Dominance (AD)	(8, 9, 9)
2, 4, 6, 8	Intermediate Values	(x-1, x, x+1), x=2,4,6,8

Collected or assessed data are used in the process of air transport connection alternatives pairwise comparison. Pairwise comparison of criteria and sub criteria was based on primary expert group responses (Table 2).

Linguistic expression which in a largest extent corresponds to a fuzzy number generated as the arithmetic mean of primary expert group preferences was adopted as an arithmetic value of expert's group preferences, according to the folowing expression:

$$Pgroup = \frac{\sum_{i=1}^{n} Pexp\ i}{n} \tag{7}$$

where is

n - number of correspondents.

Table 2: Results of survey conducted on primary expert group

Linguistic expression	SS	WD	SD	VSD	AD	Average expert group preference
C1				4		Strong dominance C1 over C2
C2			4	26	4	
C1		4	3		4	Weak dominance C3 over C1
C3			4	19	4	
C2		4	22	4		Weak dominance C2 over C3
C3			8			
SC11		4	23	4		Weak dominance SC11 over SC12
SC12				7		
SC21	1	10	13			Same significance SC21 and SC22
SC22		4	7			
SC31	4	4	22			Weak dominance SC31 over SC32

[4] a_l – lower value; a_m – medium value; a_u – uper value

Linguistic expression	SS	WD	SD	VSD	AD	Average expert group preference
SC32		4	4			

Congruence of expert group preferences fuzzy arithmetic mean with specific linguistic expression from Table 2 is identified according to the maximum fuzzy functional dependence sections height of the observed fuzzy numbers. When elaborating linguistic expression of experts preferences on specific criteria/sub-criteria pair, it is accepted that expression which fuzzy interpretation A = (A_l, A_m, A_u) has highest functional dependence section height with functional dependence of fuzzy number $P_{experts\ group}$ = ($P_{experts\ group\ l}$, $P_{experts\ group\ m}$, $P_{experts\ group\ u}$) that presents arithmetic mean of experts preferences for observed criteria/sub-criteria ratio.

$$max\ [\mu P \cap A] \quad (8)$$

where is:

$$A \in \{A_{same\ significance}, A_{weak\ dominance}, A_{strong\ dominance}, A_{very\ strong\ dominance}, A_{absolute\ dominance}\} \quad (9)$$

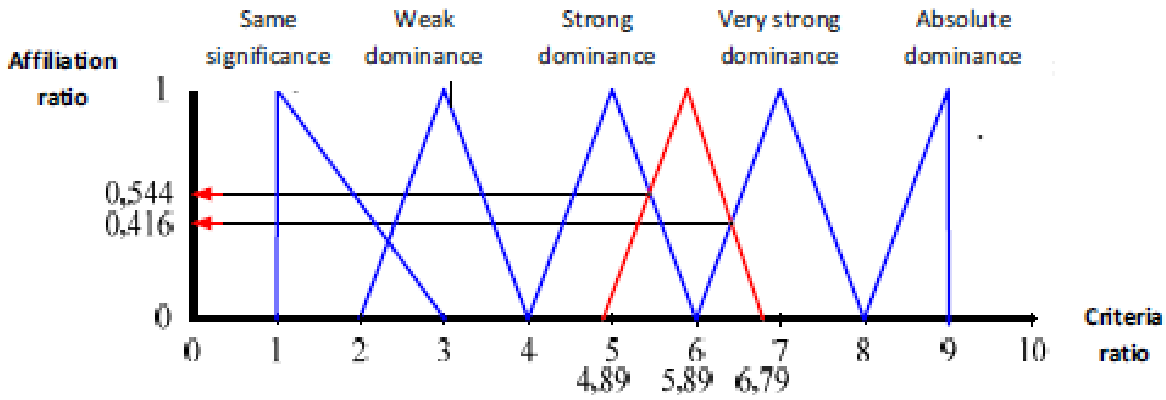
The example of linguistic expression determination for expert group preferences when comparing criteria 1 (C1) and criteria 2 (C2) is shown on Graph 1. According to the described procedure, arithmetic mean of expert group preferences for criteria C1 and C2 ratio corresponds to linguistic term “strong dominance”.

$$max[\mu P_{experts\ group} \cap A] =$$

$$= max[\mu P_{experts\ group} \cap A_{strong\ dominance}, \mu P_{experts\ group} \cap A_{very\ strong\ dominance}] =$$

$$= \mu P_{experts\ group} \cap A_{strong\ dominance} = 0.544 \quad (10)$$

Linguistic values of expert’s group preferences in criteria/sub-criteria comparison are presented as fuzzy values for each criteria/sub criteria, respectively negation of correspondent fuzzy value if other criteria/sub criteria within evaluated pair received higher preference score. In that way, the relative ranking weights of criteria and sub-criteria are defined on expert group preferences.



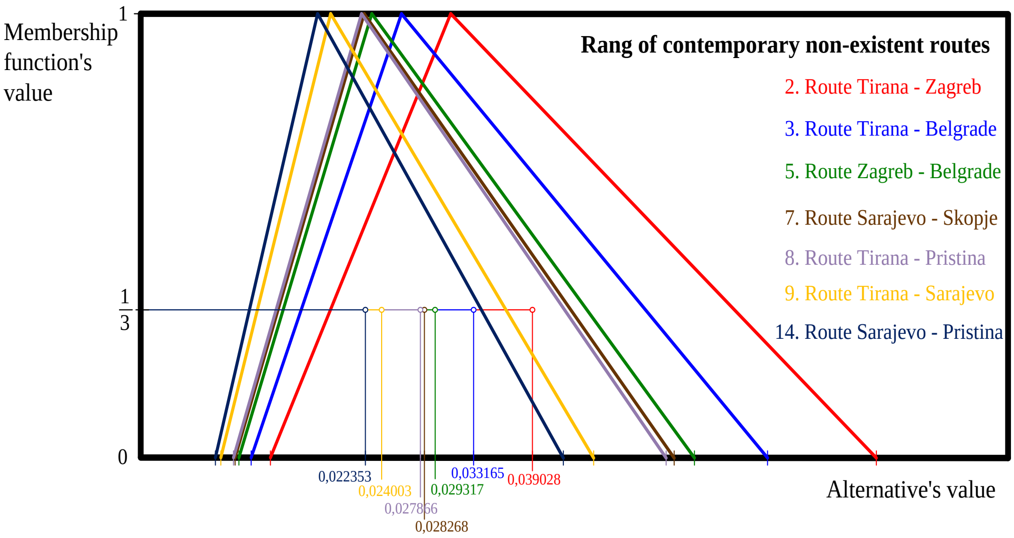
Graph 1: Primary expert’s group preferences on C1 and C2 criteria ratio

Consistency Ratio (CR) for previously described procedure of criteria/sub criteria rating is derived through defuzzification technique (method Center of Gravity). Lower, medium and upper CR values are defined following traditional crisp consistency CR calculation in AHP method, for all values of fuzzyficated comparison matrices (lower, medium, upper):

$$CI = \left(CR_{lower} + CR_{medium} + CR_{upper}\right)/3 \tag{11}$$

According to the described procedure, defined expert groups preferences consistency index[5] amount CI = 0.0834 [7].

Furthermore, the air transport connections among the SCN airports are mutually ranked and their relative weightings are determined following the defined criteria, perceived input alternative parameters, expert's group preferences and applied defined prioritization model based on conducted fuzzy AHP method. In order to identify the final list of air transport connection alternatives, the defuzzification technique, Center of Gravity method, was applied on the first outgoing results. The seven air transport connections of highest importance without established air transport services is presented on Graph 2.



Graph 2: Fuzzy relative weightings of first seven of air transport connections without established air transport services

Out of 18 operable air transport connections among the SEETO Comprehensive Network airports, 15 are positioned among 26 highest ranked connections with percentage cumulative sum share of the total sum of the connection alternatives relative weights lower than 50%. It proves credibility of models air transport connections ranking results in reality and on the scientifically proven basis further accentuate necessity for establishment of new air transport connections in the SEE.

---

[5] CI – Consistency Index

3.2 Validation of the model

With the purpose of model results confirmation, it was necessary to conduct a process of Air Transport Connectivity Model in the SEE verification and validation. Although verification and validation of the model are conceptually different, the fact that they are in a dynamic feedback enabled simultaneous performance of both processes.

Given that the concept of AHP is scientifically accepted, and that no standardized and universally accepted procedure of various models verification and validation exists in the scientific literature, the process of the Air Transport Connectivity Model verification and validation is focused at relative weighting criteria verification and evaluation of the impact of changes in mutual ranking criteria on final results which are most delicate stages of each multi-criteria prioritization.

Table 3: Results of survey conducted on control expert group

Linguistic expression	SS	WD	SD	VSD	AD	Average expert group preference
C1						Strong dominance C1 over C2
C2			2	5	2	
C1				1	1	Weak dominance C3 over C1
C3			1	5	1	
C2		2	6			Weak dominance C2 over C3
C3			1			
SC11		2	4	1		Weak dominance SC11 over SC12
SC12			2			
SC21		4	1			Same significance SC21 and SC22
SC22		2	2			
SC31	2	3	1			Weak dominance SC31 over SC32
SC32		2	1			

Relative weights of criteria/sub-criteria are identified following the responses on the survey conducted on air transport experts group (38 experts) while as previously mentioned, additional survey has been conducted on control experts group (9 experts) with the purpose of Air Transport Connectivity Model in the SEE results validation. Control expert group preferences have been analyzed according to the same procedure as primary expert group preferences used for model development.

Consistency index (CI) for control expert group criteria/sub-criteria rating is identified through using defuzzifcation technique (Center of Gravity Method) analogue as in primary experts group and is in the frame of acceptable values amounting CI = 0.0885.

When comparing primary and control group preferences, it is apparent that ranking of criteria is identical, although values of mutual ranking among pairs of criteria are different. According to control expert group preferences, dominance of criteria C2 over criteria C1 and C3 is more pronounced than is primary expert group preferences. It is also considered according to the control experts groups preferences that sub-criteria SC31 and SC32 are of same significance which is not the case in primary expert group preferences where the weak domination of sub criteria SC31 is indicated.

In the process of Air Transport Connectivity Model in SEE validation, ranking of air transport connection alternatives is done based on control expert group criteria preferences. When comparing outgoing results derived on the basis of control and primary experts group input parameters, it is apparent that the only differences are in relative weightings while ranking of the alternatives remains unchanged.

Considering that criteria and sub criteria ranking is the same in both cases (except for sub-criteria SC31 and SC32), and that final ranking of air transport connection alternatives is the same in both cases as well, it can be stated that validity of criteria/sub-criteria relative weighting is confirmed. Scientifically conducted verification of applied AHP method process in the development of Air Transport Connectivity Model in the SEE confirms validity of criteria/sub-criteria relative weights and accordingly it confirms validity of the Air Transport Connectivity Model in the SEE. Consequently, it can be concluded that developed Air Transport Connectivity Model in the SEE provides scientifically approved solution which can be used for resolving of stated scientific problem that "identified insufficient development of inland transport infrastructure and of air transport connections within the SEE region which hinders citizen's mobility as well as economic progress of the region".

4 MODEL RESULTS APPLICATION AND DISCUSSION

Improvement of flight efficiency and reduction of air transport impacts on the environment are of the most important issues in European air transport development strategies specified in SES[6] legislation – regulatory packages I and II, which are the basic mechanisms to overcome future challenges, currently apparent in inefficiency of flight operations and extra costs amounting to 1 billion Euros per year.

The reform of the European air traffic management system aims to meet the challenge of significant air traffic increase, as well as contribute the regional services harmonization and functional integration [8]. It should generate sufficient capacity to manage the growing number of flights over the European continent, to decrease delays, to enhance safety and cost efficiency and to lessen the impact on the environment based on four pillars: performance, single safety framework, new technologies and managing capacity on the ground [9].

Introduction of services on proposed air transport connections in the SEE is in conformity with the SES objectives, primary relating to routes distance reduction and consequently improvement of flight and cost efficiency, reduction of fuel consumption and negative impact on the environment.

At European level it has been calculated that in 2007 the actual flight distance flown per aircraft was 49 kilometers longer than optimum distance, while reduction of 4 kilometers per flight would result in cost savings of about €200-250 million per annum, and an annual reduction in CO_2 emissions of approximately 120,000 tones [10].

Due to underdevelopment of direct connections among the SCN[7] airports, several airports are reachable only through European hubs. Four highest frequency air transport connections in the SEE are linking the SEE and the Western Europe, with the largest number of flights to European nodal airports (Frankfurt, Munich and Vienna).

---

[6] SES – Single European Sky
[7] SCN – SEETO Comprehensive Network

Comparison of distances flown by proposed sample (11 connections) of direct air transport connections and transfer connections through Airport Vienna is presented on Table 4, whereas the distance increase of average 278% on transfer connections is apparent.

Table 4: Travel distances on direct and transfer (via Vienna Airport) air transport connections

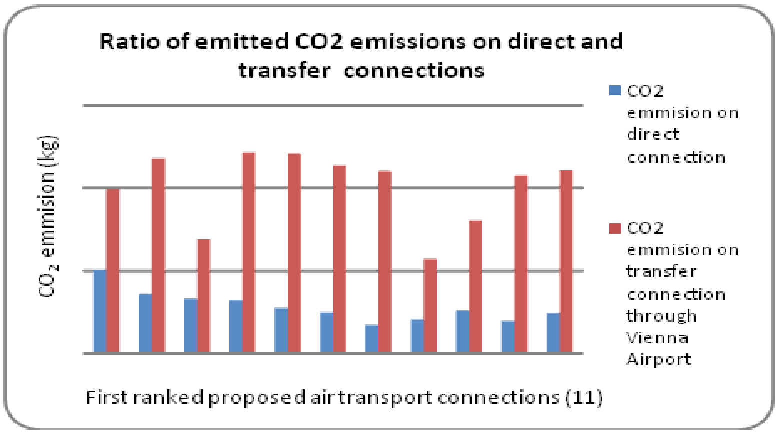
SCN Airport 1	SCN Airport 2	Direct connection (km)	Transfer connection through Airport Vienna (km)	Increase (%)
Tirana	Zagreb	536	1,049	96
Tirana	Belgrade	381	1,249	228
Zagreb	Belgrade	348	730	110
Sarajevo	Skopje	339	1,285	279
Tirana	Sarajevo	290	1,279	341
Sarajevo	Pristina	260	1,202	362
Sarajevo	Podgorica	179	1,167	552
Osijek	Zagreb	216	605	180
Banja Luka	Sarajevo	275	851	209
Belgrade	Nis	208	1,138	447
Belgrade	Pristina	256	1,172	358

When comparing value of passenger time saved or lost with road and rail passenger services, loss of 2,369 Euros is apparent in road transport services and 3,728 Euros in rail (Table 5).

Table 5: Travel time saving on potential air transport connections comparing to road and rail

SCN Airport 1	SCN Airport 2	Travel time saving - personal road transport (EUR)	Travel time saving -business road transport (EUR)	Travel time saving - personal rail transport (EUR)	Travel time saving business - rail transport (EUR)
Tirana	Zagreb	158	290	0	0
Tirana	Belgrade	108	199	0	0
Zagreb	Belgrade	40	73	97	178
Sarajevo	Skopje	145	265	416	763
Tirana	Sarajevo	90	165	0	0
Sarajevo	Pristina	126	231	212	389
Sarajevo	Podgorica	53	98	426	781
Osijek	Zagreb	24	44	65	119
Banja Luka	Sarajevo	31	57	49	91
Belgrade	Nis	12	22	50	92
Belgrade	Pristina	49	89	0	0
Total		836	1,533	1,316	2,413

The value of travel time that might alternatively be spent working has been calculated by applying gross wage costs. For leisure travel, the approach has been to apply the net wage rate since that is the amount the wage earner must sacrifice to have additional leisure time [11].



Graph 3: CO_2 emissions on direct and transfer (via Vienna Airport) air transport connections

The increase in air transport connection distance is in direct correlation to the increase of fuel consumption and of negative environmental impact apparent the amount of emitted CO_2 emissions as presented on Graph 3. Hence, one step forward in meeting SES targets could be done by the introduction of the services on proposed air transport connections.

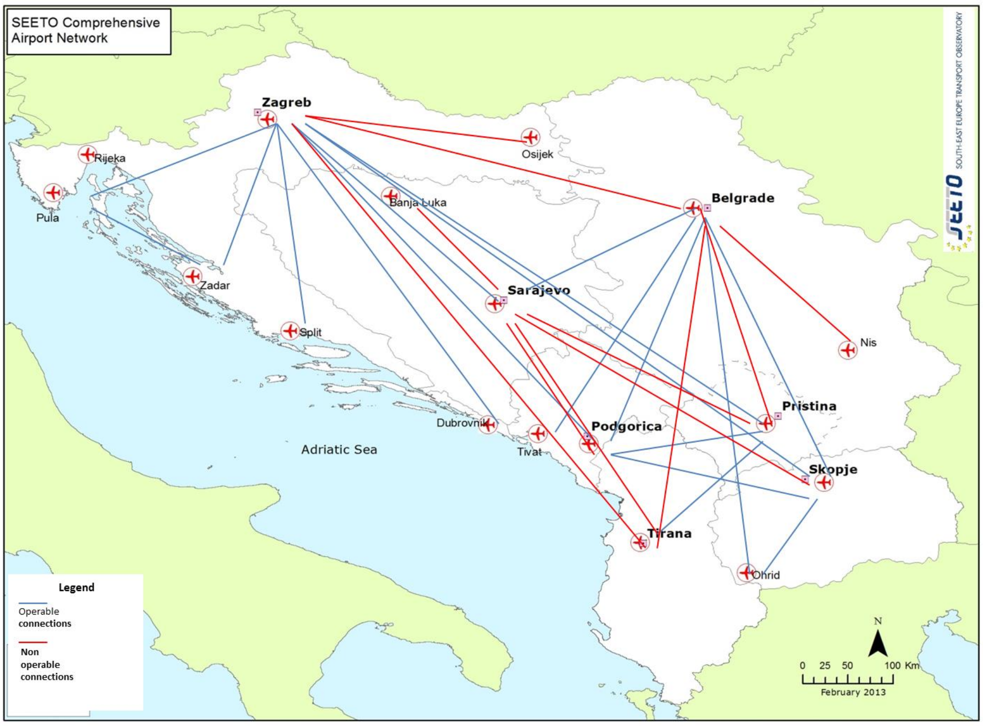


Figure 3: Operable air transport connections in 2010 and proposed air transport connections

5 CONCLUSIONS

Targeted research methodologically was based on infrastructure and performance assessment of road, rail and air transport modes in the South East Europe. Evaluated weaknesses of inland transport modes argue the potential of the intra-regional route network development. Following the outcome of the intraregional air transport connectivity assessment, inland traffic dynamics and planned infrastructure development [12], the Air Transport Connectivity Model in the South East Europe has been developed. Scientifically conducted verification of applied AHP method in the development of Air Transport Connectivity Model in the SEE confirms validity of the model and proposed ranking of potential air transport connections.

Results of the assessment of air transport system in the SEE and the list of proposed air transport connection by the Air Transport Connectivity Model in the SEE has been confirmed by identified underdevelopment of road and rail transport services on the connections among the SEETO Comprehensive Network airports, the reduced passenger mobility caused by low share (10%) of intraregional air transport connections and identified potentials for regional development.

New air transport connections within the SEE region could considerably improve mobility and accelerate economic and social cohesion. The unleashed potential of South East European air transport market should be highly and efficiently exploited in the following period as to attract growing demand for air transport from congested EU airports thereby enabling win-win situation for both parties.

REFERENCES

[1] Simecki, A. (2013). *Air Transport Connectivity Model in South East Europe*. *Doctoral Dissertation*. Zagreb: Faculty of Transport and Traffic Sciences, University of Zagreb.

[2] Redondi, R., Burghouwt, G. (2010). Measuring connectivity in air transport networks: technical description of the available models. Working Paper, Version 11.

[3] Burghouwt, G., De Wit, J. (2005). Temporal configurations of European airline networks. *Journal of Air Transport Management, 11* (3), 185-198.

[4] Veldhuis, J., Kroes, E. (2002). Dynamics in relative network performance on the main European hub airports. European Transport Conference, Cambridge.

[5] Tinkler, K. J. (1977). An introduction to graph theoretical methods in geography. *Concepts and Technics in Modern geography 14*. Norwich: GEO Abstracts, University of East Anglia.

[6] Chin, W.C., Lee, H.J., Mak, C.M., Amy, L.H.L. (2008). Design and Development of Decision Making System Using Fuzzy Analytic Hierarchy Process. *American Journal of Applied Sciences, 5* (7), 783 – 787.

[7] Triantaphyllou, E. (2000). *Multi-Criteria Decision Making Methods: A Comparative Study*. Boston: Kluwer Academic Publishers.

[8] Steiner, S., Mihetec, T., Božičević, A. (2010). Prospects of Air Traffic Management in South Eastern Europe. *Promet-Traffic&Transportation, 22* (4), 293-302.

[9] European Commission (2008). Single European Sky II: Towards more sustainable and better performing aviation. COM 389 final, Brussels.

[10] Department of Air Transport, Cranfield University (2011). *Fuel and air transport, Report for European Commission*, Cranfield.

[11] EUROCONTROL (2011). Standard Inputs for EUROCONTROL Cost Benefit Analyses. Brussels.

[12] Šimecki, A., Steiner, S., Čokorilo, O. (2013). The Accessibility Assessment of Regional Transport Network in the South East Europe. *International Journal for Traffic and Transport Engineering. 3* (4), 351-364.

ROAD TRAFFIC NOISE ALONG MAIN ROAD ARJA VAS – VELENJE

Petra Sušec, B.Sc
GKN Driveline Slovenija d.o.o.
Rudniška cesta 20, 3214 Zreče, Slovenia
petra.susec@gkndriveline.com

Marko Bek, B.Sc
Nikola Holeček, D.Sc
Gorenje d.d.
Partizanska 12, 3503 Velenje, Slovenia

ABSTRACT

The last decade has brought significant investment in the economy of Šaleška region (Thermal Power Plant TEŠ 6, Gorenje), resulting in a greater traffic load on the road Arja vas - Velenje. In this paper, we address the problem of increasing road traffic noise in areas along the main road. This noise significantly reduces the quality of life of in urban areas along the mentioned main road. Due to its spatial distribution, there are several possibilities of noise protection actions.

In the paper we present road traffic noise load of this area and compare it with the permitted limit values laid down in Regulation of noise from road and rail traffic in 2004. For the determination of noise levels a method for the visualization of noise was used - acoustical beamforming. This is a method used for determination of spatial propagation of acoustical waves.

Key words: Road traffic, road traffic noise, noise measurements, acoustic beam-forming, road Arja vas – Velenje.

1 INTRODUCTION

Considering the number of population, Velenje is the fifth largest city in Slovenia (around 25.000 inhabitants) and it is an important center for employment. At the same time it has also a transit role. Recently, the city of Velenje has been faced with a deteriorating quality of the living environment, ie. with the excess noise pollution, particularly in the urban arterial roads. The negative impact is also reflected in the valley axis in the direction of the neighboring municipal centres, Šoštanj and Šmartno ob Paki. The valley axis represents the concentration of traffic and industrial activity in connection with the settlement function area. In the last decade, this area has been very active regarding investment (TEŠ, Gorenje) aggravating the conditions of living and working environment of these areas Savinja statistical region. Similarly, congestion increases beyond the urban space of the valley. There is a pressure increase in transport activities in the rural areas of the Šaleška Valley, representing a strong background in terms of daily migration.

One of the greatest sources of noise pollution is certainly road traffic. It causes the most complaints about the deterioration of the quality of life and therefore noise reduction in road traffic takes precedence of most other noise sources (Crocker, Introduction to transportation Noise and Vibration sources, 2007).

The road Velenje – Arja vas is a dangerous road, called the road of death, and is the responsibility of the Roads Directorate of the Republic of Slovenia under the Ministry of Transport. There are pressures from local communities and the police, warning that the road is long overdue, and it no longer meets daily traffic volumes and should be renovated. For the Koroška region and the Šaleška valley this seventeen kilometers long road between Velenje and Arja vas is the only connection to the highway towards Ljubljana (Strgar, 2002).

The former Mayor of the city of Velenje Mr. Srečko Meh once said: "The local economy, all the large companies Gorenje, Esotech, Coal Mine Engineering Velenje, Thermal Power Plant Šoštanj, and the inhabitants are very dependent on the only road link and the situation on the road is bad" (Meh, 2002). Local statistical data says that in year 2012 daily traffic on the road Velenje – Arja vas is about 17.000 vehicles (1.534 trucks and 421 trucks with trailer) what is 60% of increase from year 2000 (ERICO Velenje Inštitut za ekološke raziskave d.o.o., 2014). Statistics predicts nearly 25.000 vehicles daily in year 2021 considering the projection of three per cent annual increase of traffic, which is less than Europe anticipates. Considering this information Mr. Meh also said that this includes the fact that the connection to the highway is impossible because on the whole route there are a lot of black spots. For example on the way from Velenje to Pirešica overtaking is not possible, due to the unbroken line and speed limits: in Pirešica 50, at the Quarry 60 kilometres per hour, then there is a problem with water on the road and with the trucks coming from the Quarry directly to the road (Strgar, 2002).

2 CURRENT LEGISLATION IN THE FIELD OF ENVIRONMENTAL NOISE

2.1 Road, rail, aviation, shipping noise traffic

Values and management of noise in the area of road, rail, aviation, shipping is governed by the following directives:

- Commission Directive 2004/446 / EC of 29 April 2004 laying down the basic parameters of the noise of freight wagons
- Directive of the European Parliament and of the Council 2002/30 / EC of 26 March 2002 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Community airports (Text with EEA relevance)
- Council Directive 89/629 / EEC of 4 December 1989 on the limitation of noise emission from civil subsonic jet airplanes
- Commission Regulation (EC) No. 991/2001 of 21 May 2001 amending the Annex to Council Directive 92/14 / EEC on the restriction of the use of airplanes covered by Part II, Chapter 2, Volume 1 of Annex 16 to the Convention on International Civil Aviation, second edition (1988) Text with EEA relevance.

2.2 Regulation of motor vehicle noise

Regulatory test that were developed by engineering body which main expertise are measurements of product characteristics, were summarized as technical standards. International Standards Organization (ISO) is the main regulator of motor vehicle noise in European countries. In some cases, European countries have in addition to adopting ISO regulatory procedures introduced modified procedures, which causes to variety of different regulatory procedures. The ISO test procedure (distance between driving line and microphone is 15 m) is given in Table 1 (Crocker, Noise and vibration Control, 2007).

Table 1: Exterior Motor Vehicle Noise Limits* in Overall A-weighted Sound Pressure Level, dB

Regulatory Group	Passenger Cars	Trucks and Buses	Motorcycles	Tires
European Union	74	74 - 80	80	72 - 76

* Limits shown do not encompass the entire detailed variants based on mass, power on/off usage.

Source: (Crocker, Noise and vibration control, 2007)

Regarding new vehicle noise regulations in reducing noise levels, there has been some debate on its effectiveness, since the EU 1995 Green Paper showed that in two decades limiting did not contribute significantly enough to population exposure to noise (Commision, 1996).

Among the reasons for the situation we can list more important ones: low exchange rate of older, noisier vehicles to new, quieter ones; a trend toward bigger, more powerful trucks and light vehicles; lack of in-use controls; the underlying levels of tire-pavement noise: and a lack of the test procedure that represents actual vehicle operation (Sandberg, 2001).

3 ROAD TRAFFIC NOISE EMISSION IN GENERAL

Main noise sources in vehicles like cars, trucks and buses are engines, (cooling) fans, transmission and exhaust system. Other important sources are rolling noise (generated in contact of tire and wheels) and vibration and aerodynamic noise of vehicle. In the past few years, vehicle and aerodynamic noise have been successfully reduced; however this still remains an important issue due to the fact that the number of vehicles on roads is increasing. From literature it is known that dominant source of exterior noise in new cars comes from rolling noise, coupled by aerodynamic noise (with an exception of first gear). The levels of noise increase considerably with high speeds and can overcome train noise, which contains engine, air inlet, exhaust, cooling system and transmission. Table 2 (Nelson, 1992) presents review of vehicle noise and how it changes with speed and vehicle class. From this table it can be seen that that rolling noise has a negligible effect on the noise produced by heavy vehicles at low speed, but at speeds above 20 km/h for cars and 80 km/h for heavy vehicles, rolling noise contributes significantly to the overall noise and becomes the dominant source of noise source (Nelson, 1992).

Table 2: Comparison of Rolling and Power Train A-weighted Sound Pressure Levels

Road Speed km/h	Vehicle Class	Rolling Noise (dB)	Power Train Noise (dB)	Total Noise (dB)
20	Heavy*	61	78	78
	Light	58	64	65
80	Heavy*	79	85	86
	Light	76	74	78

* Heavy vehicles are defined as having an unloaded mass of greater than 1525 kg

Source: (Nelson, 1992)

In modern cars driving at steady speeds (in top three gears) compared to driving at the same speeds without operating engine shows little difference. This implies that the rolling noise together with aerodynamic noise is the dominant source of noise. For trucks the dominant source of noise is engine at low speeds, at speeds above 80 km/h, rolling noise and aerodynamic noise become more pronounced (see Figure 1, which shows small differences at speeds above 70 – 80 km/h) (Crocker, Introduction to transportation Noise and Vibration sources, 2007).

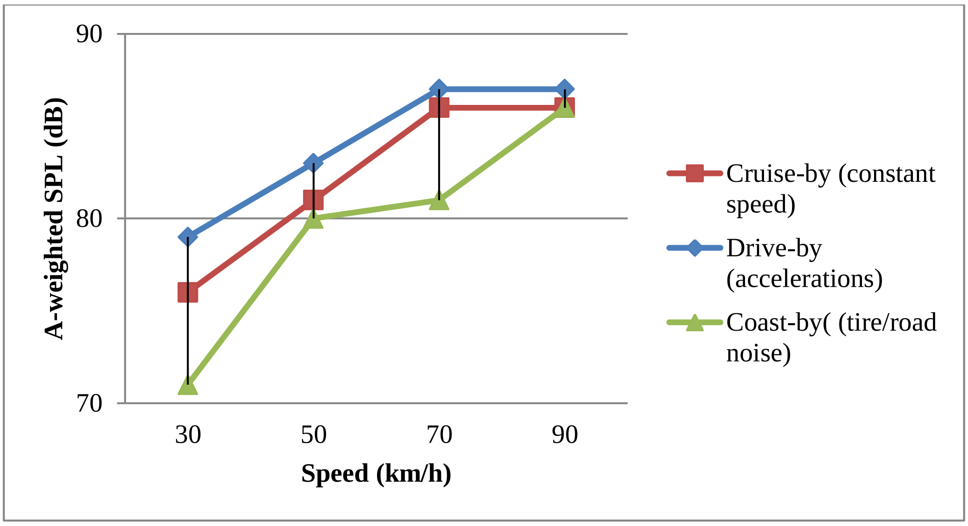


Figure 1: Exterior noise of a Volvo F12 truck under different driving conditions

Source: (Sandberg & Ejsmont, 2002)

4 AREA OF RESEARCH

Measurements of sound pressure and intensity were made alongside the road Velenje – Arja vas, carried out on Thursday 26 February 2015 at 9 am. The location of the measuring point is indicated in Figure 2. The area has been chosen 500 m outside Velenje, where speed limit is 70 km/h. The reason for the selected location is marginal population density on the road to the city and the vicinity of the shopping centre "Veleja park".

Figure 2: Measuring position on the road Velenje – Arja vas

Source: (Google maps)

Figure 3: Experimental setup for measurement using an array of 60 microphones (beamforming technique) on the road Velenje – Arja vas
Photo: (Sušec, 2015)

5 MEASURING AND EVALUATING NOISE DISTURBANCE OF ROAD VELENJE – ARJA VAS

For the purpose of this investigation beam forming technique was used. Beamforming is a measuring technique where the microphone array is placed in the far field. It is not well defined where the far field starts, however, as a rule of thumb, the far field is defined as being further away from the source than the array dimensions or diameter. In the far field, sound waves hitting the array are planar waves. Under these conditions, it is possible to propagate the measured sound field directly to the test object. All microphone signals measured by the beamforming array are added together, taking into account the delay corresponding to the propagation distance. The pressure can be calculated at any point in front of the array, allowing propagation to any kind of surface. Beamforming requires that all data points (all microphones) are measured simultaneously, from the time when the wave hits a particular microphone and the distance between microphones it is possible to localize the source of the sound. This is also the reason why beamforming is sometimes called “sum and delay” (Lanslots, Filip, & Karl, 2010).

For the purpose of this investigation 60 randomly placed microphones (Bruel&Kjaer Typ: 4957) positioned on a rectangular frame to form a microphone array was used. The microphone array was connected to 5 channel signal amplifiers Bruel& Kjaer Type 3053-B-12/0 and to the personal computer for measuring and analyzing the results.

Measurements were done in the time interval of 60 s, when four vehicles pass-by noise was recorded as indicated in Figure 4. Figure 4 shows the time recording and the pressure of one point in the acoustic array. The microphone array was positioned 15 m away from the road. In continuation, the sound pressure measurements and the sound intensity measurements are presented for all four vehicles. All values were evaluated using A-weighted filter.

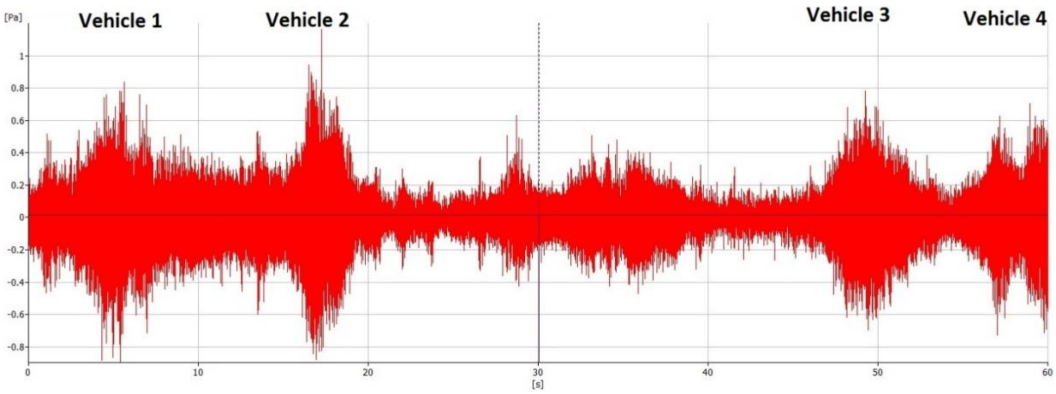


Figure 4: Recorded four vehicles in the time interval of 60 s

Source: (Bek, Holeček, & Sušec, 2015)

Figure 5 shows sound pressure measurements for all four cases of vehicle pass-by. It represents different values of sound pressure with maximal sound pressure from 72dB (A) (Figure 3 bottom right) to 78dB (A) (Figure 3 top left). For the clarity reasons the bottom right figure is shown transparent, vehicle entering and vehicle leaving can be seen.

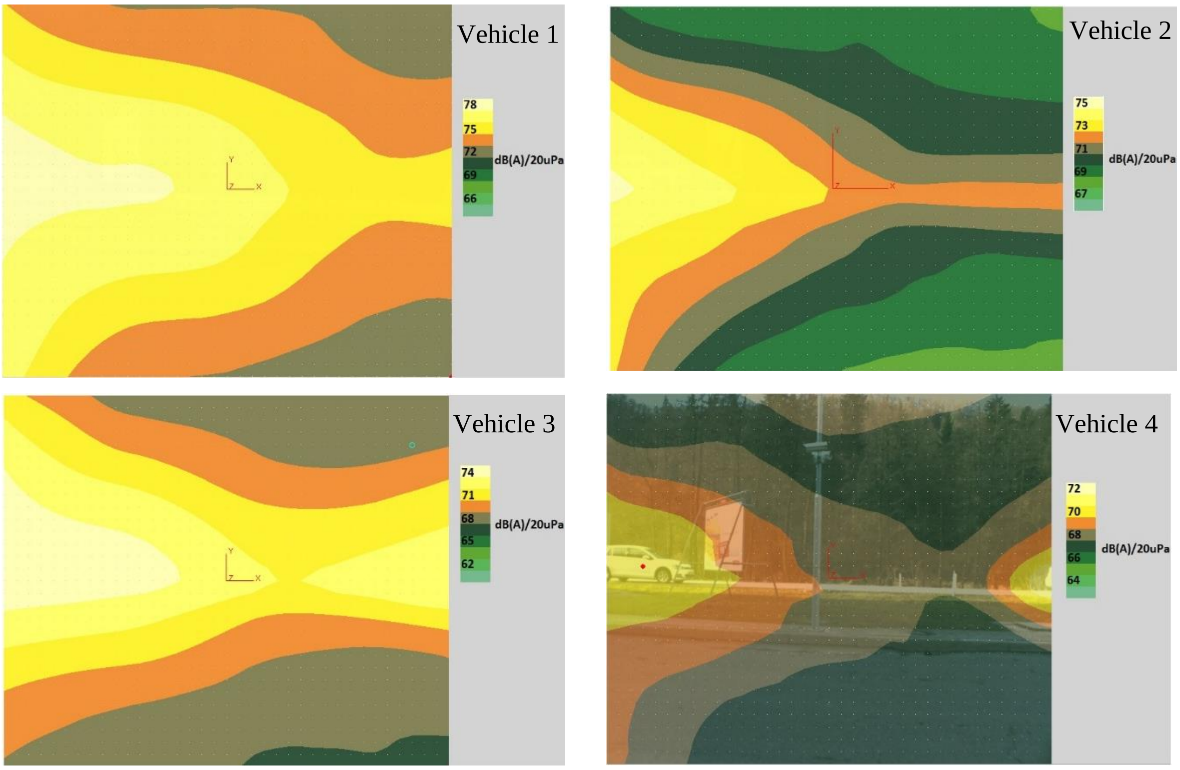


Figure 5: Sound pressure for 4 vehicle pass-by

Source: (Bek, Holeček, & Sušec, 2015)

Figure 6 shows sound pressure in frequency range from 100 Hz to 10.000 Hz. From this figure we can observe that frequencies in the range from 500 – 1.000 Hz significantly contribute to the total sound pressure.

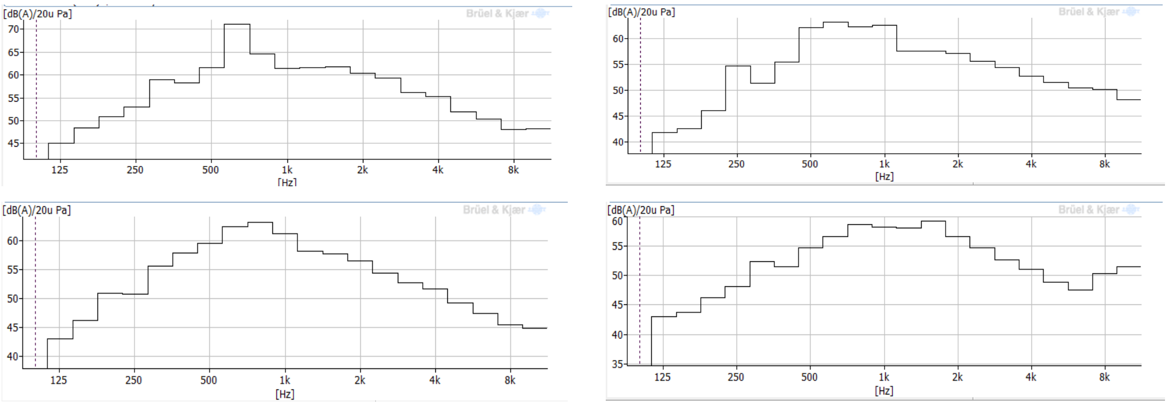


Figure 6: Sound pressure as a function of frequency for all four vehicle pass-by

Source: (Bek, Holeček, & Sušec, 2015)

Figure 7 shows sound intensity measurements for all four cases of vehicle pass-by. It shows different values of sound intensity with maximal values ranging from 71 dB (A) (Figure 3 bottom right) to 77dB (A) (Figure 3 top left). For the clarity reasons the bottom right figure is again shown as transparent, vehicle entering and vehicle leaving can be seen.

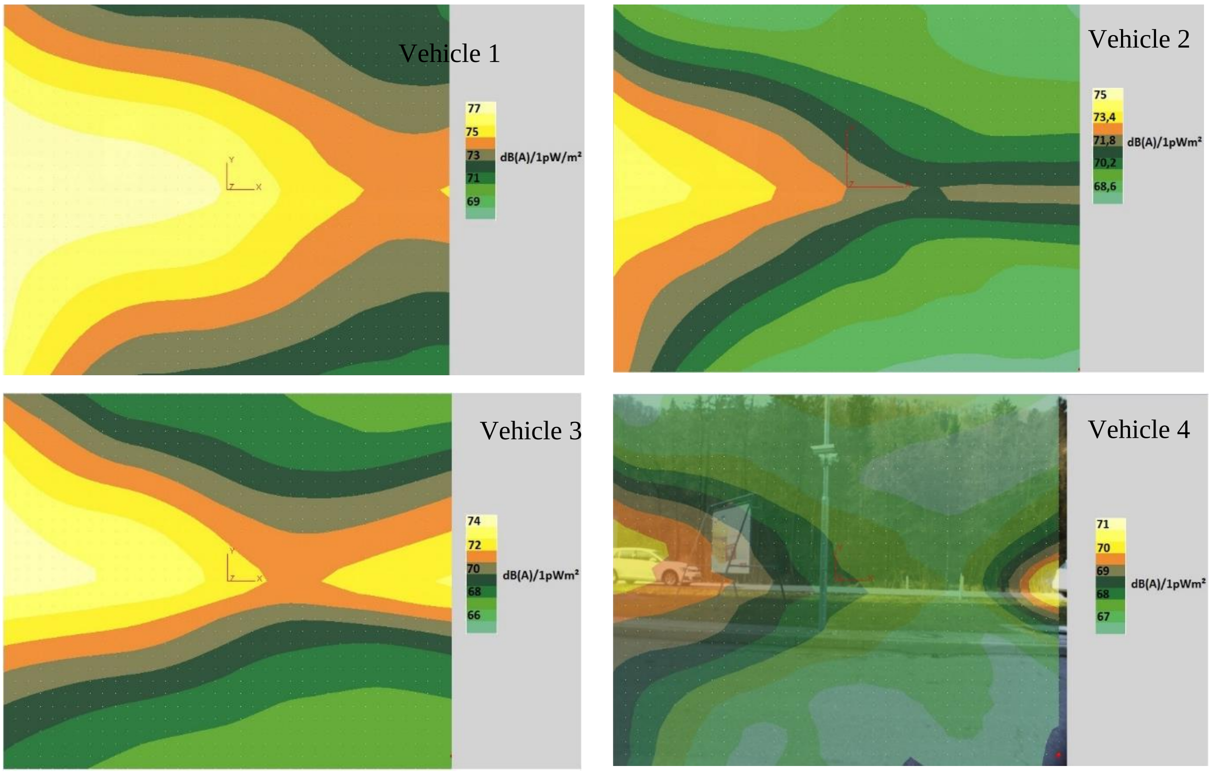


Figure 7: Sound intensity for 4 vehicle pass-by

Source: (Bek, Holeček, & Sušec, 2015)

Figure 8 shows sound pressure in frequency range from 100 Hz to 10.000 Hz. Similarly as before, we can observe that frequencies in the range from 500 – 1.000 Hz significantly contribute to the total sound pressure.

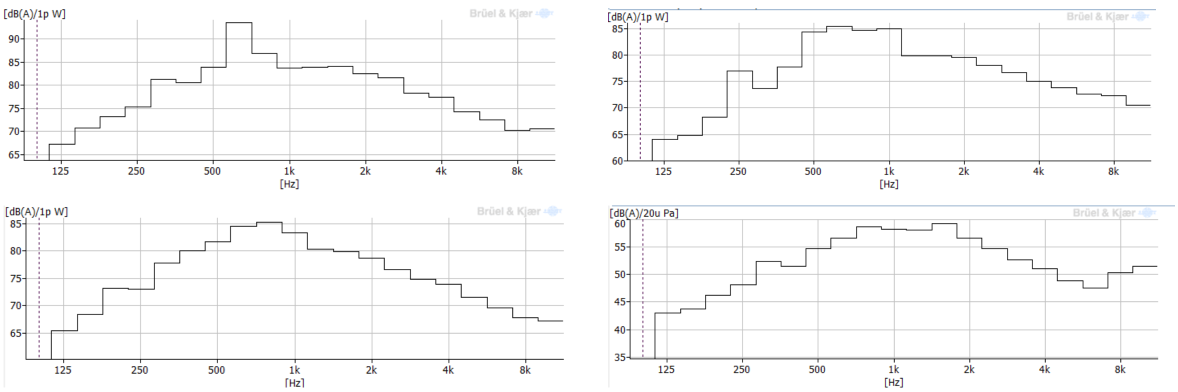


Figure 8: Sound intensity as a function of frequency for all four vehicle pass-by

Source: (Bek, Holeček, & Sušec, 2015)

6 CONCLUSION

Noise in the living and working environment represents a major disturbance for population and may significantly lower the quality of the living environment. In the urban environment, transport (road) noise is by far the most troublesome. In addition the problem of noise increases with the increase of traffic.

Noise may have undesirable effects on people. At lower sound pressure levels (SPL), noise may cause annoyance and sleep disturbance. At increased levels, noise begins to interfere with speech and other forms of communication; at still higher levels that are sustained over a long period of time in road traffic and other occupational environments, noise can cause permanent hearing damage. Sleep disturbance is a common effect of exposure to community noise, especially for transportation noise such as that from aircraft, road traffic, and railways.

In this paper, we discussed road traffic noise along the main road Arja vas - Velenje. The assessment of noise pollution in general refers to measured values obtained in different time periods of the day, but this varies from country to country. The most difficult is to meet the requirements of the night period. World Health Organization (WHO) proposed noise values between 55 and 60dB for newly constructed roads. However this is often disregarded by the national legislation. The noise limits as a result of transport and transport infrastructure are usually well above the recommended levels. This is also the reason why the so-called "Grey" areas where there is excess noise, are still expanding. Our measurements undoubtedly confirm this and show that the noise value in the selected area of the road Arja Vas - Velenje is above recommended.

The presented values are the result of preliminary measurements that need to be upgraded in the future (repetition in different times of a day). More measurements will contribute to more accurate noise exposure pollution assessment coming from transport noise in measuring point as indicated in Figure 2 (location along main road Arja Vas – Velenje). The results of further studies could also be used for: a) the creation of proposals on anti-noise measurements throughout the area with a special treatment of noise-critical areas alongside the road Velenje – Arja vas b) with the data, we would complement the spatial basis (plans) and define the conditions for purposive use of space and to determine the levels of protection against noise.

REFERENCES

[1] Bek, M., Holeček, N., & Sušec, P. (2015). Measurement report of road noise on the road Arja Vas - Velenje February 26, 2015. Velenje: VŠVO.

[2] Commision, E. (1996). *Future Noise Policy*. Brussels: Commission of the European Communities.

[3] Crocker, M. J. (2007). Introduction to transportation Noise and Vibration sources. Auburn: Auburn University.

[4] Crocker, M. J. (2007). *Noise and vibration control.* New Yersey: John Wiley&Sons.

[5] ERICO Velenje Inštitut za ekološke raziskave d.o.o. (2014). *Poročilo o stanju okolja v mestni občini Velenje.* Velenje: ERICO d.o.o.

[6] Google maps. (brez datuma). Prevzeto 5. Feruar 2015 iz Google: https://www.google.si

[7] Lanslots, J., Filip, D., & Karl, J. (2010). Selecting soundsource localization techniques for industrial applications. *Sound and Vibration* , 6-9.

[8] Meh, S. (16. December 2002). Lokalno - *Cesta smrti Arja vas* - *Velenje*. Prevzeto 5. Februar 2015 iz Dnevnik: https://www.dnevnik.si/38947/lokalno/38947

[9] Nelson, P. (1992). Controlling Vehicle Noise - A General Review. *Acoustic Bull.* , 33-57.

[10] Sandberg, U. (2001). *Noise Emission of Road Vehicles* - *Effectiveness of Regulations*. Hague: International Institute of Noise Control Engineering.

[11] Sandberg, U., & Ejsmont, J. A. (22. June 2002). *Tyre/Road Noise Refference Book*. Prevzeto 14. Januar 2015 iz Infomex: http://www.informex.info

[12] Strgar, Z. (16. December 2002). *Lokalno* - *Cesta smrti Arja vas* - *Velenje*. Prevzeto 5. Februar 2015 iz Dnevnik: https://www.dnevnik.si/38947/lokalno/38947

MONTENEGRIN MARINAS AND NAUTICAL PORTS: POTENTIAL AREA FOR IMPROVEMENT

Maja Škurić, M.Sc.
University of Montenegro
Maritime Faculty
Dobrota 36, 85330 Kotor, Montenegro
mskuric@ac.me

Milena Bataković, M.Sc.
Ervin Spahić, B.Sc.
Aleksandar Božović, M.Sc.
Environmental protection Agency of Montenegro
IV Proleterske 19, 81000 Podgorica, Montenegro
milena.batakovic@epa.org.me, epamontenegro@gmail.com, aleksandar.bozovic@epa.org.me

Milijana Đinović, B.Sc.
University of Montenegro
Maritime Faculty
Dobrota 36, 85330 Kotor, Montenegro
mdjinovic91@gmail.com

ABSTRACT

This paper introduces the actual trends and vessel traffic in Montenegrin marinas and nautical ports. We provide a statistical analysis of the achieved traffic for foreign visitors from 2010 to 2013. In addition, paper gives overview on main environmental impacts and aspects and in those context possibilities for improvement of management practices. Montenegrin coastal area is very attractive in south Adriatic and has improved its yachting and sailing activities. Regarding operational policies in some marina, we investigate possibility for capacity improvement in AD Marina Bar using sustainable development concept. Here we pay attention on the summary in respect to mentioned marina. For applying and promoting marina sustainable development concept, out methodology will try to provide the high quality standards. It includes steps for implementation and improvement of performances.

Expected results are correlated with the current situation as the output of the some models includes a strategic approach and cooperation between marina's management and local institutions. Adaptation of official policy for implementing quality system management in marinas is of prime interest. Finally, the results are related to the integration of available resources in marinas and environmental management system which is directly affected the development plan for future marina actions.

Key words: Marinas, nautical ports, environmental management system.

1 INTRODUCTION

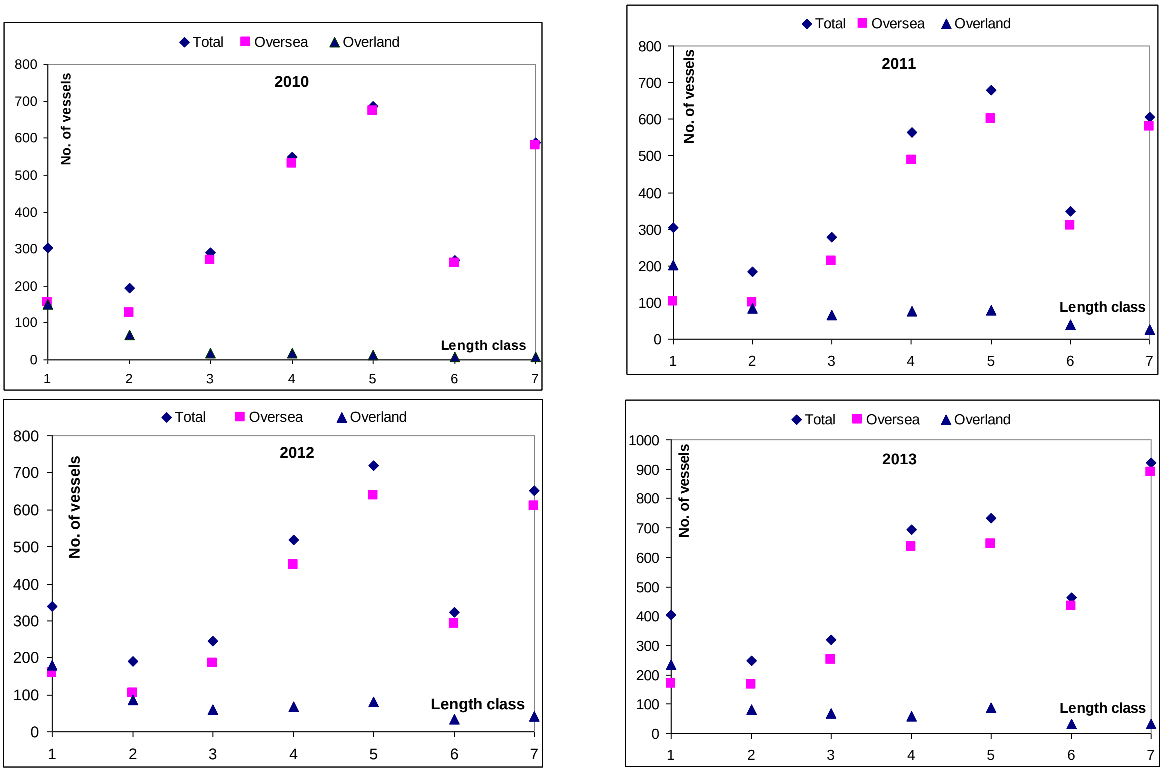
Recently, nautical ports concept became very famous in Montenegro due to the very competitive environment and neighborhood that are specialized for sustainable marina concept in Italy, Greece and Croatia (Dragović and Tselentis, 2014; Dragović et al., 2014a,b; SUST-MARINA, 2014; Škurić et al., 2014). In this paper, we investigate the Montenegrin marinas and nautical ports, present their achievements in the sense of vessel traffic analysis and also, pay attention to the sustainable concept and the level of environmental management system in coastal areas. The paper should describe the current conditions and provide the directions for improvement. Definitely, there is area for improvement since the country disposes with 300 km of coast and some new marinas were developed in the past few years.

As a matter of fact, the Environmental Management System (EMS) provides a mechanism for environmental management throughout all functional areas of port facility. The EMS is designed to cover environmental aspects that facility can control and directly manage as well as those aspects it does not control or directly manage but can be expected to influence. This can contribute to general improvement of management performances of marina operations and such will be considered as an area of potential improvements. Overall, Environmental Management System can be defined as a set of evaluation results, in which the policies, plans, procedures and review mechanisms is applied by some organizations in order to achieve the set goal in relation to the performance of the organization when it comes to the environment (Bataković et al., 2011; Bataković, 2013).

The structure of the paper is organized as follows. Section 2 gives the parameters for determination of capacity achievements in the sense of foreign vessel traffic in marinas and nautical ports. Section 3 discusses about the EMS in order to provide a background and advantages of the applied system in marinas. Section 4 explains the current conditions in AD Marina Bar as the biggest one in the country while Section 5 gives concluding remarks.

2 CAPACITY ANALYSIS

From the official Statistical Office of Montenegro and indicators for arrival of foreign vessels for entertainment, sport or recreation in the internal sea waters of Montenegro, in Figure 1 we provide a statistical analysis of achieved throughput of vessels from 2010 to 2013. Vessels are presented as a vessels' length class whose characteristics are given in the legend below (MONSTAT, 2015).



Legend: Class 1: to 6 m; Class 2: 6 - 8 m; Class 3: 8 - 10 m; Class 4: 10 - 12 m; Class 5: 12 - 15 m; Class 6: 15 - 20 m; Class 7: more than 20 m (*Source: MONSTAT*, 2015).

Figure 1: Achieved throughput of foreign vessels in nautical ports in Montenegro from 2010 to 2013

From Figure 1 can be noted that there were a steadily growth in the achieved throughput from 2010 to 2012 and a big increase in traffic for 2013. This achieved throughput of foreign motor yachts and sailboats is very important parameter because it reflects the attractiveness of the region. In that sense, and on the basis of increased arrival of foreign visitors with vessels, nautical ports and marinas have to define and determine the environmental policy in the area.

3 ENVIRONMENTAL MANAGEMENT SYSTEM ISSUES IN MARINAS

Existing management practices regarding environmental issues in Montenegrin nautical ports are focused on the fulfillment of legal obligations and compliances. Overall approach within existing management practices which implies constant improvement of marinas performances regarding protection of environment is missing. Based on analyses of activities in relation to the impact on the environment in nautical ports and marinas, it is obviously that more strategic approach would be necessary. In relation to that, as a first step of implementation of EMS, it is necessary to recognize significant environmental aspects in relation to port activities as potential points for improvement from the management point of view. After recognizing of significant aspects, it is necessary to define a goals and targets and to develop environmental policy of port as main tools for improvement of existing performances of marina in relation to the environmental important issues and by that to improve overall management of organization (Bataković et al., 2011; Bataković, 2013).

Defining the general and specific objectives implies consultations with managers of sectors within the marina authority and to analyze the relevant legal requirements and significant environmental aspects. This means that it is necessary to consider:

- Relevant legislation,
- Significant aspects of environmental organizations and operations,
- Technological, financial, operational and other business requirements,
- Reviews of employees and other stakeholders.

Based on the defined objectives and targets for the significant environmental aspects environmental protection program should be developed as a main tool for that represents an action plan (plan of specific activities) with defined responsibilities, which will lead to achieving the defined goals. In Table 1 are presented characteristics and issues for potential areas of EMS improvement and corresponding activities.

Table 1: Characteristics for potential areas of EMS improvement (*Source: Bataković et al.,* 2011)

Environmental issue	**Activities**
Soil and Waste	Waste disposal Accidental oil spills Traffic Bunker operations Dragging (disposal of polluted sediments)
Water	Water consumption Waste water discharges
Chemicals	Oil products discards Accidental oil spills Bunker operations
Air quality	Traffic Hydrocarbons manipulation, storage and emissions
Noise	Handling equipment Transport system
Odors	Transport emissions
Energy consumption	All marina and port activities
Accidents	Handling of liquid Spills

4 CASE STUDY: AD MARINA BAR

Thanks to the sustainable development project in AD Marina Bar, the international team as well as marina management recognized the potential and main benefits from the introduction of EMS in the marina in relation to the established practice of management as follows (SUST-MARINA, 2014):

- Improving the performance of the organization relating to the protection of the environment;
- Improving compliance operations and processes which ultimately results in better compliance with the legal standards and requirements;
- The possibility of a more competitive business market, increase efficiency, which implies a reduction of costs, additional staff motivation (greater involvement, awareness, responsibility), raising awareness of employees compared to the importance of environmental protection;
- Improving corporate social responsibility.

To define sustainable development concept in Montenegro, some main objectives have to be evaluated, and are related already in the case of AD Marina Bar to seeking the Blue Flag programme, ISO 14001:2004, ISO 9001:2008 and Gold Anchor Scheme. The main point is to reduce the costs and to have environmentally protected area. The linkage between the Blue Flag, ISO standards and Gold Anchor Scheme to provide all environmental aspects of the marina's activities, using a logical, objective (rather than subjective) methodology to rank such aspects into order significantly impact upon the environment (SUST-MARINA, 2014). For marinas that have introduced Quality Management System (QMS), it is considered as a good base to facilitate the development and implementation of EMS. Since, activities of marinas are very connected with impact on the environment issue of good management practices of activities in regard to the environmental standards are more then important aspects in overall management of marinas. Therefore, the introduction of EMS for marinas that have QMS already in place would represent an upgrade of the existing management system, which would significantly contribute to the further improvement of the management of the organization through the application of standards ISO 14000.

5 CONCLUSION

According what is presented in the previous Sections, the introduction of the EMS system and sustainable development concept in marinas and nautical ports evidently would contribute to develop a new approach to the management of the organization. Identified aspects and issues clearly lead to the assumption that certain activities of marinas have a negative impact on the environment, to some extent, so there is space to improve organizational management performances in relation to the environment. Based on capacity analysis and activities towards environmental issues as well as a case study of AD Marina Bar, the main objective of recognition of potential areas for improvement are specified. This implies development and implementation of principle of 'pollution prevention' through operational best practice actions, emissions management, waste minimization and efficient resource use. In that regards, management of marina should develop and implement programs and procedures regarding management of main environmental aspects to assure compliance with relevant national and international legislation and best sustainable practices.

It can be concluded that non-compliance activities with the legislation can cause significant expenditures and therefore have a significant impact on the financial operations of the marinas. This will especially be the responsibility in the upcoming period bearing in mind the strict policy of the European Union on environmental issues. Therefore, the application of environmental standards as a tool to achieve adequate compliance activities with legal norms in relation to the protection of the environment should be very important issue and area of improvement in relation to build sustainable management system, which contributes to the fulfillment of legal obligations but also which will lead to achieving the highest standards in overall management principles.

ACKNOWLEDGEMENT

The study was carried out within the Project MNE-HERIC-81180, "Applying and promoting the concept of sustainable development to A.D. Marina Bar (SUST-MARINA)", financed within the scope of "Higher Education and Research for Innovation and Competitiveness in Montenegro" – ("HERIC") project, from the International Bank for Reconstruction and Development loan, in accordance with the Decision of the Ministry of Science of Montenegro on awarding the grant: Number: 01-1062 from 29th May 2014.

REFERENCES

[1] Bataković, M. (2013). Effects on Environmental Management Standards' Requirements on the Development of a New Approach to System Management, Master thesis, University of Montenegro.

[2] Bataković, M., Vukčević, M., & Bulatović, I. (2011). Environmental Analysis of Port of Bar. Project ECOPORT 8, Environmental Management of Transborder Corridor Ports, Code SEE/A/218/2.2/X.

[3] Dragović, B., & Tselentis, B.S. (2014). Some Approaches to the Sustainable Marina Concept. *Proceedings of* 3rd *International Conference on Production and Supply Chain Management*, Athens, Greece (pp. 1-4).

[4] Dragović, B., Tselentis, B.S., Škurić, M., Meštrović, R., & Papan, S. (2014a). The Concept of Sustainable Development to Marina. *Proceedings of* 14th *International Conference Research and Development in Mechanical Industry – Special Session*: *Sustainable Development in Maritime Transportation and Logistics*, RaDMI 2014, Topola (Serbia), Bar and Kotor (Montenegro), *1*, (pp. 340-345).

[5] Dragović, B., Tselentis, B.S., Papadimitriou, S., Šerović, D., Škurić, M., Meštrović, R., & Mikijeljević, M. (2014b). A Study Approach of Marina Sustainable Development Framework. *Proceedings of* 14th *International Conference Research and Development in Mechanical Industry – Special Session*: *Sustainable Development in Maritime Transportation and Logistics*, RaDMI 2014, Topola (Serbia), Bar and Kotor (Montenegro), *3*, (pp. 1031-1038).

[6] Statistical Office of Montenegro MONSTAT, (2015). http://www.monstat.org/eng/index.php

[7] SUST-MARINA Project, (2014). Application Form - Applying and Promoting the Concept of Sustainable Development to AD Marina Bar. HERIC project, Collaborative Research and Development Subprojects, approved in 2014 to Maritime Faculty, University of Montenegro by Ministry of Science (Montenegro).

[8] Škurić, M., Dragović, B., Ćorić, A., Markolović, T., & Božović, A. (2014). Study of Marina Development: Evaluation and Perspective. *Proceedings of* 14th *International Conference Research and Development in Mechanical Industry – Special Session*: *Sustainable Development in Maritime Transportation and Logistics*, RaDMI 2014, Topola (Serbia), Bar and Kotor (Montenegro), *3*, (pp. 1011-1016).

ANALYSIS OF EUROPEAN AIRPORTS' STRATEGY DURING THE GLOBAL ECONOMIC CRISIS

Igor Štimac, M.Sc, IAP, AvMP
Damir Vince, M.Sc, IAP, AvMP
Zagreb Airport Ltd.
Rudolf Fizira Street no.1, P.O. Box 40, HR - 10150 Zagreb, Croatia
istimac@zagreb-airport.hr, dvince@zagreb-airport.hr

Ivica Kovačić, B.Sc.
International Air Transport Association
800 Place Victoria, P.O. Box 113, Montreal, Quebec, Canada
KovacicI@iata.org

ABSTRACT

An airport is a fundamental element of the air transport system. Airport infrastructure and operational characteristics, allows versatility to other transportation modes. Looking back, a significant expansion of airport infrastructure began in the early 1960s, with the use of an aircraft jet engine for commercial purposes. From the 1970s to the 1990s a significant proportion of the financial resources for building and expansion of airports was invested by states. In the Commonwealth countries, especially in the UK, Australia and Canada those investments were mainly obtained from public funds. Throughout the 100 years of commercial aviation, most of the airports were state-owned and operated as a public company run by the civil servants. State bodies and agencies were policy makers and at the same time they were responsible for airport operability, efficiency, financing and marketing, with the objective to increase traffic and ultimately increase revenue. While many airports were privatized, those remaining in state ownership are still dependent on the state money and the state investment strategy. Any unforeseen event that as a result causes economic crises has a strong negative impact on sustainable development. The last global economic crises began at the end of the year 2007 in the United States, its expansion to Europe and other parts of the world was significantly felt at the end of the year 2008, and in the year 2009 the entire economies of the European countries started with the negative GDP trend. The global economic crisis has significantly affected all sectors of the economy, but it was mostly reflected on one of the most vulnerable sectors, and that is the tourism sector, which goes hand in hand with air transportation. The past trends show that both, leisure and corporate travellers are amongst the main contributors to the strong development of airport capacity worldwide, maintaining over one million jobs in both developed and developing countries. The world economy has become dependent on air transport industry. The consequences of the economic crisis felt in the air transport industry, primarily airports, and how the airports have reacted by changing their strategy with the aim of saving their sustainable development, will be presented in this research paper.

Key words: Airport strategy, global economic crisis, aviation trends, aviation economy.

1 INTRODUCTION

Over the years, many crises have affected the developing trend of air traffic with varying intensity. Figure 1 shows the cross-section of crises from the year 1968 to the year 2012 in relation to the movement of RPK (Revenue per kilometer). Looking from the aspect of the European Union, the transport system has become a very important economic factor of its economy. At the same time it is a very sensitive system whose trends are dependent on economic developments in other sectors. By the end of 2008, the world financial crisis has reached increasing proportions and it has become a real global economic crisis. The global economic crisis has significantly affected all sectors of the economy, but mostly it was reflected in one of the most vulnerable sectors: tourism industry that is closely related to air transport. The past trends show that the tourism and travel of passengers contributed to the strong development of airport capacity worldwide, maintaining over one million jobs in both developed countries and those which are marked as „developing“ countries. The world economy has become dependent on air transport. The consequences which the economic crisis has left on the air traffic were the following: a drastic reduction in traffic demand for the transport of passengers and cargo; changes in traffic flows (e.g. through connecting routes); lower company profits and a dramatic financial condition of airline companies which lead to the change of strategy.

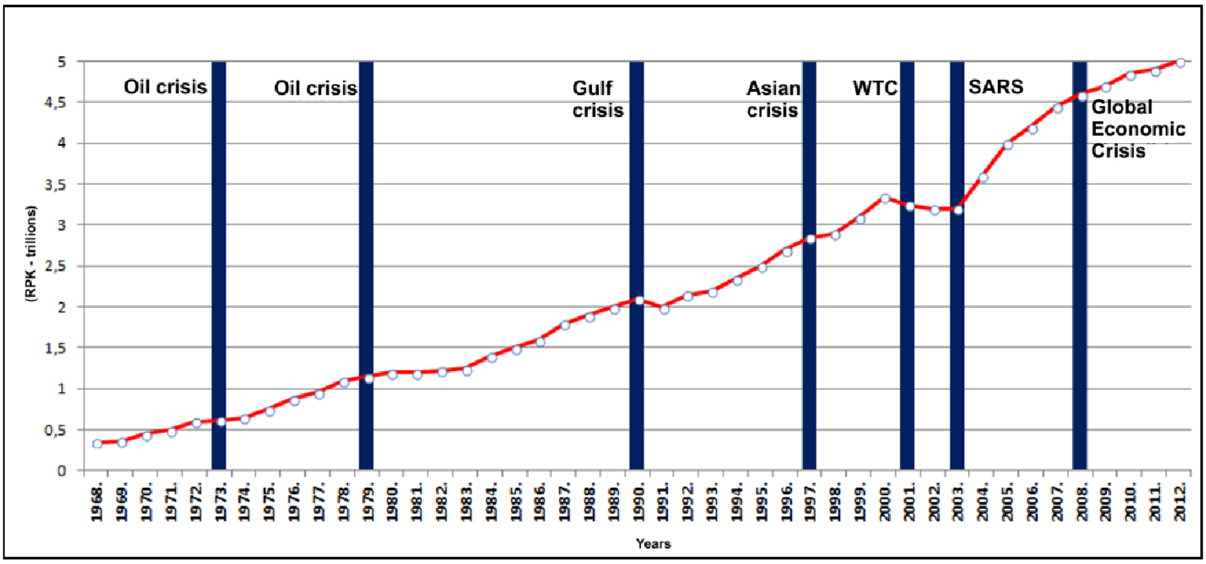


Figure 1: Overview of the trend of the RPK for the period from year 1968 to year 2012

Source: Prepared by the author according to Advola presentation (IATA, Airbus) & Airbus Forecast

2 ANALYSIS OF ECONOMIC CRISIS EFFECT ON EUROPEAN AIRPORTS

Although experts started to talk about the economic crisis in the United States during the late 2007, its spread to Europe and other parts of the world was significantly felt in the late 2008 and in 2009 when the entire economies of all the countries in Europe started with the negative trend of GDP. This trend can be read especially in the relationship between economic parameters and changes in the number of passengers. When the world economy grows, the need to travel increases and it results on the increasing number of passengers at airports. When the global economy is in decline (especially the amount of GDP), the number of passengers is also falling. The relationship between economic parameters, changes in the number of passengers and the number of tourist arrivals divided to the individual countries can be found in the table 1.

Table 1: GDP/capita by countries with a GDP < $ 30,000 compared to year 2000

State	Segment	2006	2007	2008	2009	2010	2011	2012
Austria	GDP per capita	6,0%	15,0%	10,0%	-7,7%	-2,1%	10,4%	-4,8%
	Number of passenger air transportation	5,1%	3,8%	5,7%	-2,8%	21,2%	3,1%	4,2%
	% of total unemployment working citizens	4,7	4,4	3,8	4,8	4,4	4,1	n/a
	The number of international tourist arrivals	1,6%	2,5%	5,6%	-2,6%	3,0%	4,6%	n/a
Belgium	GDP per capita	5,3%	14,1%	9,5%	-7,5%	-1,9%	8,2%	-6,7%
	Number of passenger air transportation	9,0%	12,0%	44,2%	-17,3%	2,2%	14,7%	2,7%
	% of total unemployment working citizens	8,2	7,5	7,0	7,9	8,3	7,1	n/a
	The number of international tourist arrivals	3,7%	0,7%	1,7%	-4,9%	5,4%	4,3%	n/a
Croatia	GDP per capita	11,3%	19,1%	17,3%	-10,5%	-5,2%	8,3%	-8,4%
	Number of passenger air transportation	2,3%	-28,1%	13,4%	-4,2%	-6,1%	14,9%	3,3%
	% of total unemployment working citizens	11,1	9,6	8,4	9,1	11,8	13,4	n/a
	The number of international tourist arrivals	3,2%	7,1%	1,2%	0,3%	4,8%	9,0%	n/a
Finland	GDP per capita	5,8%	17,9%	10,0%	-12,4%	-2,2%	11,4%	-5,5%
	Number of passenger air transportation	7,4%	9,1%	-4,5%	-6,2%	13,6%	9,5%	-9,4%
	% of total unemployment working citizens	7,6	6,8	6,3	8,2	8,4	7,7	n/a
	The number of international tourist arrivals	7,5%	4,3%	1,8%	-4,5%	7,2%	14,2%	n/a
France	GDP per capita	4,8%	13,8%	9,0%	-8,0%	-3,2%	8,5%	-6,5%
	Number of passenger air transportation	13,5%	3,4%	-0,5%	-4,7%	-4,4%	5,5%	2,3%
	% of total unemployment working citizens	8,8	8,0	7,4	9,1	9,4	9,3	n/a
	The number of international tourist arrivals	3,9%	3,8%	-2,0%	-3,1%	1,2%	4,8%	n/a
Germany	GDP per capita	5,1%	14,7%	9,2%	-8,7%	-0,3%	9,6%	-5,7%
	Number of passenger air transportation	9,8%	6,5%	1,7%	-4,2%	-1,5%	10,0%	-1,3%
	% of total unemployment working citizens	10,3	8,6	7,5	7,7	7,1	5,9	n/a
	The number of international tourist arrivals	9,6%	3,6%	1,9%	-2,7%	11,0%	5,6%	n/a
Greece	GDP per capita	8,6%	16,2%	11,4%	-6,4%	-9,1%	-0,8%	-13,8%
	Number of passenger air transportation	0,3%	7,6%	-7,5%	-6,9%	12,9%	-7,6%	-13,5%
	% of total unemployment working citizens	8,9	8,3	7,7	9,5	12,5	17,7	n/a
	The number of international tourist arrivals	8,6%	0,8%	-1,4%	-6,4%	0,6%	9,5%	n/a
Hungary	GDP per capita	2,2%	21,1%	13,5%	-17,8%	1,8%	8,1%	-9,3%
	Number of passenger air transportation	-5,2%	20,9%	-0,7%	-5,1%	299,2%	10,0%	-13,9%
	% of total unemployment working citizens	7,5	7,4	7,8	10,0	11,2	10,9	n/a
	The number of international tourist arrivals	-7,2%	-6,7%	2,0%	2,8%	5,0%	7,8%	n/a
Iceland	GDP per capita	-0,1%	19,6%	-19,1%	-28,3%	3,9%	11,7%	-3,3%
	Number of passenger air transportation	0,5%	12,0%	-17,3%	-4,1%	13,8%	16,2%	14,1%
	% of total unemployment working citizens	3,0	2,3	3,0	7,2	7,6	7,1	n/a
	The number of international tourist arrivals	12,8%	14,9%	3,5%	-1,6%	-1,0%	15,7%	n/a
Italy	GDP per capita	4,3%	12,7%	7,6%	-9,0%	-3,7%	6,9%	-8,5%
	Number of passenger air transportation	1,6%	3,1%	-18,9%	8,2%	-1,7%	3,9%	-8,5%
	% of total unemployment working citizens	6,8	6,1	6,7	7,8	8,4	8,4	n/a
	The number of international tourist arrivals	12,4%	6,3%	-2,1%	1,2%	0,9%	5,7%	n/a
Netherlands	GDP per capita	6,0%	15,2%	10,8%	-9,0%	-3,2%	7,4%	-8,0%
	Number of passenger air transportation	5,1%	5,1%	2,6%	-1,7%	-9,6%	11,0%	3,7%
	% of total unemployment working citizens	3,9	3,2	2,8	3,4	4,5	4,4	n/a
	The number of international tourist arrivals	7,3%	2,5%	-8,2%	-1,8%	9,7%	3,8%	n/a
Poland	GDP per capita	12,5%	24,6%	24,5%	-18,7%	8,9%	8,8%	-5,0%
	Number of passenger air transportation	2,0%	17,8%	8,5%	-7,7%	-4,2%	8,5%	10,3%
	% of total unemployment working citizens	13,8	9,6	7,1	8,2	9,6	9,6	n/a
	The number of international tourist arrivals	3,1%	-4,4%	-13,5%	-8,3%	4,9%	7,1%	n/a
Portugal	GDP per capita	4,8%	14,6%	8,6%	-7,2%	-2,9%	5,2%	-10,3%
	Number of passenger air transportation	-6,9%	9,3%	8,2%	-11,3%	5,4%	5,6%	2,5%
	% of total unemployment working citizens	7,7	8,0	7,6	9,5	10,8	12,7	n/a
	The number of international tourist arrivals	10,1%	6,9%	2,6%	-7,5%	4,9%	7,5%	n/a
Spain	GDP per capita	7,6%	14,6%	8,9%	-9,3%	-5,5%	6,8%	-8,7%
	Number of passenger air transportation	6,6%	14,2%	-9,0%	-10,7%	7,6%	-0,2%	-15,4%
	% of total unemployment working citizens	8,5	8,3	11,3	18,0	20,1	21,6	n/a
	The number of international tourist arrivals	3,7%	1,1%	-2,5%	-8,8%	1,0%	7,6%	n/a
United	GDP per capita	6,2%	14,4%	-6,9%	-18,1%	2,6%	7,5%	-1,1%

State	Segment	2006	2007	2008	2009	2010	2011	2012
Kingdom	Number of passenger air transportation	4,2%	4,2%	3,0%	-2,1%	-0,6%	9,9%	2,7%
	% of total unemployment working citizens	5,4	5,3	5,3	7,7	7,8	7,8	n/a
	The number of international tourist arrivals	9,3%	0,7%	-2,4%	-6,4%	0,3%	3,6%	n/a

Source: Prepared by the author according to the World Bank

According to the analysis of the available data from the World Bank, ACI and IATA, the global economic crisis was significantly manifested in the air transport industry in the last quarter of 2007, when profits started to decline significantly. Travel agencies were the first to report the sudden drop of 20% in reservations and bookings. In late September, US airlines announced the first data which indicatively marked the disruption of the market with a reduction in RPK. This also happened in a short time in Europe, where in October it increased by a modest 4%, while in the second half of November there was a significant reduction, which results in a 1% increase only for European companies at the end of the year. The next several figures show the influence of the global economic crisis on several European airports segmented into categories, such as primary and secondary HUB airports, regional airport and airport for low-cost airlines.

HUB airport - Analyzing the four airports categorized as Super Hubs an almost identical trend can be noticed in passenger traffic during the monitored months in the period between the years 2008 and 2013. On Super hubs airports, economic crisis in passenger traffic began to be felt in the middle of the year 2008, and it lasted until September 2009, when airports recorded the first continuous growth in passenger numbers (Figure 2). Although the economic crises had a significant impact on the negative trend of air traffic in Europe, due to the well development of network destinations, super hubs recorded a smaller negative trend of passenger traffic on an average of -4.5%. A significant drop in traffic is visible in April 2010, caused by the closure of airspace over Europe due to the eruption of the Icelandic volcano Eyjafjallajökull.

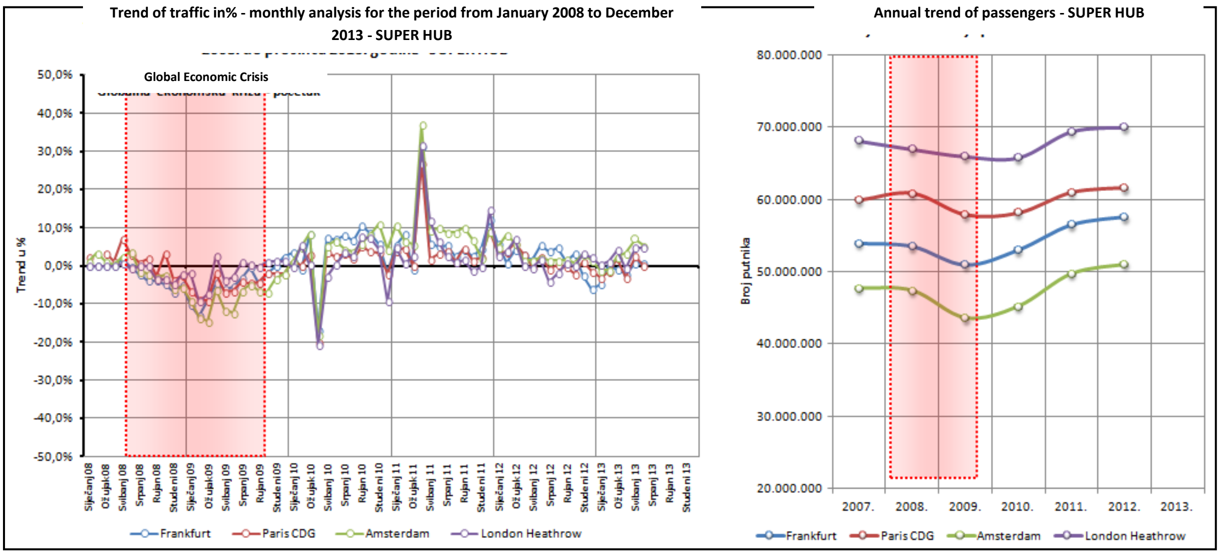


Figure 2: Analysis of the impact of the economic crisis on the Super Hub airports

Source: Prepared by the author according to the database Anna Aero

Primary HUB airport - Comparing the impact of the economic crisis on primary hub airports in relation to the Super HUB airports, it is evident that the crisis began to be felt a little earlier, in the first part of the year 2008, and the first recovery in passenger traffic can be seen in mid-2009 (Figure 3). On primary hubs airports significant fluctuations can be seen in the trend of passenger traffic between the observed airports, and the average amount fall in passenger traffic during the impact of the crisis was -7.5%. On the right side of Figure 3 it can be noticed that the trend in passenger traffic at the Istanbul Ataturk Airport which, despite the small decline in traffic during the end of 2009 in certain monthly periods, recorded a significant growth in passenger traffic compared to similar airports at the annual level.

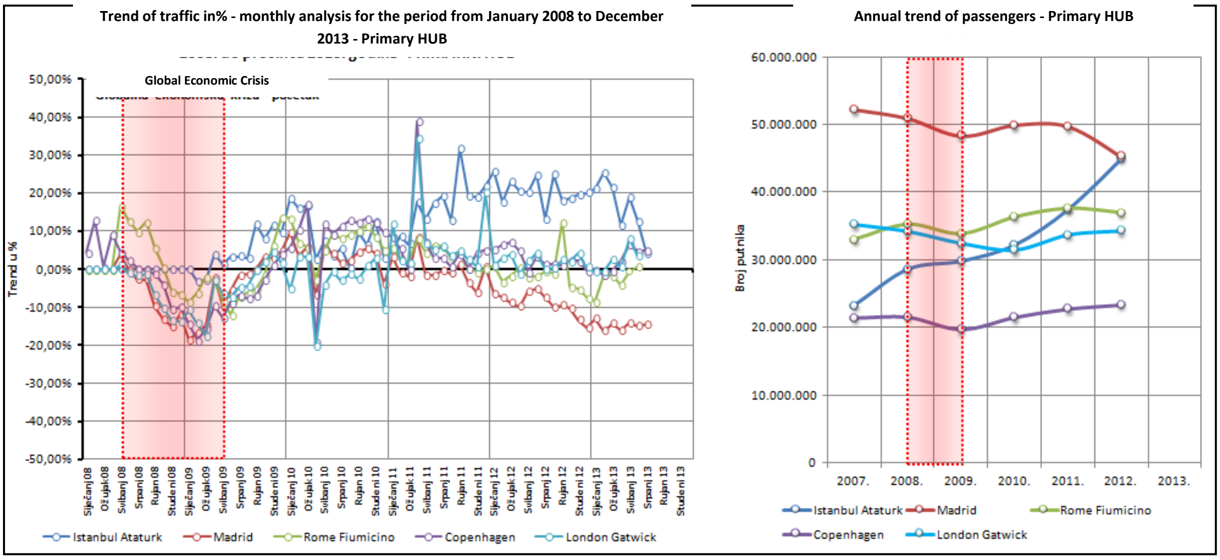


Figure 3: Analysis of the impact of the economic crisis on the primary HUB airports

Source: Prepared by the author according to the database Anna Aero

Regional Airports - From the analyzed data of the observed regional airports, the airports began to feel the economic crisis and follow a negative trend in May 2008, which lasted until November 2009. Although the Figure 4 shows a roughly similar trend in the passenger numbers, it is important to note significant differences in the percent value by an average of observed airport that was -9.2%, and the biggest decrease was recorded in Ljubljana Airport in February 2009 with -25.2%. Looking at the annual traffic trends, regional airports show that only Ljubljana Airport is following the negative trend, also caused by the negative financial situation and the poor performance of the Slovenia national flag carrier Adria Airways, which has a share of the turnover of 73.7% at Ljubljana Airport. Zagreb Airport recorded stagnation in traffic, although the largest airline, Croatia Airlines is in serious financial problems, and for Zagreb Airport this represents a serious threat given the fact that the traffic share of Croatia Airlines is approx. 62% of the total passenger traffic.

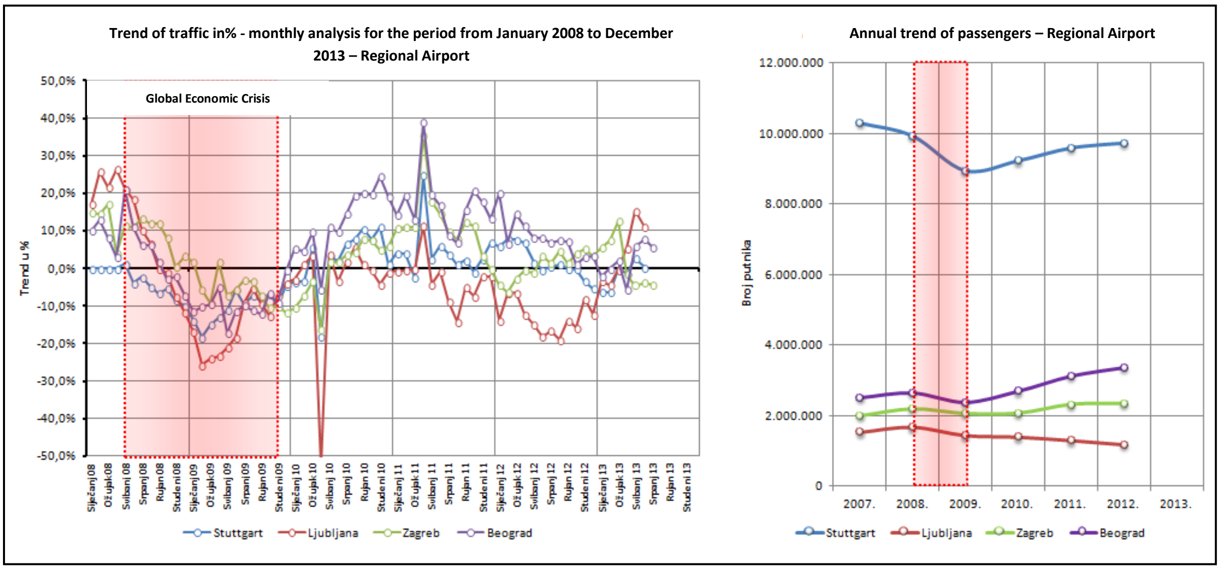


Figure 4: Analysis of the impact of the economic crisis on regional airports

Source: Prepared by the author according to the database Anna Aero

Low-cost Airports - Airports with more than 95% share of low cost carriers throughout the study period showed significant fluctuations in passenger traffic regardless of the impact of the economic crisis. Although the economic crisis started the negative trend in most of the observed airports in September 2008, the same negative trend continues until the beginning of 2012 (Figure 5). Airport Charleroi, known for its airline Ryanair, which is used as a base in times of crisis, has shown a positive growth trend compared to the same months in recent years.

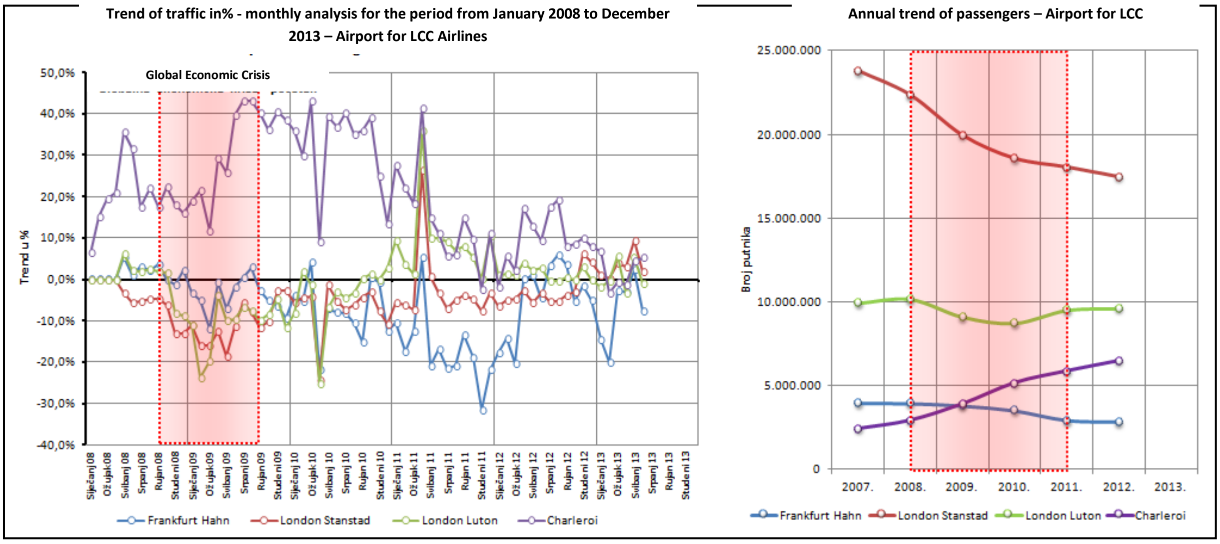


Figure 5: Analysis of the impact of the economic crisis on "low-cost" airport

Source: Prepared by the author according to the database Anna Aero

3 REACTION OF EUROPEAN AIRPORTS ON THE GLOBAL ECONOMIC CRISIS

Business of airlines and airports is directly connected. The drastic decline in the business of airline in Europe and a number of airline bankruptcies due to the economic crisis has severely affected the European airports, especially in the segment related to their primary business. The economic crisis has affected the airport with a sharp drop in aeronautical revenues as a result of a small number of flights, and reducing non-aeronautical (commercial) revenues due to the fact that there were also fewer passengers in the terminals. The percentage of airports in Europe that recorded a decline in passenger traffic amounted to 86%.

Due to all the mentioned facts, the reaction of airports had to be fast and efficient, but unlike the airlines that can stop flight to one destination and open another route to different (profitable) destination, the airport had to "live" with the cost of the entire infrastructure that they had to maintain regardless of the level of traffic. For this reason the strategy of airports is focused on cost cutting and restructuring that includes reducing the number of employees in some cases up to 25%. In that context, most European airports seek not to increase costs or limit the increasing of planned costs with the aim of protecting its competitive position for the duration of the global economic crisis[1]. For the sustainability of the airport in the period of the global economic crisis and huge instability of air traffic, certain activities had to be taken with the aim of adapting airports to the emerging market conditions. These activities include:

- **Cost reduction**
  - Reducing the number of employees: Amsterdam-Schiphol -25%, Dublin -20%, Manchester -5%, SEA Milan -30%
  - Reduction of capital investment: -2.8 billion €
- **Confirmed the most capital investment**: 50 billion €
  - Accepted long-term plan and sustainable development of the airport
  - The airports must be prepared for traffic growth = expected doubling of air traffic by the year 2030
- **Correction of aeronautical charges in the price lists of airports**
  There is a problem with the payment of provided services = reaction carrier in crisis situations
  - about 50% of airports in Europe have reduced aeronautical fees
  - about 19% of airports in Europe have retained the same price aeronautical charges
  - about 25% of airports in Europe have slightly increased aeronautical fees
  - about 6% of airports in Europe have significantly increased aeronautical fees
- **The strategy of focusing negotiations with a strong network and low-cost airlines**
  Airports have focused their business on tracking and negotiations with those airlines that recorded stagnation or growth during the global economic crisis, which is primarily related to the strong network airlines, such as Lufthansa and Turkish Airlines and low-cost airlines such as Ryanair, easyJet, Wizz Air and Norwegian Air Shuttle. By analyzing the available traffic data of the above mentioned airlines, mostly those using low-cost model, it can be concluded that their model is recognized as a

[1] Airports Council International (ACI), European Airports Responsive and Responsible in the Crisis, 23 July 2009

factor of success at the time of crisis, and their impact on airports increased significantly with the result of softening very negative business airport trends related to passenger traffic. One of the examples that illustrates the power and operability of the low-cost airline model during the economic crisis is the example of the bankruptcy of Hungary national flag carrier Malev. The Budapest Ferihegy International Airport had about 60% share from the Malev airline in total passenger traffic. When the Malev suddenly bankrupted due to the economic crisis, it was expected that the airport would have a significant decline in the number of passengers, but a week after the bankruptcy, the two strong European low cost airline, Ryanair and Wizz Air started negotiations with the airport management, after which they opened a large number of routes to many destinations from Budapest. The results showed that before the bankruptcy, the share of low cost carriers in Hungary on international flights was 23.6% in year 2011, while after the bankruptcy of Malev and entering of Ryanair and Wizz Air, the share was increased to 48.1% in 2012 with the similar amount of total passengers.

4 KEY GUIDELINES TO OVERCOME THE ECONOMIC CRISIS IN EUROPE

It is impossible to determine the exact formula of all the elements that could be implemented in the operations of the airport in order to completely eliminate the influence of the economic crisis on business, but there are several elements that airports used to facilitate the operations of the already unstable market of air transport and already affected airports. Some of them are the following:

- Implementation of differentiation facilities and services according to the requirements and needs:
    - Low cost airlines / Network airlines (Alliance)
    - Facilities intended to the network carriers were adapted to the needs of low-cost airlines (Marseille, Amsterdam, Bordeaux, Copenhagen, Milan Malpensa, Brussels, ...)
- Reduced dependency on the dominant air carrier:
    - For the unstable air transport market it is highly risky to have a large share of each operator in the total passenger or cargo turnover for the possible scenario of bankruptcy and for this reason its proportion is trying to be reduced,
    - The airport should make a decision according to which category the airlines (models) their business will adjust: the network operator or low cost airline
- Competitive airline fees "must" be:
    - about 3.5% (excluding Ground Handling) cost airline (ICAO recommendation)
    - Fees can be collected from the air carrier: 22% of total revenues airport
    - Air Traffic Control must follow the same example / principle
- Developing new sources of revenue
    - Commercial development - as much revenue from concession fees – Risk sharing
    - about 47% of total revenues airport
- International growth and the creation of alliances airports
    - Airport starts with the merger of airports with a common strategy and marketing. Example: ADP & Schiphol, SEA Milan & ADR, etc.
- Introduction of new technology - technology solutions

The introduction of new IT technology which speeds up the process and replaces the number of employees while reducing costs (CUSS kiosks, Web CKI, HBS Level 3)

5 CONCLUSION

The global economic crisis significantly affected any category of airports and airlines regardless of their typical business models. It is evident that the airports ware in a worse position than airlines by the fact that airlines are able to put out unprofitable lines and open those profitable, while the airport had to deal with the specifics of its business and location. Although it was difficult to survive and operate during economic crisis, very few airports operated with a profit. Their willingness to change policy and turning to new strategies that are primarily related to better negotiate with airlines, the increasing efficiency in all business segments and modification of aeronautical and non-aeronautical charges were the basis for creating a positive environment for the survival of the global economic crisis. Although sometimes it may seem that the airports, airlines, and even air traffic control are "islands with huge walls" whose cooperation is very often full of obstacles and sometimes unequal competition, during the global economic crisis it was once again confirmed the theory that only the cooperation of all stakeholders can lead not only to overcoming the crisis but also generate additional income in the same. A great example of how to operate in such difficult times showed Alliance strategy between Istanbul Airport and Turkish Airlines.

REFERENCES

[1] Štimac, I.; Vince. D.; Vidović, A. 2012. Efect of Economic Crisis on the Changes of Low-Cost Carriers Business Models. In proceedings of the 15th International Conference on Transport Science ICTS 2012.

[2] The World Bank Database: web: http://data.worldbank.org/indicator/NY.GDP.MKTP.CD

[3] Anna Aero Database; web: http://www.anna.aero

[4] Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR). 2008. Topical Report: Airline Business Models. Available from internet: http://ec.europa.eu/transport/

[5] Centre for Aviation (CAPA) and Innovata. 2013; web: http://centreforaviation.com

[6] Great Recession; web:http://en.wikipedia.org/wiki/Great_Recession

[8] IATA and Airbus - Advola presentation

[9] Airbus Forecast: web: http://www.airbus.com/company/market/forecast/

DRIVER`S AND PEDESTRIAN`S INTERACTION AT ZEBRA CROSSINGS IN URBAN SETTINGS

Matúš Šucha, PhD.
Palacky University in Olomouc
Krizkovskeho 8, 771 40 Olomouc, Czech Republic
matus.sucha@upol.cz

ABSTRACT

Our work is based on the social psychological theory of power distribution and psychological theory of communication, and how they explain how our behaviour in the public space is shaped. We assume, that power distribution between drivers and pedestrians is unbalanced, in favour of the drivers (the one who can force his way with his car as a shell). This affects drivers' and pedestrians' behaviour and their interactions at zebra crossings. The aim of this work was to describe pedestrian-driver communication and strategies at marked unsignalised crossings in urban areas. We aimed to understand strategies that pedestrians and drivers use in order to maximize their benefits (whether this means to save time, to feel safe or something else). Implications of this work are in identification of risky factors in drivers' and pedestrians' behaviour. Studying these processes should help to better understand pedestrians' needs and demands with respect to infrastructure design. In this paper, results concerning driver's yielding behavior and pedestrian's wait /go decision strategies are presented.

Key words: Pedestrians**,** zebra crossing**,** driver-pedestrian interaction/ communication**,** road-crossing strategies**,** pedestrian safety**,** pedestrians` accidents/ collisions**,** pedestrians` behaviour.

1 BACKGROUND

1.1 Walking as a mode of transport

Walking, the most traditional mode of transportation, can carry a high risk of injury or death on many roads. Motor vehicles have only been around for about a century but during that short time, they have often made walking hazardous. Walking as a means of transport is commonly used for rather short trips. This means that it is actually difficult to assess pedestrian mobility at country level, as the national travel surveys often do not register the shorter trips. Additionally, the walking parts of trips made primarily by public transport are usually not taken into account. At present, the importance of walking is therefore underestimated (Wittink, 2011). Walking is particularly important for children below the age of 12 and adults aged 75 and above. Survey data from a selection of seven European countries show that 12-30% of all trips are made by walking (as the main mode of transport), the highest figures being for the United Kingdom and the Netherlands (ERSO, 2013), the lowest for Finland. The average length of walking trips varies from just under 1 km (United Kingdom) to 2.8 km (Finland).

1.2 Encounters between pedestrians and drivers

Swedish studies (Danielsson et al., 1993, Trafikkontoret, 1994, Hyden et al., 1995) showed that only 30%, 4-6% and 24%, respectively, of drivers gave priority to pedestrians at zebra crossings. Griffiths and Marlow (1984) found in the UK that most drivers were only prepared to stop at a zebra crossing when a pedestrian still occupied or was approaching their part of the carriageway. In Finland, Himanen and Kulmala (1988) found that the most important explanatory variables influencing drivers' behaviour included pedestrians' distance from the kerb, the size of the city, the number of pedestrians crossing simultaneously, vehicle speed, and vehicle platoon size. In encounters, the drivers mostly continued to drive on; 10% of the drivers braked or weaved slightly, and 15% clearly braked/weaved. 16% of the drivers stopped because of the pedestrian. In a literature review on communication between road users, Persson (1998) found that the likelihood of a driver giving precedence increases if information about the pedestrian's intention is increased by way of the combination of various forms of signs. While almost none of the drivers gave precedence at a zebra crossing when the pedestrian just stopped at the kerb and looked at the approaching drivers, 31% stopped or slowed down when the pedestrian looked at the driver, put his foot on the carriageway, and made a hand sign that he was about to cross.

Situations in which the pedestrian passes first can be divided into three categories (Varhelyi, 1998):

1. crossing before the arrival of the car without influencing its speed;
2. situations when the approaching car is provoked to brake by the pedestrian who does not stop before crossing;
3. ideal situations, when the approaching car brakes on the driver's own initiative in order to give way to the pedestrian.

In encounters, three out of four drivers maintain the same speed or accelerate and only one out of four slows down or brakes (Varhelyi, 1998). The profile of mean speeds reaches its highest value at a distance of 40-50 metres before the zebra crossing, where it is statistically significantly higher than in non-encounters. This may be an indication of "competitive behaviour" in the form of "signalling by speed" that the driver does not intend to give way to the pedestrian. The driver's decision on the approach strategy is made approximately at this distance from the zebra crossing. In most cases, drivers expect pedestrians to stop and they place the responsibility for avoiding a collision on the pedestrian and thereby influence both the safety and access of the pedestrian. Drivers do not lower their speeds sufficiently in order to be prepared to stop in an unexpected dangerous situation.

It might be argued that it is better for pedestrians to cross the street with extra-large margins (when there are no cars nearby) instead of finding strategies that make drivers lower their speed. But pedestrians can also make mistakes; they may be unaware of an approaching car and they can step in front of it by mistake. For such a mistake they should not be sentenced to death (Varhelyi, 1998). Pasanen (1993) found that the speed of colliding vehicles was higher that the average speed of free vehicles in the reference traffic and the probability of a driver being involved in a pedestrian accident at a speed over 50 km/h was more than double when compared to a speed less than 50 km/h. On the basis of observations of car-pedestrian encounters at pedestrian crossings at non-signalised intersections in four European countries, Westra and Rothengatten (1993) found that the probability of a conflict was greater if the speed of the approaching vehicle was higher. The main findings from earlier studies on driver behaviour at zebra crossings can be summarised as follows:

1. The willingness of drivers to give way to pedestrians at zebra crossings is low (4-40%). However, what drivers claim to do is one thing and what they actually do is another. In a questionnaire (Dahlstedt, 1994) Swedish drivers were asked "How often

do you give way to a pedestrian at pedestrian crossings?" 67% answered "very often" or "always";
2. the presence of pedestrians at a zebra crossing has little or no speed-reducing influence on approaching vehicles;
3. drivers do not lower their speeds sufficiently to maintain a readiness to be able to handle a possible unexpected dangerous situation;
4. drivers are more willing to slow down or stop for crossing pedestrians when the speed of their vehicle is low;
5. explanatory variables with significant effects: the distance of the pedestrian from the kerb, the number of pedestrians crossing simultaneously, vehicle speed, and vehicle platoon size, but also the size of the city;
6. explanatory variables with no significant effects: street width, the presence of a refuge, the pedestrians' age or sex, and whether they are pushing a baby carriage or a bicycle;
7. the so-called free vehicles have a central significance.

Encounters between cars and pedestrians at zebra crossings are critical situations in which there is a need for better speed adaptation. In an encounter with a pedestrian, the driver has to be influenced before he or she reaches the "decision zone" 50 to 40 metres before the zebra crossing in order to prevent the "signalling by speed" behaviour. Empirical research with humps and mini-roundabouts shows that when vehicular speeds at zebra crossings are brought down to 30 km/h and below, the interaction between vehicles and pedestrians becomes more equitable and drivers are more willing to give way to pedestrians (Hyden et al., 1995).

2 AIM OF THIS STUDY

The aim of this work was to describe pedestrian-driver encounters, communication, and decision strategies at marked crossings. This included:

- pedestrians' behavior before and while crossing the road at marked crossings (and when a car is approaching),
- drivers' behavior while approaching a marked crossing when a pedestrian is on the sidewalk or about to cross the street,
- pedestrian-driver communication (such as eye contact, gestures, verbal expressions, and signals, such as the flashing of lights) in situations before and while crossing at marked crossings.

In this paper, results concerning driver's yielding behavior and pedestrian's wait /go decision strategies are presented.

3 STUDY DESIGN AND DATA COLLECTION

Mixed methods design was used, following these steps:

1. Exploration of pedestrian and driver needs and conflict situations (identification of the problem) – focus groups with pedestrians and drivers (separately).
2. Pilot observation and survey (spots, questionnaire, observation sheet, camera recordings).
3. Data collection: on site observations (4 spots - zebra crossing, in urban area, 3 observers, at each spot 50 hours), camera recordings (24 hour), speed measurement, car a pedestrians densities measurement and interviews (on site rapid interviews with pedestrians).

4. Exploration generalisation & development of recommendations – expert workshops.

On site observations were carried out during December 2013 – March 2014, observation times: 7.00 – 9.00, 12.00 – 13.00, 16.00 – 17.00. No snow, ice or wet conditions. Cameras recording – from selected spots, 24 hours, car and pedestrian densities were counted. Speed measurement at selected spots during observing times.

All together 1584 observations (observed situations at 4 spots) were analysed.

4 SITE DESCRIPTION

Four observation sites were selected - zebra crossings in the urban area of the city of Olomouc (approx. 100,000 inhabitants). Sites (Figure 1 – 4) were chosen based on these data:

- information from pedestrians and drivers from focus groups
- traffic data (accidents, densities)
- observation feasibility (possibility to have camera installed, suitable spot for observation)

Requirements for spots:

- unsignalised, marked pedestrian crossing
- 2 lane street (one lane each direction)
- high densities of pedestrians flow

Description of selected spots:

Figure 1: Single crossing, narrow street with turning vehicles, no traffic lights. Average speed: 28.2 km/h. Densities (cars/pedestrians: 3358/1903, ratio 1.76)

Source: Google maps.

Figure 2: Single crossing, narrow street, no traffic lights. Average speed: 29.9 km/h. Densities (cars/pedestrians: 3477/791, ratio 4.4)

Source: Google maps.

Figure 3: Crossing including a tram line and bicycle lane, narrow street, no traffic lights. Average speed: 29.9 km/h. Densities (cars/pedestrians: 4672/546, ratio 8.56)

Source: Google maps.

Figure 4: Crossing including a tram line and bicycle lane, narrow street, turning vehicles, no traffic lights. Average speed: 31.2 km/h. Densities (cars/pedestrians: 4609/930, ratio 4.96)

Source: Google maps.

5 RESULTS

Drivers in one third of the cases (36%) did not yield to the pedestrian, even though it was their duty, and when yielding to pedestrians, drivers prefer to slow down (47%) instead of stopping (17%) (Figure 5). On the other hand, pedestrians prefer drivers to stop (not only slow down) to feel safe and cross the road. 47% of all pedestrians waited until car stops before he or she started to cross the road. Only 18% of pedestrians started to cross when noticed, that driver is decelerating (Figure 6).

Approximately 1 out of 50 pedestrians cross the road even though car is approaching and driver is not yielding, which may lead to force driver to stop or to the traffic conflict.

Majority of drivers did not actively search for the eye contact with pedestrian (34%), on the other hand, great majority of pedestrians (84%) searched for eye contact and waited for confirmation from driver, before starting to cross.

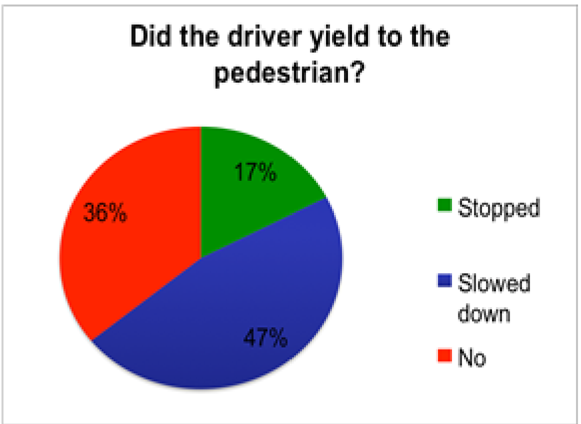


Figure 5: Did the driver yield to the pedestrian?

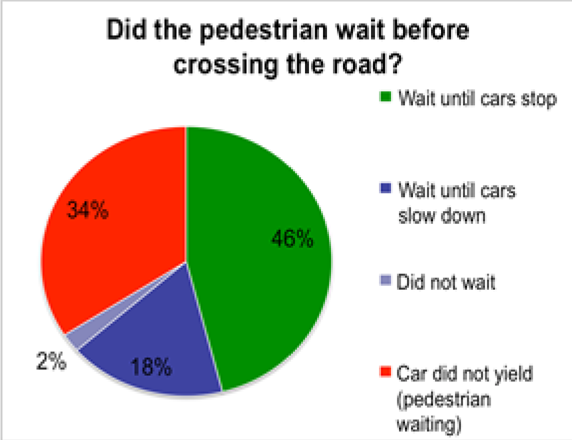


Figure 6: Did the pedestrian wait before crossing the road?

Factors which influence driver's yielding behaviour are presented in the table 1. We can summarize, that generally there is a strong relationship between preparedness/ willingness to yield to pedestrians and speed of approaching car, density of traffic, number and position of pedestrians waiting at sidewalk. The probability of a driver yielding to a pedestrian declines as the speed increases and as the traffic density increases. A driver is more likely to yield to a pedestrian when there is a platoon of cars and when there is a group of pedestrians is waiting to cross. A driver is less likely to yield if a pedestrian stands waiting more than half a meter away from the curb and if the latter is engaged in a different activity (such as writing a text message).

Table 1: Factors influencing willingness of driver to yield to pedestrian

Independent variable	B	Wald	Sig	Exp(B)
Car speed	-0,30	17,82	0,00	0,74
Road traffic density	-0,15	4,52	0,03	0,86
Pedestrian traffic density	0,12	2,13	0,14	1,12
The car was less than 10 metres away	-0,71	25,45	0,00	0,49
A line of cars was approaching (driving in platoon)	0,50	16,37	0,00	1,65
Child (0-12)	0,35	0,68	0,41	1,42
Male (13-25)	0,11	0,24	0,62	1,12
Female (13-25)	0,22	1,28	0,26	1,24
Female (13-25)	-0,04	0,03	0,85	0,96
Senior citizen (65+)	0,98	2,26	0,13	2,67
Group of pedestrians	1,04	24,49	0,00	2,82
The pedestrian stood waiting more than 0.5 m away from the curb	-1,06	6,64	0,01	0,35
The pedestrian used at least eye contact to give the driver a sign.	0,87	2,04	0,15	2,39
The pedestrian waited less than 5 seconds.	0,73	3,60	0,06	2,08
The pedestrian waited more than 5 seconds.	-1,04	55,33	0,00	0,35
The driver engaged in other activities while driving.	0,59	0,95	0,33	1,81
The pedestrian engaged in other activities while crossing the road.	-0,39	5,24	0,02	0,68
Invariable	0,00	0,00	0,99	1,00

On the other hand, it seems, that pedestrians wait/go decisions is mostly influenced by the influence of the car traffic. Data from the field observation showed statistical significant relationship according to the traffic density:

- pedestrians waited until the car came to a complete standstill (rather than slowed down) when the traffic density rates were low,
- pedestrians find it safer to cross the road when the traffic density is low,
- pedestrians waited for more than 5 seconds to cross when the traffic density rate was high.

6 CONCLUSIONS

Generally, the most relevant predictors of pedestrians' and drivers' behavior at crossing were densities of car traffic and pedestrian flows and car speeds.

Factors which influenced pedestrians' wait/go behavior were: car speed, distance of the car from the crossing, traffic density, whether cars are approaching from both directions, various signals from the driver (eye contact, waving, flashing of lights), presence of other pedestrians.

Factors influencing drivers' yield/go behavior were: speed (higher speed = lower willingness to yield), traffic density (higher density = lower willingness to yield), driver's willingness to yield increases where there is a group of pedestrians, pedestrian being distracted = lower willingness to yield.

The probability of conflict situations increases with cars travelling at higher speeds, higher traffic density, pedestrians being distracted by a different activity while crossing.

REFERENCES

[1] Björklund, G. (2005). *Driver Interaction – Informal rules, Irritation and Aggressive Behaviour*. Digital Comprehensive Summaries of Uppsala Dissertations from the Faculty of Social Sciences 8. Uppsala Universitet.

[2] Bjornskau, T. (1996). Why are the safest norms, attitudes and types of behavior not typical for the safest drivers? *Transport Reviews 16 (2),* 169-181.

[3] Dahlstedt, S. (1994). The SARTRE-tables. Opinions about Traffic and Traffic Safety of Some European Drivers. (VTI Report No. 403/403A): VTI, Linkoping, Sweden.

[4] Danielsson, S., Gustafsson, S., Hageback, C., Johansson, U., & Olsson, C. (1993). *Korsningen Radhusgatan-Storgatan, Seminarieuppgift i trafikanalys*. Tekniska Hogskolan i Lulea, Sweden.

[5] Diaz, E. M. (2002). Theory of planned behavior and pedestrians' intentions to violate traffic regulations. *Transport Research Part F, 5,* 169-175.

[6] European Research Safety Observatory. (2013). *Road safety knowledge base: Pedestrians and cyclists*. Retrieved on September 4, 2013 from http://ec.europa.eu/transport/road_safety/specialist/knowledge/pedestrians/index.htm.

[7] Griffiths, J. D., & Marlow, M. (1984). Delays at pedestrian crossings. 1. Site Observations and the Interpretation of Data. *Traffic Engineering and Control, 25 (7/8),* 365-371.

[8] Himanen, V., & Kulmala, R. (1988). An application of logit models in analyzing the behavior of pedestrians and car drivers on pedestrian crossings. *Accident Analysis & Prevention, 20 (3),* 187-197.

[9] Hjorthol, R., Assum, T., & Solheim, T. (1984). *Sociology in transport research*. Oslo, Norway: Transportokonomisk institutt.

[10] Hyden, C., Odelid, K., & Varhelyi, A. (1995). *Effekten av generell hastighetsdampning i tatort. Resultat av ett storskaligt forsok i Vaxjo*. (Bulletin 131): Lund University, Lund, Sweden.

[11] Hydén, C., Nilsson, A., & Risser, R. (1998). *WALCYNG. How to enhance WALking and CYcliNG instead of shorter car trips and make these modes safer*. European Commission, Transport RTD programme, 4th framework. Project WALCYNG. Deliverable D6.

[12] Katz, D., et. al. (1975). *Bureaucratic encounters: a pilot study in the evaluation of government services*. Ann Arbor, MI: Institute for Social Research: University of Michigan.

[13] Pasanen, E. (1993). *The Video Recording of Traffic Accidents*. Helsinki City Planning Department, Helsinki, Finland.

[14] Persson, H. (1988). Kommunikation mellan fotgangare ochbilforare (Communication between pedestrians and car drivers). Lund University, Lund, Sweden.

[15] Ross, L. (1977). The intuitive psychologist and his shortcomings: distortions in the attribution process. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (pp.173-220). New York: Academic Press.

[16] Ross, L., Greene, D., & House, P. (1977). The "false consensus effect": An egocentric bias in social perception and attribution processes. *Journal of Experimental Social Psychology, 13,* 279-301.

[17] Rothengatter, J. A. (1993). Road users' attitudes and behaviour. In G. B. Grayson (Ed.) *Behavioural research in road safety III (pp.128-134).* Crowthorne: Transport Research Laboratory.

[18] Rumar, K. (1990). The basic driver error: late detection. *Ergonomics, 33,* 1281-1290.

[19] Trafikkontoret. (1994). Lamnar bilister gaende fo retrade vid oreglerade overgangsstallen? Studie av sakerhet och beteende. (Do car drivers give priority to pedestrians at unsignalised zebra crossings? A study on safety and behaviour). (Rapport No. 10): Trafiknamnden, Goteborg, Sweden.

[20] Varhelyi, A. (1998). Drivers' speed behavior at a zebra crossing: a case study. *Accident analysis and prevention, 30 (6),* 731-743.

[21] Wittink, R. (2011). Cycling for sustainable development. Sharing Dutch expertise with the world. Delhi: EST forum.

[22] World Health Organisation. (2013). Pedestrian safety: A road safety manual for decision-makers and practitioners. Geneva: WHO.

[23] Zaidel, D. M. (1992). A modelling perspective on the culture of driving. *Accident Analysis and Prevention, 24 (6),* 585-597.

THE ANALYSIS OF TRANSPORT ACCESSIBILITY IN AIRPORTS AS THE PART OF THE COMPETITIVENESS IN REGIONS. CASE STUDY OF POLISH AIRPORTS

Dariusz Tłoczyński, Ph.D.
University of Gdansk
Faculty of Economics, Department of Transportation Market
81-824 Sopot, Armii Krajowej 119/121, Poland
University of Bydgoszcz
85-059 Bydgoszcz, Unii Lubelskiej 4C Street, Poland
dariusz.tloczynski@ug.gda.pl

ABSTRACT

Air transport is a dynamic component of a modern economy and the global transportation system. It is the youngest and the fastest-growing category of transportation, with its functions, structure and technologies well suited to meet the diverse market needs in terms of the carriage of passengers, cargo and mail. Air transport also fosters economic globalization, technological advancement and innovation. It is an important factor in bridging the gaps in the socio-economic development and civilization of countries, regions and continents.

As a result of the development of air transport in Poland, since the introduction of „open sky" policy, there is a need to provide research in relation to the availability of transport in regions. The airports are essential elements of a transport infrastructure. The research in this matter is vital for the economic development of airports and surrounding regions.

The problem of proper investment decisions in Polish airports is an important element in the development of competition between cities, between regions.

The aim of this paper is to present the factors influencing accessibility of the air transport in the region. The following analysis of air traffic is based on the statistical data. The relations between air traffic and economic development in regions have been clearly presented.

Basing on market research about development air transport in Poland, I analyzed the accessibility in Polish air transport market. Airport links as well as the most important infrastructure investments in the Polish airports have been clearly presented. In the last part of this paper, the results of research about availability of Polish airports have been analyzed.

Key words: Airport, accessibility, system airport links, Poland.

1 INTRODUCTION

Air transport is a dynamic element of modern economy and the global transport system. It is the youngest and the fastest-growing mode of transport, with its functions, structure and technologies well suited to meet the diverse market of needs in terms of the carriage of passengers, cargo and mail. Air transport also fosters economic globalization, technological advancement and innovation. It is an important factor in bridging the gaps in the socio-economic development and civilization of countries, regions and continents.

Due to the rapid development of the air transport market in Poland and the strong commitment of regions, there is a need for research on the issue of accessibility.

The main objective of this article is to determine the coefficient of accessibility - as an important instrument for shaping the supply offer on the Polish air transport market. For this purpose, an analysis of the air services market was carried out, as well as on the basis of the methods used in foreign airports research on the availability of air transport in the region was conducted.

2 THE THEORETICAL APPROACH OF ACCESSIBILITY ISSUES

The concept of accessibility is associated with the words: access and the ability [1]. Although in the English literature the availability is examined in relation to service and in relation to transport, the availability of transport is closely linked to the availability of services [2, 3].

In the English-language literature there is no unambiguous interpretation of this phenomenon. It is therefore necessary to consider transport accessibility of the market from three perspectives as:

- a system of airport links,
- airport accessibility,
- connectivity.

The term "airport links" specifies the way the passengers commute to the airport. By analyzing the problems of travelling to and from the airport, there are three approaches to the this problem:

- in terms of the time required for access to the airport,
- in terms of travel costs, parking cars, those are the aspects that can be dimensioned in monetary terms,
- competition between systems forming airport system links, the passenger then uses all possible instruments to compare different costs of getting to the airport.

It can be assumed that this is the dimension of the multi-criteria given by the following formula:

$$LogSum = \log\left(\sum_{i=mode} e^{-\beta GenConst(i)} + X\right) \qquad (1)$$

where:

X indicates all other factors included in the utility function, LogSum is a kind of inverted travel impedance: the more options you have to travel, the higher the LogSum value (and the better the accessibility is). Cheaper and faster options contribute more than slow and expensive options.

Similar studies for the system of airport links led Paul Koster, Eric Kroes and Erik T. Verhoef. They determined the cost model and travel time to the airport by the formula:

$$E(C)=\alpha * E(T) + \beta * E(SDE) + \gamma * E(SDL) + \theta * PMF + Z \qquad (2)$$

where:

E(C) - expected access travel costs, α – the value of airport access time, E(T) – expected travel time, β – the value of schedule delay early, E(SDE) – expected schedule delay early, γ – the value of schedule delay late, E(SDL) – expected schedule delay late, θ – the value of the probability to miss a flight, PMF – probability of missing the flight, Z – other time of day independent expenses, such as parking cost.

The main idea of the model presented by them is to determine the ideal time needed to get to the airport, so that the passenger is not too early or too late at the airport, at an acceptable cost.

The whole transport system of passengers commuting to airports consists not only of connections to and from the airports, but also transportation within the city or region. A specific type of agglomeration transport which are developing rapidly are connections to the airport. In the case of an increase in traffic of passengers at airports, bus is not the preferred means of transport. What is more, it should be taken into account that it is not able to provide such high comfort of travelling, high commercial speed, reliability and not exposing to transport congestion. Therefore, the expected part of air service offer is connecting the airport with the city center basing on rail transport.

The term "airport accessibility" means the ability of the region to communicate using the air transport, and therefore it is the air offer for a passenger of an airport, the number and frequency of air connections from the airport.

Accessibility of the region in relation to air transport may be defined as:

$$Access = \sum_{i=1}^{n} (Total\ number\ of\ seats)_{ij} * (weight_j) \tag{3}$$

where:
the total number of seats is the seating capacity of all flights to destination j from origin i, in the period and weightj is the index applicable to the jth destination airport.

The most important elements affecting the number of offered seats on the plane include:

- the number of direct flights from airports,
- the number of carriers operating at airports,
- the value of the GDP for the region,
- assessment of the investment attractiveness of the region [7].

Large regional airports, central airports together with the carriers, by the network of connections seek to create an interesting offer for the passenger's itinerary. The traveler selects the transport route (direct flight, with transit) (see Figure). In addition to the cost and time of travel analysis, the carrier, the interchange port, the time of waiting are also analyzed.

Airports Council International presents two types of connectivity:

- airports connectivity:
  - direct connections between the two airports,
  - indirect connections between the two airports using hub airports,
- hub airports connectivity - offering connections between two different airports through a hub airport [8].

In addition, you need to distinguish connectivity when traveling within Europe (medium haul) and global (long haul). In literature you may find several methods of calculating the communicate factor. Maligetti P., S. and R. Paleari Redoni have identified this index as a matrix of connectivity for the airport :

$$CI_i = \sum_{i=1, i\neq j}^{n} \frac{SPL_{ij}}{N-1} \tag{4}$$

where:

SPL_{ij} – the shortest path length between airports i and j, the N*N matrix of shortest path lengths, N- number of airports.

This matrix allows the estimate of the average number of steps needed to connect airports using the transit port(s), with a minimum waiting time at the transit airport. It takes into account the data contained in the schedules for all global carriers and airports, in particular: airport (where the take-off takes place), departure time, destination airport, arrival time or flight, the minimum transit time for the airport, the frequency of connections.

3 ACCESSIBILTY IN POLISH AIRPORTS

In Poland the airport links are based mainly on public transportation, connections to the airports are carried by rail (rail airport links) are slowly beginning to develop.

The first railway connection was launched on the route: the center of the city - the airport in Krakow in 2006. Although this is the connection dedicated to the airport, the passengers travelling from Krakow commute by train to Krakow Balice and continue the journey by airport bus (Shutte bus) or walk approximately 500 meters on foot. While in the first year of operating (from June 2006 to June 2007) the carrier handled approximately 325,000 passengers, but in 2013 the number rose to 400,000 passengers.

On 1st June 2012 installed rail connection Legionowo and Sulejówek Milosna (through the city center of Warsaw) with Chopin Airport was launched. This connection is served by two rail carriers: Fast City Rail and Mazowieckie Railways. In 2013 this form of transport was used by over 1 million passengers.

Table 1: The system rail airport links in Poland

Airport	**Name of railway**	**Frequency [min.]**	**Fares one way [PLN]**	**Travel time between the city center and airport [min.]**
Bydgoszcz	-			
Gdansk	Pomeranian Metropolitan Railway*	15	-	23
Katowice	future			
Crakow	Balice Ekspres	30	14,50	20
Lublin	-	5 times per day**	5,30	16
Lodz	-			
Modlin	-			
Poznan	-			
Rzeszow	-			
Szczecin	Szczecin Airport Express***	8 times oer day****	12	40
Warsaw	-	15	4,40	25
Wroclaw	-			

* start in summer / autumn 2015.
** - timetable is dependent on the arrivals and departures of aircraft
*** - conections only to airport
**** - frequency depends on the days of the week

Source: www.pkp.com.pl, www.airport.com.pl, www.lotyzlublina.pl, www.krakowairport.pl, www.ztm.waw.pl – (15 January 2015).

At the end of 2014 in several Polish airports the system rail airport links connections developed (Table 1).

In the coming years, we expect greater cooperation between rail operators and airlines. Just as it is in DB German railway, those traveling by plane will be able to use the special train fares on routes between the selected cities in Poland and other European countries.

While investments related to rail transport require substantial financial expenses for essential infrastructure and are possible to realize in the long run, bus connections are cheaper and it is possible to start them faster. Thus, in Poland and also at many European airports, public bus transport is essential for efficient service of transport between the airport and the city center.

Passengers of Polish airports most frequently made their way to the airport from the place of residence in 20 minutes. Half of the passengers arrived at the airport in less than 50 minutes, while for the other passengers in more than 50 minutes. The average time of travel to the airport was 66 minutes.

Way of getting to the airport is closely related to the nature of air travel and with social status. In Europe passengers using the services of low-cost carriers and charter trips and passengers who travel for tourism using aircraft carriers in economy class, mostly in transport to the airport use public transport services. In Poland every tenth passenger uses public transport services.

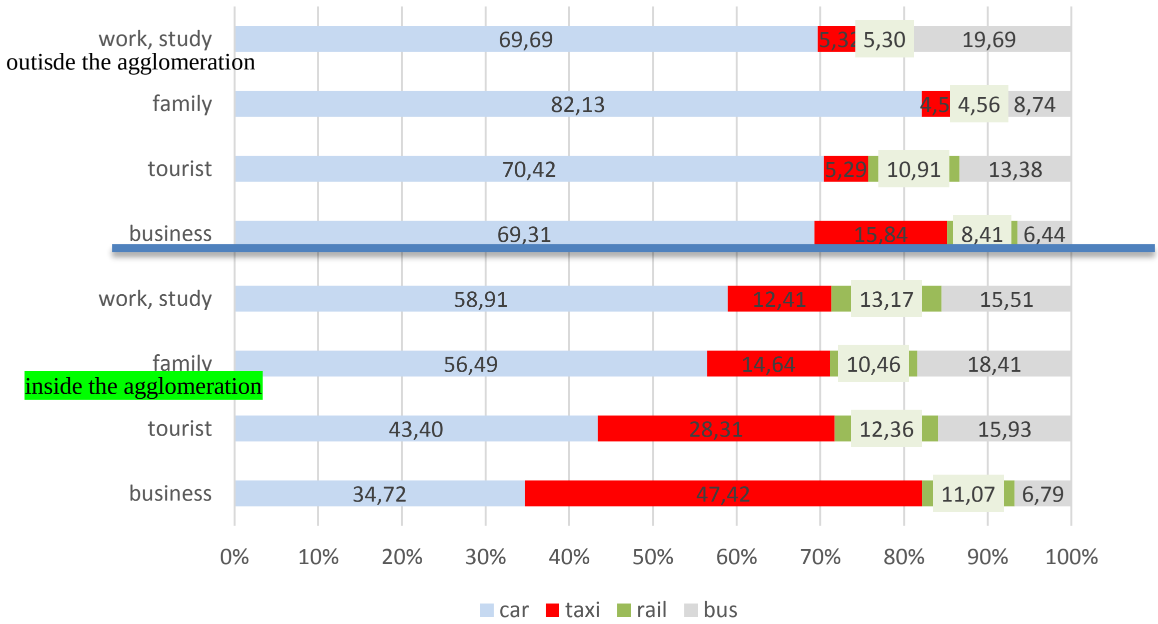


Figure 1: Travel between the city center and airport

Source: Based on the Author's research

Respondents who are passengers of Polish airports passengers most frequently used the car. This form of travel was chosen by commuters from outside agglomerations in which the airport is located. At small airports this form of commuting to the airport is dominant, regardless of destination. With regard to business travel contribution of public transport (bus 23%) of commuting to work, school, college and sport competitions is noticeable from large regional airports. At those airports a taxi is also essential means of transport. The lack of attractive offer of airport links system causes the dominance of individual transport in commuting to the airport, it varies according to the type of airports.

According to IATA's data carriers offering air transport services offered in the third week of June 2013 almost 305,000 seats in the aircraft. The supply of seats on selected flight connections is shown in Table 2.

Table 2: ASK on selected flight connections

Connections	Air carrier	Weekly frequency	Weekly ASK
Gdansk – London	Wizz	13	2340
	Ryanair	14	2646
Crakow – London	easyJet	7	1116
	Ryanair	14	2646
Katowice-London	Wizz	14	2520
	Ryanair	14	2646
Lublin - London	Wizz	3	540
	Ryanair	4	756
Poznan – London	Wizz	7	1260
	Ryanair	7	1323
Wroclaw-London	Wizz	5	900
	Ryanair	10	1890

Source: IATA (International Air Transport Association).

Competition occurs also on other routes, e.g. from Gdansk to the Scandinavian countries, from Krakow to Italy, but the most visible processes shaping the availability of air connections are visible between the regional airports and the United Kingdom.

Table 3: Indicator accessibility for regional airports in Poland[1]

Airport	ASK	Accessibility
Bydgoszcz	3 999	2 118,9
Gdansk	32 993	16 000,4
Crakow	46 701	25 964,8
Katowice	22 420	10 801,1
Lodz	4 408	2 392,4
Lublin	2 412	1 305,0
Poznan	13 771	8 157,1
Rzeszow	8 145	4 470,9
Szczecin	4 618	2 628,8
Wroclaw	22 829	11 237,0

Source: IATA (International Air Transport Association), Polish CAA (Polish Civil Aviation Authority) and ACI (Airport Civil International).

[1] In June 2013 Modlin Airport was closed.

Based on the ranking of European airports (the importance of the port of destination in the aviation system) the analysis of the availability of the flight in selected regions in Poland has been carried out (Table 3).

In the case of regional airports competing with each other for the carrier the accessibility factor reflects the air traffic in airports and the attractiveness of the region (Airport Krakow: accessibility factor – 26,000, air traffic – 3.6 million passengers, the place in the ranking of attractiveness- fourth). The ACI divided the European airports into four categories. The first group form the largest group of European airports (14) serving more than 25 million passengers, the second group are 23 ports operating from 10 to 25 million passengers, the third group contains 34 airports serving from 5 to 10 million passengers, while the fourth group consists of 390 airports that handle less than 5 million passengers. The largest airports in terms of connectivity are shown in Table 4.

Table 4: Europe's biggest airports of the world connectivity

Rank	Airport	Share of the world connectivity [%]	ASK by Polish airports					
			Gdansk	Katowice	Krakow	Poznan	Warsaw	Wroclaw
1	Frankfurt	13	1470	1400	3081	490	6193	1470
2	Amsterdam	8	216	-	288	-	5095	-
3	Paris	8	-	-	1092	-	6003	-
4	Stambul	6	-	-	-	-	1231	-
5	Munich	6	2212	770	2836	1918	3856	2034
6	London Heathrow	4	-	-	-	-	5026	-
7	Wien	3	-	-	1303	-	2950	-
8	Zurich	3	-	-	360	-	2913	-
9	Moscow	3	-	-	609	-	3364	-
10	Madrit	3	-	-	567	-	994	-
	Warsaw	Less than 1	3116	772	3402	1196		3238

Source: ACI and IATA

4 THE SUMMARY

An important role in shaping the region's air accessibility plays the importance of the port of destination, type of travel and the place of departure. At airports in Warsaw, Krakow, Lublin and Szczecin there is a airports links system based on railways, in Gdansk and Katowice it is planned to launch rail link. In 2014 all airports had an efficiently-functioning network of bus connections to the airports.

In the case of Polish regional airports low cost carriers adjust network of connections to the needs of residents of the region. The demand for air transport services in the particular region is often the result of migration processes of the residents of Poland. Therefore, we can observe an increase in the availability of air to the Scandinavian countries, Germany from the airport in Gdansk, to Germany, France from Poznan, Wroclaw and Katowice, and to countries in the Southern Europe from Krakow and Katowice.

Another factor affecting the development of airport accessibility in Polish conditions is unattractive offer of rail connections between large urban areas and the lack in the analyzed of competitive air services on domestic connections.

In 2013 on the Polish market there were dozens of air carriers offering a diverse range of aviation services. The supply of air services is tailored to the needs of people in the region, but it is also a result of the investment attractiveness of the region examined. Thus, the following models of grid connections have influence on the formation of the supply of air services offer:

- business model (to hub ports: Frankfurt, Munich, Copenhagen, Berlin and major European capitals: London, Paris, Rome, Milan),
- tourist model (to Rome, London, Paris, Barcelona, Greece),
- migration model (to the British Isles, Scandinavian countries, Southern European countries, Germany, Spain, etc.).

Although accessibility depends on the attractiveness of the region, it is also an important factor in the development that improves the competitiveness of regions. The use of accessibility factors in economic practice will help to increase the range of air services in a competitive transport market.

REFERENCES

[1] El-Geneidy, A.M. Levinson, D.M. (2006). Access to destinations: development of accessibility measures (p. 1).University of Minnesota, Minneapolis.

[2] Bell, MGH. May, AD. Nash, CA. Leake, GR. Bonsall, PW. (2003) *Strategic transport and trafic plan.* Rockdale City Council.

[3] Geurs, KT. Van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography*, vol. 12, 127-140.

[4] Kouwenhoven, M. (2008) The Role of Accessibility in Passengers' Choice of Airports, Airline Competition, *Systems of Airports and Intermodal Connections, International Transport Forum*, 8.

[5] Koster, P. Kroes, E. Verhoef, E.T. (2010) Travel Time Variability and Airport Accessibility, Tinbergen Institute Discussion Paper, TI 2010-061/3, pp. 8-9.

[6] Reynolds-Feighan, A. McLay, P. (2006). Accessibility and attractiveness of European airports: A simple small community perspective. *Journal of Air Transport Management*. 12. 315.

[7] Tłoczyński, D. (2014)Accessibility jako instrument kształtowania polskiego rynku usług transportu lotniczego [in:] Problemy ekonomii, polityki ekonomicznej i finansów publicznych. Ed. J. Sokołowski and A. Żabiński. Prace Naukowe Uniwersytetu Ekonomicznego we Wroclawiu no 348. Wyd. UE.

[8] Airport industry. (2014). Connectivity report, ACI, p. 11.

[9] Maligetti, P. Paleari, S. Redoni, R. (2007). Connectivity of the European airport network: “self-help hubbing” and business implications, Department of Economics and Technology Management. University of Bergamo, Working Paper no 10.

NEW LEGISLATION IN THE FIELD OF MARITIME LAW IN THE REPUBLIC OF SERBIA

Nataša Tomić-Petrović, D.Sc.
University of Belgrade
Faculty of Transport nad Traffic Engineering
Vojvode Stepe 305, Belgrade, Serbia
natasa@sf.bg.ac.rs

ABSTRACT:

In this paper author analyzes new legislative changes in the field of maritime law in the Republic of Serbia. Three new laws were adopted in the last five years introducing many innovations, especially in separating regulation of maritime navigation from internal navigation regulation in our country. These are: the Law on navigation and ports on inland waters ("Official Gazette RS" no.73/2010, 121/2012), the Law on maritime navigation ("Official Gazette RS" no. 87/2011) and the Law on nationality and registration of vessels ("Official Gazette RS" no. 10/2013). Before adoption of these laws we applied the Law on Maritime and Inland Navigation adopted in 1998 that is today void except certain provisions that still remained in force. The Law on navigation and inland waters regulates the conditions and manner for safe navigation on inland waters of the Republic of Serbia, waterways and boating, boats and their ability to sail, the crew, search and rescue, ports and harbors, monitoring and other issues related to navigation on inland waterways. This law brings modern tendencies and harmonization with international regulatory trends of inland navigation. New legal framework of Maritime Law will enable seamen to deal effectively and proactively with challenges of a dynamic work and a complex external environment. Modernization of Maritime Law appears as a result of recent legislative changes in the Republic of Serbia. The process of reorganization of the Serbian Marine will draw strength and inspiration from the highlights of our past.

Key words: Regulation, navigation, Serbia.

1 INTRODUCTORY CONSIDERATIONS

Today the Gulf of Guinea is the new global center of pirate attacks[1]. The most of pirates were during 17th century and while until the early 19th century they were almost exterminated, at the end of the 20th century they reappeared at Sea.

Throughout history, pirates have been used by many states and kingdoms. And while „gusari" [2] looted for the country, they were in the service of the State concerned, the pirates aimed at their own interests.

---

[1] At the World Sea from January till September 2014. one-seventh of all pirate attacks (total 231) was carried out between Nigerian oil port Harkur and Senegalese capital , Dakar. The public learned that the decline of sea raids and kidnappings around the Horn of Africa is directly linked to the presence of many foreign armadas in those waters, as well as the influx of private companies that protect ships on the western rim of the Indian Ocean.

[2] „Gusari" were able to be pirates or civilian owners of armed ships, and for their attacks they were given the so-called royal or pirate letters, which allowed them attacks on merchant and warships of the country which was then at war with the country that issued them a letter. That letter was a guarantee that in the event of capture they can not be hanged as pirates, but treated as prisoners of war, which will be released on ransom or exchange. Also, by letter they were committed to hand over the part of the booty acquired, at no charge at the country that

Warning comes today from the participants of the First International Forum on Peace and Security held in Senegal during December 2014. However, unlike Somali pirates, who sailed around the horn of Africa in the middle of last decade, now a new generation of pirate - hijackers is present in the Gulf of Guinea. Unfortunately, if the kidnappers demands, the required money does not arrive, the fate of the kidnapped sailors is uncertain, warns the International Maritime Bureau based in Kuala Lumpur, capital of Malaysia.

From our history is known that the island of Vis (now in Croatia, before it belonged to ex Yugoslavia) at one time, while it was in the possession of the English, and when Russian ships abandoned Adriatic Sea, were the center of piracy and smuggling. Then the English ships were cruising around the Adriatic, and only in year 1808. Dalmatia lost 140 ocean-going vessels because of the actions of the English pirates.

In the area of combating terrorism, there are numerous conventions including the European Convention on the Suppression of Terrorism Act (1977), International Convention against the Taking of Hostages Act (1979), the International Convention against the Recruitment, Use and Financing and Training of Mercenaries of 1989, etc. There is also a certain codification of rules in the field of international conflicts, on land, as well as at sea and in the air.

In this paper author analyzes new legislative changes in the field of maritime law in the Republic of Serbia. Three new laws were adopted in the last five years introducing many innovations, especially in separating regulation of maritime from internal navigation regulation in our country. These are: **Law on navigation and ports on inland waters** (“Official Gazette RS“ no.73/2010, 121/2012), **Law on maritime navigation** (“Official Gazette RS“ no. 87/2011) and the **Law on nationality and registration of vessels** (“Official Gazette RS“ no. 10/2013). Before adoption of these laws we applied the Law on Maritime and Inland Navigation adopted in 1998, that is today void except certain provisions that still remained in force.

2 NEW ACTS OF MARITIME LAW IN THE REPUBLIC OF SERBIA

The **Law on navigation and ports on inland waters** (“Official Gazette RS“ no.73/2010, 121/2012) regulates the conditions and manner for safe navigation on inland waters of the Republic of Serbia, waterways and boating, boats and their ability to sail, the crew, search and rescue, ports and harbors, monitoring and other issues related to navigation on inland waterways. This law brings modern tendencies and harmonization with international regulatory trends of inland navigation.

Long-term development of water transport is regulated by the Strategy of Water Transport Development of the Republic of Serbia adopted by the Government for a period of 10 years, and that in exceptional cases may be amended when there is a particular need arises.[3]

Plans related to the development of international and interstate waterways made by the Ministry, are the basis on which their technical maintenance, improvement and transport-

---

protects them. During the fight pirates on their ships hoisted the flag of a country that protects them, and since 1694, by order of the British Admiralty, English pirates have hoisted additional red flag. When the wars were over, „gusari“ were going out of business, and then they became pirates and then attacked all ships, including those of their former patrons.

[3] See: article *8, paragraph 2 and 3.* of the Law on navigation and ports on inland waters (“Official Gazette RS“ no.73/2010, 121/2012).

technological modernization is performed by the Directorate for Inland Waterways.[4] Directorate for Inland Waterways "Plovput" created by Article 41 of the Law on Ministries ("Official Gazette RS" no. 65/08 i 36/09.) continued to work as a Directorate for Inland Waterways, in accordance with this Law.[5] This Directorate is established as a body within the Ministry for the performance of state administration, as well as professional and technical jobs related to international and interstate waterways.[6]

Harbor Authority is a unit of the Ministry, which performs administrative, technical, inspection and other professional activities that ensure the safety of navigation within its jurisdiction.[7]

Ports and harbors in the Republic of Serbia are the property of general interest.[8] According to the Law on navigation and ports on inland waters terms ports and docks are both used for inland waters. Port is defined as water and with water immediately connected shore space with facilities for docking, anchoring and protection vessels, as well as loading and unloading of passengers and goods in which activities with the goods or vessels in direct economic, traffic or technological relation are carried out. Dock is the water and with water immediately connected shore space with facilities for mooring, anchoring and protection vessels, as well as loading and unloading of passengers and goods.[9] Management of ports and harbors is performed by the Agency for management ports, regardless of ownership status of ports and harbors.[10]

Port Governance Agency is an agency established by the Government of the Republic of Serbia responsible for planning and inland port development in Serbia. Port Governance Agency is a Government regulatory body established to carry out development, technical and regulatory affairs in the field of development of ports and port activities in the Republic of Serbia. This Agency provides the short, medium and long term plans for the construction and development of inland ports, in the form of development studies with evaluation of financial and economic effects.

The Law on navigation and ports on inland waters has provided for establishing of the Authority for Determination of the Seaworthiness as an administrative body within the Ministry of Infrastructure and Energy authorized to provide professional and technical services within the area of determination of the seaworthiness.[11] According to the provisions

---

[4] Article *10, paragraph 1. of the* Law on navigation and ports on inland waters ("Official Gazette RS" no.73/2010, 121/2012).
[5] Article *282, paragraph 1. of the* Law on navigation and ports on inland waters ("Official Gazette RS" no.73/2010, 121/2012).
[6] Article *16. of the* Law on navigation and ports on inland waters ("Official Gazette RS" no.73/2010, 121/2012).
[7] Article *166. of the* Law on navigation and ports on inland waters ("Official Gazette RS" no.73/2010, 121/2012).
[8] Article *203, paragraph 1. of the* Law on navigation and ports on inland waters ("Official Gazette RS" no.73/2010, 121/2012).
[9] See: article 4. of the Law on navigation and ports on inland waters ("Official Gazette RS" no.73/2010, 121/2012).
[10] Article *205, paragraph 1. of the* Law on navigation and ports on inland waters ("Official Gazette RS" no.73/2010, 121/2012).
[11] See: article *85, paragraph 2. of the* Law on navigation and ports on inland waters ("Official Gazette RS" no.73/2010, 121/2012).

of this Law, the Authority took over from the Federal Public Institution – Yugoslav Register of Shipping rights and obligations, objects, archives and other registered materials.

In accordance with the Law on Ministries ("Official Gazette RS" no. 44/2014) of 26 April 2014, the Authority for Determination of the Seaworthiness is a part of the Ministry of Construction, Transport and Infrastructure. According to the Law on navigation and ports on inland waters, the services provided by the Authority for Determination of the Seaworthiness are the following:

1. determination of structural and technical seaworthiness of ships, safety and survey during manufacture of their devices, machinery, equipment and materials that serve to maintain the safety of navigation of ships, protection of life, safety and health during work activities of crew members and other persons on board the ships and preventing pollution of inland waters from ships;
2. determination of structural and technical safety of gear for loading cargo into the ship and unloading from the ship;;
3. determination of structural and technical safety of equipment and devices necessary for the use of River Information Services (RIS);
4. tonnage measurement of ships;
5. issuing the documents to ships as empowered by Serbian Law.

In order to improve the safety of inland navigation from 1st January 2014 the use of River Information Services (RIS) is required.[12] The e-reporting from vessels (ERI) and electronic navigation charts (ENC) became mandatory for all participants in navigation also from the beginning of 2014. In the last three years the four base stations to track navigation (Belgrade, Novi Sad, hydroelectric power station Đerdap 1 and Djerdap 2) were set what covered by tracking over 200 kilometers of the Danube River[13].

River Information Services (RIS) are established at least for waterways class IV and higher, as well as in the ports open to international traffic.14 RIS is established by Directorate15, while the Ministry, at the proposal of the Directorate, brings plans for development of RIS.16

In order to improve the safety and efficiency of shipping traffic and environmental protection the Minister establishes the provision of services for ship traffic management (VTS), in areas where traffic safety demands that (high intensity traffic, transport of dangerous goods, dangerous and complex navigational situations, difficult hydrographic, hydrological and meteorological conditions, the mutual influence of water transport and other activities on the waterway, the increased number of accidents in a certain area, the existing plans of the ship traffic in a particular waterway and because of the need for cooperation between neighboring

---

[12] In May 2008, the European Union and the Republic of Serbia signed an Agreement on the use of grant programs in 2007. envisaged by the project of implementation of RIS in Serbia.

[13] Electronic navigational charts (ENC) for the entire course of the Danube River (590 km) and the Tisa River (160 km) through Serbia are also developed.

[14] Article *177. of the* Law on navigation and ports on inland waters ("Official Gazette RS" no.73/2010, 121/2012).

[15] See: article *179, paragraph 1. of the* Law on navigation and ports on inland waters ("Official Gazette RS" no.73/2010, 121/2012).

[16] See: article *180, paragraph 1. of the* Law on navigation and ports on inland waters ("Official Gazette RS" no.73/2010, 121/2012).

countries, narrow passes, special port configuration, bridges, locks and similar barriers, existing or anticipated changes in the traffic system in a certain area etc.)

VTS service allows identification and monitoring of vessels, strategic planning of vessel movements and provision of navigational information and assistance. VTS service should provide accurate and clear information, as well as assist in reducing the risk of pollution and coordination when taking measures against environmental pollution.[17] The Ministry manages the VTS, while the Harbor Authority performs services for ship traffic management (VTS), within which the VTS center is established.[18] However, the use of services of VTS service does not relieve the commander of the vessel of his responsibility for the safe navigation and maneuvering of the vessel.[19]

The Director of the Institute for Standardization of Serbia passed a Decision no. 1065/33-20-02/2011. to establish the Committee for standards and related documents CS R188, Shipbuilding and marine structures. This Committee was set up to carry out the standardization in the area of shipbuilding for inland waterway vessels and navigation, as well as of the equipment, and structural elements of small craft, including boats and life-saving appliances. The Committee held several sessions and adopted a number of standards passed the public enquiry.

On the 16th of October 2012 the **Rules on the method of conducting trial trips and on navigation zones** ("Official Gazette of the Republic of Serbia", no 99/2012), passed by the Minister of Transport according to article 93(3) of Law on Navigation and Ports on Inland Waters ("Official Gazette of RS", no 73/10), were published. These Rules lay down the method of conducting a trial trip of vessels and floating equipment, and zones intended for trial trip are listed in the Annex thereto. The **Rules on the method of conducting trial trips** ("Official Journal of FRY", no 29/98) cease to have effect when the new Rules entered into force.

The Law on nationality and registration of vessels ("Official Gazette RS" no. 10/2013) regulates the nationality of the vessel, identification, type and content of the register of the vessel registration, vessel registration process conditions. According to this Law the ship of inland navigation must have ENI number. Ministry competent for traffic affairs will on the basis of the concluded agreement, which guarantees the same level of data protection, notify the competent authorities of the Member States of the European Union (EU), as well as third countries on assigned ENI numbers, and other data necessary for the identification of inland vessels.[20]

Monitoring of the implementation of the provisions of this Law and regulations adopted on the basis of this law, governing nationality, identification and registration of vessels is performed by Ministry.[21] Inspection Supervision is performed by the Ministry inspectors for

---

[17] Article *188. of the* Law on navigation and ports on inland waters ("Official Gazette RS" no.73/2010, 121/2012).
[18] See: article *189., stav 1. and 3. of the* Law on navigation and ports on inland waters ("Official Gazette RS" no.73/2010, 121/2012).
[19] See: article *196. of the* Law on navigation and ports on inland waters ("Official Gazette RS" no.73/2010, 121/2012).
[20] Article *9, paragraph 1. and 4. of* the Law on nationality and registration of vessels ("Official Gazette RS" no. 10/2013).
[21] Article *175. of* the Law on nationality and registration of vessels ("Official Gazette RS" no. 10/2013).

navigation safety, while inspection supervision activities over the implementation of the provisions of this law over naval ships in the ports of the coastal State may conduct also professionals with the special authorization of the Minister, in accordance with the law governing maritime navigation.[22]

Within 30 days from the date of entry into force of the Law on navigation and ports on inland waters the Commission for offenses in navigation from article 279 of this Law shall be formed.[23] Proceedings for offenses prescribed by the Law on nationality and registration of vessels in the first instance are led by the Commission for violations in navigation of the Ministry competent for traffic affairs from article 279 of the Law on navigation and and ports on inland waters.[24]

The conditions and manner for safe navigation at sea naval ships flying the flag of the Republic of Serbia and other vessels registered in a national register of their seaworthiness, crew, protection from pollution from ships, surveillance and other issues related to safety maritime navigation are regulated by the **Law on maritime navigation** (“Official Gazette RS“ no. 87/2011).

According to the Law on maritime navigation shipper is the vessel owner, lessee, charterer or manager who is the holder of the vessel, the holder of a navigational responsibilities; - vessel (“*plovilo”)* is a ship, technical craft, yacht, boat and other facility that is capable of navigation at sea and who participates in navigation, as well as the facility which is fully or partially buried in the seabed or laid on the seabed; - *SafeSeaNet* is the system of the European Union for the exchange of information on maritime navigation established by the European Commission in order to monitor the application of relevant secondary sources of EU law by the member states of the EU; [25] National system SafeSeaNet is established and used in accordance with the technical requirements laid down by the European Commission, kept in electronic form and enables the transmission of data on maritime navigation continuously 24 hours a day.[26]

Domestic ship, has to be equipped by the system for automatic identification (AIS), in accordance with standards prescribed by IMO.[27]

Seaworthiness according to the provisions of article 17, paragraph 1 of this law, shall be determined by a recognized organization performing technical supervision and proved by issuing of appropriate ship documents and books in accordance with the provisions of the Technical Rules. Recognized organization is a classification society that is a member of the International Association of Classification Societies (IACS), which is recognized by the European Commission for technical supervision and statutory certification of maritime vessels.[28]

---

[22] See: Article *176. of* the Law on nationality and registration of vessels (“Official Gazette RS“ no. 10/2013).
[23] Article *286. of the* Law on navigation and ports on inland waters (“Official Gazette RS“ no.73/2010, 121/2012).
[24] Article *188. of* the Law on nationality and registration of vessels (“Official Gazette RS“ no. 10/2013).
[25] See: article 4. of the Law on maritime navigation (“Official Gazette RS“ no. 87/2011).
[26] See: article 134. of the Law on maritime navigation (“Official Gazette RS“ no. 87/2011). The provision of article 134 of this Law shall apply from the date of receipt of the Republic of Serbia in the full membership of the European Union.
[27] Article *132, paragraph 1.* of the Law on maritime navigation (“Official Gazette RS“ no. 87/2011).
[28] Article *18, paragraph 1. and 3.* of the Law on maritime navigation (“Official Gazette RS“ no. 87/2011).

Training and examinations for obtaining authorization of qualification or special qualification of the crew members of ships in accordance with the requirements of STCW Convention regarding duration and contents of training, perform training centers for seafarers, on the basis of approval issued by the Ministry.[29] Training centers must meet quality standards system in accordance with the requirements of the STCW Convention and implement international and domestic legislation regulating the matters of maritime navigation. Recognized organization verifies the operation of training centers and compliance with the quality standards system at the expense of training centers every two years, and even earlier if the Ministry deems it necessary.[30]

Old Law on Maritime and Inland Navigation ("Official Gazette FRY" no. 12/98, 44/99, 74/99, 73/00, "Official Gazette RS" no. 85/05 , 101/05, 73/10, 87/11, 10/13*)* still regulates the bases of property - legal relations, shipper liability and its limitation, contractual and other relations (ship building contract, charter party, contracts for exploitation of ships, like contract for carriage by sea - river, towage, naval agency, contract of naval insurance, legal rights of pledge on things embarked on the ship), naval disasters, collision of ships, reimbursement of costs for tracking and salvage and remunerations, extraction of sunken objects, general average, liability in tort, liability of nuclear ship user, the procedure of execution and real guaranty on ships - execution for reimbursement of non-monetary claims – delivery of the ship.

3 CONCLUSION

Today, many discussions are led on the future of cities on the water, and this project was launched in the 90s. It was considered as a utopian project, but the idea of "Freedom Ship"[31] is a very up-to-date today, because the crew of the ship would consist of even 20,000 people.

The Parliament of the Republic of Serbia at February the 10th disscussed on amendments of three laws in the area of maritime transport, which are harmonized with EU legislation, and that should help development of water traffic in Serbia, especially Corridor 7, so called "Dunabe's corridor".

The Minister of Construction, Transport and Infrastructure concluded that water traffic in Serbia in the overall transport participates with only 4.7 % and that this share must be increased, because it is lower than in other European countries, and our country in this regard has the great potential. In order to achieve that, the modernization of ports is needed, because the infrastructure is around 30 years old, and cranes over 50 years.

New legal framework of Maritime Law will enable seamen to deal effectively and proactively with challenges of a dynamic work and a complex external environment. Modernization of Maritime Law appears as a result of recent legislative changes in the Republic of Serbia. The process of reorganization of the Serbian Marine will draw strength and inspiration from the highlights of our past.

[29] Article *75, paragraph 1.* of the Law on maritime navigation ("Official Gazette RS" no. 87/2011).
[30] See: article *81, paragraph 1.* of the Law on maritime navigation ("Official Gazette RS" no. 87/2011).
[31] It would be a floating city of 1,600 meters long and 25 stories high with supporting facilities, even with a small airport on the roof, which is estimated to circle around the Earth for two years, with 70% of time spent at anchor near the world's largest ports, and to the coast would be organized flights.

Each hystorical period left its seal on this area and peace has to be considered as the one of basic universal values. With hope for keeping regional and international peace and security on the roads all over the world this paper appears, because lawyers do not have the right to withdraw in front of invasion of antilaw.

REFERENCES

[1] Antić, B. (2014). *Školski brod „Jadran“ 1933-2003.* Beograd: Odbrana.

[2] Đuran, M. (2014). *Flote kojih više nema: Ratne mornarice na istočnoj Jadranskoj obali 1797-2005*, Sudbine ljudi, brodova i podmornica. Zrenjanin: IP Beograd.

[3] Law on Maritime and Inland Navigation (“Official Gazette of the Federal Republic of Yugoslavia“ no. 12/98, 44/99, 74/99, 73/00, “Official Gazette RS“ no. 85/05 , 101/05, 73/10, 87/11, 10/13)

[4] Law on maritime navigation (“Official Gazette of the Republic of Serbia “ no. 87/2011)

[5] Law on Ministries (“Official Gazette of the Republic of Serbia “ no. 65/08, 36/09.)

[6] Law on Ministries (“Official Gazette of the Republic of Serbia “ no. 44/2014)

[7] Law on nationality and registration of vessels (“Official Gazette of the Republic of Serbia “ no. 10/2013)

[8] Law on navigation and ports on inland waters (“Official Gazette of the Republic of Serbia “ no.73/2010, 121/2012)

[9] Milićević, M. (2014). *Rat za more.* Beograd: Odbrana.

[10] Perović, S. (2014). *Besede sa Kopaonika.* Beograd: Kopaonička škola prirodnog prava.

[11] Rosić, S. (2014). *Plovidba unutrašnjim plovnim putevima*, Beograd: Odbrana.

[12] Rules on the method of conducting trial trips and on navigation zones (“Official Gazette of the Republic of Serbia“, no 99/2012)

[13] Tomić, N. (2009). *Navigation on Danube and its pollution - Serbia’s and international problem*, International Conference Maritime transport 2009, Barcelona.

[14] Živojinović, M. (2011). *Život pretočen u pamćenje*. Beograd: Biblioteka zapis, Pravni fakultet u Beogradu.

STUDY OF SUSTAINABLE MARINAS IN MONTENEGRO

Vassilis Tselentis, D.Sc.
University of Piraeus
Department of Maritime Studies
Greece
tselenti@unipi.gr

Branislav Dragović, D.Sc.
University of Montenegro
Maritime Faculty
Dobrota 36, 85330 Kotor, Montenegro
branod@ac.me

Aleksa Ćorić
AD Marina Bar
Obala 13 Jula, 85000 Bar, Montenegro
acoric@marinabar.org

Ervin Spahić, B.Sc.
Environmental protection Agency of Montenegro
IV Proleterske 19, 81000 Podgorica, Montenegro
epamontenegro@gmail.com

Danijela Orlandić
AD Marina Bar
Obala 13 Jula, 85000 Bar, Montenegro
dorlandic@marinabar.org

ABSTRACT

Marine tourism represents very significant sector of Montenegrin industry. Since the state disposes with almost 300 km of the coast line, it is currently the most dynamically growing sector of the Montenegrin economy. Even though marinas have to be sophisticated and offer different services, the need for commercial marinas is still presented but requires constant improving in order to provide competitiveness in the Adriatic area. In this paper, we elaborate and describe the current conditions in a Montenegrin marina. First, we describe the level of development in AD Marina Bar. Second, we discuss about marinas' capacities providing some analysis. Here we emphasize the operational activities and give statistics about the throughput, available berths and other marinas' facilities. Third, after an analysis we propose a promotion of the recreational and yachting activities that are in accordance to the marinas' sustainability. The results will indicate about the sustainable development of AD Marina Bar. The level of marina growth will show the continuous efforts in providing better and competitive services for the customers and tourist. In addition, sea activities should be put in advance in order to increase the level of marine industry. However, this study will be useful for the promotion of sustainable concept in marinas and port urban areas, including the directions of ISO certification, Blue Flag and Gold Anchor Scheme awards that will be proposed in this study.

Key words: environmental issues, AD Marina Bar, sustainable development.

1 INTRODUCTION

The promotion of coastal areas and nautical tourism is highly recommended because the state is becoming aware of the need to protect and improve these areas in order to maintain their natural beauty and help to provide the long-term vitality as tourism destination. Planning and improving capacity conditions in the marina can - at the same time - have a positive effect on the economy of the marina. Performances assessment provides a structured approach for predicting potential impacts and incorporating mitigation measures during design, construction and operation phases. This requires that all elements of the environment are carefully surveyed, analyzed and considered in determining the most appropriate approach and location of development plans.

Providing clear and sustainable activities in the area of non-developed countries is very difficult. Port areas should propose plans for new locations referring to the ecological standards but not only in theoretical sense but more in practical one. Before the implementation of sustainable development concept, the current conditions performances in marina must be analyzed. Promoting green concept in marina is paramount to be qualitative and effective proposed. Several papers have studied and estimated applying and promoting sustainable development concepts in marina. For example, Dragović and Tselentis (2014) presented some approaches to sustainable marina concept and concerned with expected impacts of the concept. In the same manner, Dragović et al. (2014a) explained the quality and effectiveness of sustainable development concept with the importance of green concept in port and marina areas. Regarding the present papers, much more attention is paid to environmental issues in small ports and marinas in the following studies (Dragović et al., 2014b,c; ESPO, 2014; FEE International, 2013; Škurić et al., 2014; Tselentis and Dragović, 2014 and Tselentis et al., 2015).

2 SUSTAINABLE MARINA APPROACH

This sustainable marina approach recognizes marina Bar as a very attractive place for yachting and represents the nautical tourism port. It is a commercial small port divided in ten gates with the total quay length of 3600 m (Dragović et al., 2014b,c). There are 592 commercial berths (532 berths for yachts and visitors, 30 berths for mega yachts, 15 berths for fishing and taxi boats, respectively) while 250 of them are dry berths. The biggest vessel that can be serviced is up to 35 m length. Marina makes a part of the Port of Bar but is distanced about 0,5 km from the port, except from the ferry terminal (see Figure 1). Now, marina Bar is the biggest marina in Montenegro and disposes with 592 commercial berths and is in the process of achieving criteria for sustainable policy (Dragović et al., 2014b,c).

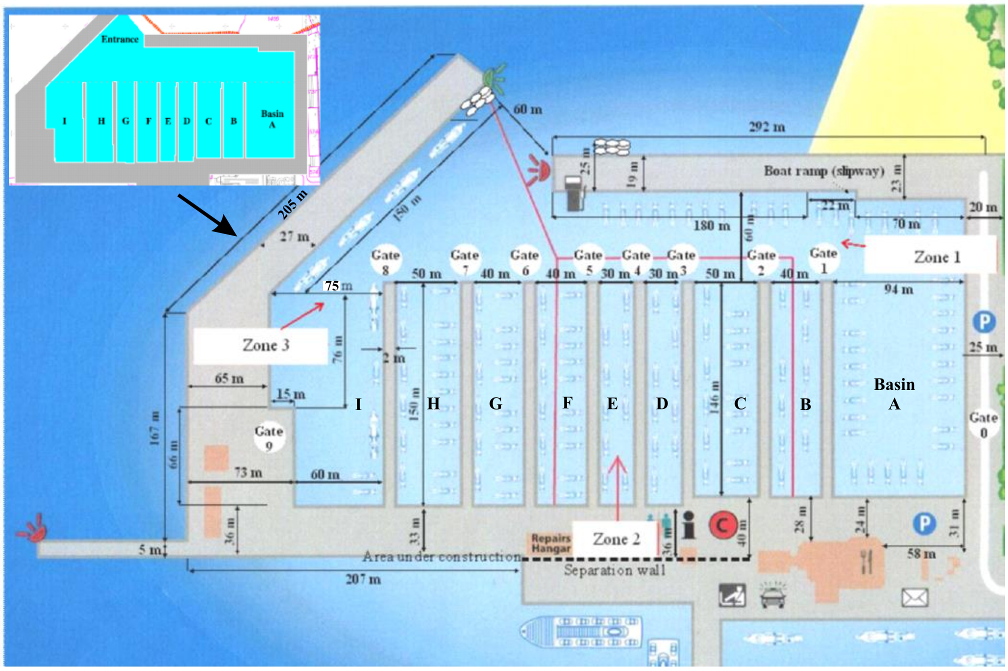


Figure 1: Marina Bar layout with main dimensions and charcheristics

Source: Dragović et al., 2014b,c

We analyze the capacity conditions together with technical specifications in marina Bar. In Figure 1 are shown all dimensional characteristics of marina aquatorium with location of basins A-I and marina entrance. It includes the area for berthing and other contents such as parking and catering services. Marina disposes with eight classical gates including gates 0 and 9 while the additional locations for vessels berthing comprise secondary breakwater and west breakwater. Other marina technical specifications are (Dragović et al., 2014b, Škurić et al., 2014): the draft in marina water area varies from 1,5 to 5 m; there is no tug pilot for the incoming vessels; there is a boat lift of capacity to handle 50 tons; the draft of a marina entrance is now reduced to 4,5 m. It is due to the erosion process of the public beach located in the other side of the secondary breakwater; the level of marina construction is 60%; in a peak season first eight months of the year, 90% of marina capacities are filled.

Marina Bar land area contains 4,5 ha of space while the water area yields more than 9,5 ha. Land part contains the area of: oil station location in secondary breakwater that covers 781,1 m^2; access to the gates that covers 10275,5 m^2; marina parking that covers 8819 m^2; service area that covers 5351 m^2; area under construction that covers 12860 m^2 and road network access and walkways that covers 7463,4 m^2. On the other hand, marina water area includes area of basins A-I and walkways at the gates. First one comprehend 9,3 ha of the area and second covers 2380 m^2. Generally, the presented dimensions of land and water areas are respectable for one marina (Dragović et al., 2014b).

Having collected data of each marina gate, we calculate the efficiency of the used areas in marina (Table 1). First we put the input parameters such as total length of each gate in meters, presented in Figure 2. We divide the left and right side of the gate (column 2). Since the width of each walkway is 2 m, we calculate the total area in square meters (column 3 and Figure 2a). The ratio between the total area and length of each gate is provided in column 4. These data are related to the land area (Dragović et al., 2014b; Tselentis and Dragović, 2014).

Table 1: Performances analysis of marina

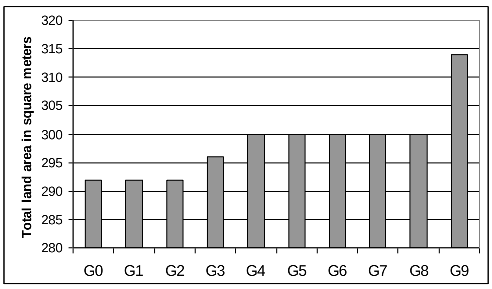
<table>
<tr><th rowspan="2">Gate
(1)</th><th colspan="2">Total length of each gate in m
(2)</th><th rowspan="2">Total area in m^2
(3)</th><th rowspan="2">m^2 per m
(4) =
50% of (3) /
(2.1 or 2.2)
(4)</th><th rowspan="2">Basin

(5)</th><th rowspan="2">Total water area in m^2

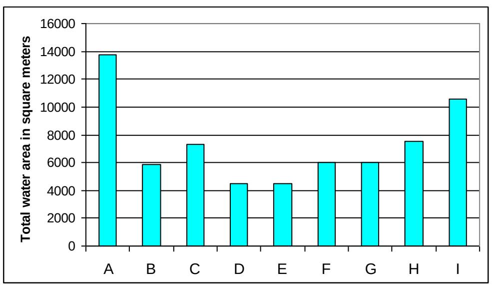
(6)</th><th rowspan="2">50 % of (6)
(belong to any side along a gate length)
(7)</th><th rowspan="2">m^2 of water area / m of gate length
(8) = (7) / (2.1 or 2.2)
(8)</th></tr>
<tr><th>Left side
(2.1)</th><th>Right side
(2.2)</th></tr>
<tr><td>0</td><td>146</td><td>-</td><td>292</td><td>2*</td><td rowspan="2">A</td><td rowspan="2">13724</td><td rowspan="2">6862</td><td rowspan="2">47</td></tr>
<tr><td>1</td><td>146</td><td>146</td><td>292</td><td>1</td></tr>
<tr><td>2</td><td>146</td><td>146</td><td>292</td><td>1</td><td>B</td><td>5840</td><td>2920</td><td>20</td></tr>
<tr><td>3</td><td>146</td><td>150</td><td>296</td><td>1,01 & 0,98</td><td>C</td><td>7300</td><td>3650</td><td>25 & 24,3</td></tr>
<tr><td>4</td><td>150</td><td>150</td><td>300</td><td>1</td><td>D</td><td>4500</td><td>2250</td><td>15</td></tr>
<tr><td>5</td><td>150</td><td>150</td><td>300</td><td>1</td><td>E</td><td>4500</td><td>2250</td><td>15</td></tr>
<tr><td>6</td><td>150</td><td>150</td><td>300</td><td>1</td><td>F</td><td>6000</td><td>3000</td><td>20</td></tr>
<tr><td>7</td><td>150</td><td>150</td><td>300</td><td>1</td><td>G</td><td>6000</td><td>3000</td><td>20</td></tr>
<tr><td rowspan="2">8</td><td>-</td><td>150</td><td rowspan="2">300</td><td>1</td><td>H</td><td>7500</td><td>3750</td><td>25</td></tr>
<tr><td>150</td><td>-</td><td>1</td><td rowspan="2">I</td><td rowspan="2">10566</td><td>5283</td><td>35,22</td></tr>
<tr><td>9</td><td>-</td><td>157</td><td>314</td><td>2*</td><td>5283</td><td>33,65</td></tr>
<tr><td>Sub-total</td><td>1334</td><td>1349</td><td rowspan="2">2986</td><td rowspan="2">-</td><td rowspan="2">Total</td><td rowspan="2">65930</td><td rowspan="2">32965</td><td rowspan="2">24,71 & 24,44</td></tr>
<tr><td>Total</td><td colspan="2">2683</td></tr>
</table>

*Note: Operational areas for gates G0 and G9 include 2 m^2 per gate length.

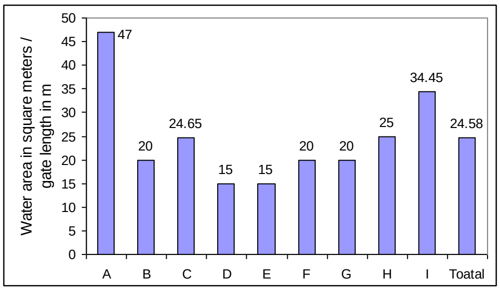
In this performances analysis, it is important to note that we have only calculated the ratio between water area and land area including basins A-I and gates 0-9. On the other hand, including basins A-I in column 5, and knowing all dimensions, we can calculate total area of each basin in square meters (column 6 and Figure 2b). If we denote that 50% of the capacity of water area is performed by each basin, then we get the results of the calculated water area in these circumstances (column 7). Finally, we get efficiency analysis of water area ratio to land area specified in column 8 and Figure 2c. The output results show square meters of water area/m of gate length for each gate. Assuming this, the result of the total ratio between water (in square meters) and land area per gate meter shows that around 24 square meters of water area corresponds to 1 m of gate area. This result reports generally the small size of water area in marina. Further researches have to be directed to increasing the capacities of marina throughput having in mind the results of the ratio between water and land area. The attained agreement of the results obtained in Figure 2d in respect to considered area (Figure 1) and total area with real parameters has been also use for performances validation. Output results correspondence give validity to applied methodology to study performances to be used for optimization of processes of servicing vessels in marina (Tselentis and Dragović, 2014).



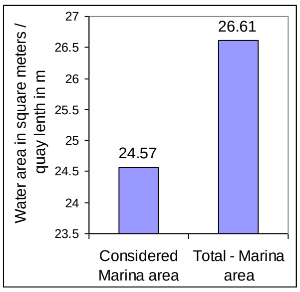
a) land area of gates 0-9



b) water area of basins A-I



c) performances and results



d) output results

Figure 2: Performances analysis

3 EXPECTED IMPACTS OF SUSTAINABLE MARINA

To define the sustainable marina, some main objectives have to be evaluated, in this analysis and are related to seeking the Blue Flag programme, ISO 14001:2004, 9001:2008 and Gold Anchor Scheme. The main point is to reduce the costs and to have environmentally protected area. The linkage between the Blue Flag, ISO standards and Gold Anchor Scheme to provide all environmental aspects of the marina's activities, using a logical, objective (rather than subjective) methodology to rank such aspects into order of significant impact upon the environment are given. The sustainable marina primarily shows the environmental management tools and methodologies, combined with the training and advisory support services that provide individual marina authorities with the option of developing and implementing their own, site-specific, environmental programme in the time-scale of their choosing and with the voluntary option of professional review and certification (SMP, 2014).

The main activities of the sustainable marina through scientific international project entitled "Applying and promoting the concept of sustainable development to AD Marina Bar" (SMP, 2014) are divided into 12 work packages: WP 1 - Elaboration of project tasks through international cooperation; WP 2 – Marina Bar planning framework; WP3 - Development of the environmental policy and environmental management System for Marina Bar; WP 4 - Applying the Blue Flag Programme to Marina Bar; WP 5 – Strategic development plan for ISO standards to Marina bar; WP 6 - Establishment of Marina Environmental Management System; WP 7 - Application of novel techniques in Marina Bar services; WP 8 – Marina Bar Sustainability: A life cycle assessment of Zero Emission marina equipment; WP 9 - Improvement of Safety and Services in Marina bar; WP 10 - Certification of Marina Bar with regard to ISO standards; WP 11 - Award to Marina bar with regard to Blue Flag and Gold Anchor Scheme; WP 12 - Final proposal for Marina Bar facility solutions.

Sustainable marina development includes steps for implementation and improvement of performances in marina. The integrated marina planning concept together with ecological standard inclusion is suggested to be achieved during the term of the concept implementation. The Figure 3 shows the large-scale dimension of the sustainable development concept to marina as well as the expected results. It is also correlated to the promotion of good environmental planning according to national strategy of sustainable development plans in the country. This sustainable marina development practically proposes to develop approaches and strategies that allow for the better planning and management of sustainable development that the growing need for marina sustainability seeks. On the other hand, this development deals with the marina capacities and conditions to become environmentally familiar. It will include the high level of knowledge which will serve to young practitioners (researchers) to become experts in this research field that can be applied in marinas. It is necessary because it has to raise the awareness of the stakeholders, city, communities on local and regional level, academicians, customers, tourists and so on (Dragovic and Tselentis, 2014).

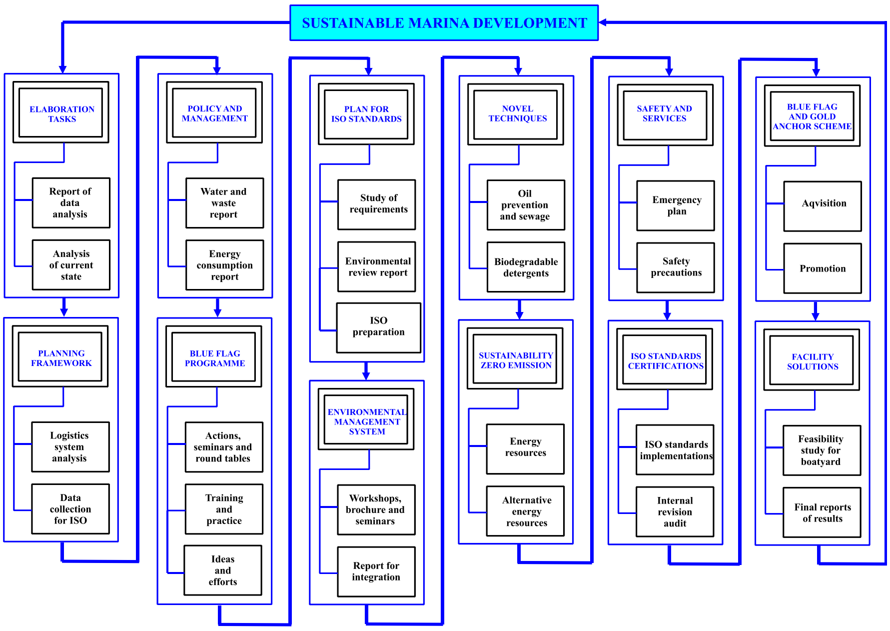


Figure 3: Sustainable marina development

Source: Dragović and Tselentis, 2014

4 CONCLUSION

Sustainable marina development provided a robust and logical structure to assess the environmental and social impacts of the marina development plan. This raised important points about emphasis and use, which needed to be reflected in future applications and promotions of concept of sustainable development marina, as well as any guidance produced. The following important lessons will be learned: the assessment of current situation of the marina showed the importance of looking at social and economic issues together with environmental issues and proved vital for gaining a good understanding of the situation and formulating practicable and achievable recommendations; the concept of sustainable development to marina assumes that once a strategy or policy is duly adopted, or laws or regulations enacted, they will be enforced. The good planning of the concept of sustainable development to marina and its management are essential in order to maximize the positive benefits of marina and minimize negative impacts in a sustainable manner. Here we provide a simple structure and basic implementation guidelines for comprehensive strategic planning, applying and promoting the concept of sustainable marina development.

ACKNOWLEDGEMENT

The study was carried out within the Project MNE-HERIC-81180, "Applying and promoting the concept of sustainable development to A.D. Marina Bar (SUST-MARINA)", financed within the scope of "Higher Education and Research for Innovation and Competitiveness in Montenegro" – ("HERIC") project, from the International Bank for Reconstruction and

Development loan, in accordance with the Decision of the Ministry of Science of Montenegro on awarding the grant: Number: 01-1062 from 29th May 2014.

REFERENCES

[1] Dragović, B., Tselentis, B.S. (2014). Some Approaches to the Sustainable Marina Concept. *Proceedings of* 3rd *International Conference on Production and Supply Chain Management*, Athens, Greece, (pp. 1-4).

[2] Dragović, B., Tselentis, B.S., Škurić, M., Meštrović, R., Papan, S. (2014a). The Concept of Sustainable Development to Marina. *Proceedings of* 14th *International Conference* RaDMI 2014, Topola (Serbia), Bar and Kotor (Montenegro), *1*, (pp. 340-345).

[3] Dragović, B., Tselentis, B.S., Škurić, M., Ćorić, A., Popović, M. (2014b). Application of Sustainable Development Model to Marina. *Proceedings of* 14th *International Conference* RaDMI 2014, Topola (Serbia), Bar and Kotor (Montenegro), *1*, (pp. 360-366).

[4] Dragović, B., Tselentis, B.S., Papadimitriou, S., Šerović, D., Škurić, M., Meštrović, R., Mikijeljević, M. (2014c). A Study Approach of Marina Sustainable Development Framework. *Proceedings of* 14th *International Conference* RaDMI 2014, Topola (Serbia), Bar and Kotor (Montenegro), *3*, (pp. 1031-1038).

[5] European Sea Ports Organization, ESPO (2014). Available on Web site: http://www.ecoports.com/.

[6] FEE International (2013). "Blue flag marina criteria and explanatory notes", Available on Web site: http://www.blueflag.org/menu/criteria/marinas/marina-criteria-and-expl-notes-2014.

[7] SUST-MARINA Project (SMP) (2014). Application Form - Applying and Promoting the Concept of Sustainable Development to AD Marina Bar. HERIC project, Collaborative Research and Development Subprojects, approved in 2014 to Maritime Faculty, University of Montenegro by Ministry of Science (Montenegro).

[8] Škurić, M., Dragović, B., Ćorić, A., Markolović, T., Božović, A. (2014). Study of Marina Development: Evaluation and Perspective. *Proceedings of* 14th *International Conference* RaDMI 2014, Topola (Serbia), Bar and Kotor (Montenegro), *3*, (pp. 1011-1016).

[9] Tselentis, B.S., Dragović, B. (2014). Analysis of Vessel Traffic Indicators and Performances in Marina. *Proceedings of* 3rd *International Conference on Production and Supply Chain Management*, Athens, Greece, (pp. 1-6).

[10] Tselentis, B.S., Papadimitriou, S., Tzannatos, E., Dragović, B. (2015). An analysis of sustainable development framework to marina, *Proceedings of* 34th *International Conference on Organizational Sciences Development*, Portorož, Slovenia, Accepted, (pp. 1-4).

EVALUATING GREEN SUPPLY CHAIN – ROLE OF TRANSPORT AND LOW-CARBON ECONOMY[1]

Blanka Tundys, Ph.D.
University of Szczecin
Faculty of Management and Economics of Services
Department of Logistics
Poland
blanka.tundys@wzieu.pl

ABSTRACT

Developing of the concepts of green supply chains are trends in a global world. They are related with the changes in the economies. A multitude of processes and the relationship between the supply chain and to global requirements for environmental principles requires a redesign and a reengineering of the processes. It contributes to the increasingly widespread use of green strategy for supply chain management. The essence and the framework of green supply chain are based on environmental aspects. There is no doubt that transport is one of the most important parts of supply chains, but this has definitely a negative impact on the environment. Analyzing the documents from the European Commission, it should be noted that the transport sector contributes significantly to air pollution and greenhouse gas emissions in the economy. Therefore it should take appropriate action to minimize the negative effects of the development and activity of this sector on the environment. It is important, in accordance with the principles of a low carbon economy, to promote the idea of sustainable development, which also contribute to the development of green supply chains.

Assumption of this paper is to indicate which role transport and low-carbon economy in the creation and evaluation of assumptions of green supply chain has. It could be submit a thesis: the development and evaluation of green supply chain is to some extent determined by the implementation of the principles of sustainable development in the transport sector and promote low-carbon economy. Green supply chain is a concept which needs redefinitions and redesign of processes. The most important is the environmental and its protection. To do this into the supply chain it needs to use and implement modern tools in area of: management, economics and logistics. Also important are another part of sustainable development (social and economical). The aim of this paper is a review of the development tools and areas of green supply chain (including the use of appropriate strategies and tools) and the impact on the development of assumptions of low carbon economy.

Key words: Green supply chain, low carbon economy, role of transport in green supply chain.

1 INTRODUCTION

Transition towards a low-carbon economy is one of the economic and environmental challenges facing the European Union and the Member States. Member States need to understand and recognize the potential shift which brings the changing and transition from traditional economy to a low carbon economy. Properly prepared transformation can be a very strong impulse for development. It should also be borne in mind that the strategy should be

[1] This paper is as part of project financed by National Science Centre granted on the basis of decision DEC-2013/09/B/HS4/02707

adapted to the socio-economic realities of the country and take account of the changing in the global context. The assumptions of low-carbon economy are supported by creating green supply chains. This represents that at the same time, elements which improve the efficiency of resource use, may contribute to the achievement of competitive advantage. Such an approach predestined to take deliberations of whether and how - assumptions of low-carbon economy could have an influence to the designing of green supply chain. Are there feedback and whether the assumptions of presented ideas are complementary? And which role plays in the evaluation of green supply chain transport and low-carbon economy. Are they a common and useful element in the evaluation of green supply chain?

The essence of the green supply chain is based on the environmental aspects; it is also known that the transport, being an integral part of the logistics process, has negatively affects to the environment. Therefore, it is essential to create, build and evaluate green supply chains, taking into account the objectives of low-carbon economy.

Development and evaluation of green supply chain is to some extent dependent on the implementation of the principles of sustainable development in the transport sector and supporting of low-carbon economy. Green supply chain is a strategy, which requires a redesign of processes, with particular emphasis on aspects of environmental protection. In this situation, the application of modern management tools must be linked to organizational activities, as well as implementation of innovation (including eco-innovation). It should not be forgotten about social acceptance, which can be the basis of changes in the supply chain. Directions for the development of green supply chains should be acceptable for all stakeholders. They are determined and supported by filling of rules of low-carbon economy.

The green supply chain includes not only the implementation of the concept of low emissions and energy consumption rather in and for the production, storage and transport, but also refers to the waste management, recycling and the introduction of green management philosophy and its instruments to all supply chain links.

2 CONCEPTIONS OF LOW CARBON ECONOMY – ENERGY AND TRANSPORT

One of the measurable effects of economics transformations should be reducing greenhouse gas emissions and other substances to the environment. A way to achieve this is to introduce a low-carbon economy. It is to ensure economic, social and environmental (according to the principle of sustainable development) resulting from action, which aims are reduce emissions, including growth of performance through an increase in innovation and implementation of new technologies, reduction of energy consumption, create new jobs and, consequently supporting of facilitating the growth of competitiveness of the economy. In the context of the discussion, considerations are focused on two areas that have a large impact on the introduction of low-carbon economy and at the same time there are an important element of the operation and evaluation of green supply chain. Namely transport and energy. Both areas are part of processes at each stage of green supply chain.

According to the proposed by the European Commission's priorities, which were supported by the European Council, the “EU economy should be based on three pillars: knowledge and innovation (smart growth), the effective use of available resources (sustainable development) and a high level of employment and social cohesion (the development of inclusion)” (Euopean Commision, 2009).

The assumptions of low-carbon economy are not new to European economies. In 2009 the European Council set the appropriate emission reduction objective. The most important is reducing greenhouse gas emissions for Europe and other developed economies at 80-95% below 1990 levels by 2050.

Document (Euopean Commision, 2009), assumes that over the next 30 years, the European energy sector will become a safe, competitive and low carbon. The document is one of a series of strategic studies, which show how to achieve the overall goal of a low-carbon economy in Europe. Another extremely important document for transport is the White Paper 2011 (European Commission, COM(2011) 144 final, 2011).

The plan for emissions and assumptions low-carbon economy is ambitious and predicts that by 2050 the target of reducing emissions by more than 80% will be achieved. For this to happen the Europe's energy production should to be characterized by an almost total lack of carbon dioxide emissions.

Commission document presents an analysis of different scenarios that will enable the achievement of the objective without interruption in the supply of energy and the deterioration of the competitiveness of the European economy. The main emphasis was placed on actions that Member States must take until 2030 to create a strategic framework for the implementation of the plan. The document contains the four fundamental aspects of decarbonisation (energy efficiency, renewable energy, nuclear power and CCS - Carbon Capture and Storage). On this basis, the scenarios were created as a result of the different configurations of elements decarbonisation. Options are to contribute to the objectives and their realignment 2050. (Unfortunately there is a high probability that none of the scenarios, for various reasons, will be realized). The obtained results are presented in Table 1.

Table 1: Expected results for the low-carbon economy in Europe (2050)

The results of a low-carbon economy	
Aim	**Characteristic**
Decarbonisation of the energy system.	It is technically feasible and economically. All decarbonisation scenarios allow achieving the emission reductions and long-term, it could be cost less than current strategies.
crucial importance of energy efficiency and renewable energy	Regardless of the selected energy mix, higher energy efficiency and a significant increase of the share of renewable energy sources are necessary to achieve targets for CO2 emissions in 2050. Electricity will be more important than it is today. Gas, oil, coal and nuclear energy are also present, in different proportions in all scenarios, allowing Member States the flexibility of options, within the energy mix, assuming, that soon will be realized internal market with strong interconnections.
Investments - started at an early stage are less expensive	Now you should making investment decisions on the implementation of the necessary infrastructure by 2030. Because it is necessary to replace the used of infrastructure, which was put to use before 30-40 years ago. Immediate action can prevent more costly changes in the future. Evolutionary changes in the field of energy in the EU need to be modernized and much more flexible infrastructure, eg. cross-border connections, smart power grids and modern low-carbon technologies for the generation, transmission and storage of energy.
Control price increases.	Currently, the investments enable the introduction of the best prices in the future. Electricity prices will continue to rise until 2030, after they can be reduced, due to the lower cost of supply, saving policies and improved technologies. The costs will lower than the high level of sustainable investments made for the benefit of the European economy, the related jobs in the different regions and less dependence on imports. In all

The results of a low-carbon economy	
Aim	**Characteristic**
	scenarios decarbonisation objective without major deviations in terms of overall costs or impact on the security of supply.
Economies of scale are necessary.	The European approach will result in lower costs and security of supply in comparison with analogous national programs.

Source: (Euopean Commision, 2009)

The European Commission has presented five scenarios that take into account elements, such are being unknowns: Oil price, increases the possibility of using a large-scale shale gas, and CCS (Table 2).

Table 2: Scenarios of low-carbon economy for Europe (2050)

Scenario for low carbon economy for Europe (to 2050)	
Name of scenario	**Characteristic**
High energy efficiency	assumes achieve high energy savings by establishing, inter alia, stringent minimum requirements for electrical equipment and new buildings. This scenario assumes a decline in demand for energy by 41% by 2050 compared to the demand in the years 2005-2006.
Diverse power generation technologies	provides for the reduction of CO2 emissions by the fiscal burden and assumes the widespread use of nuclear energy and CCS.
Significant use of renewable energy sources	assumes strong institutional support for the use of renewable energy sources, which would lead to an increase in the share of renewable energy sources in gross final energy consumption to 75% and the share of energy from renewable sources in electricity consumption up to 97% by 2050.
Delayed implementation of CCS	This scenario is similar to the scenario diversified, but it is assumed that the implementation of CCS significantly delayed, which will require greater use of nuclear energy.
Low use of nuclear energy	Scenario shows that Europe will not start new nuclear reactors, which is associated with greater use of CCS, which would be responsible for 32% of energy production.

Source: (Euopean Commision, 2009)

The reduction of carbon emissions is associated with the use of new technology and with higher production costs, which typically require higher investment. Decarbonisation policy leads to changes in the structure of the technology and fuel energy production - in the direction of less-emission technologies, causing an increase in technical costs of energy production. Analyses indicate an increase in energy prices, but it is worth noting here also economic benefits. They arise mainly from the hope of the development of production equipment and services with the needs of low-carbon technologies (nuclear power plants, power plants and gas power plants, wind turbines, biogas and biomass power plants). Solutions, related to the introduction of low-carbon economy are technological and financial. They are associated with incurring the costs and expenses associated with the transition to a low carbon economy.

Another element supporting low-carbon economy assumptions are actions taken with respect to mitigating the negative impacts of transport to the environment. And in this case, the assumptions are associated with the EU's strategic document. Namely, the White Paper 2011 (European Commission, COM(2011) 144 final, 2011) includes actions to creating a low-carbon economy in area of transport. The activities have the 10 most important objectives (Table 3).

Table 3: Ten Goals for a competitive and resource efficient transport system: benchmarks for achieving the 60% GHG emission reduction target

Scenario for low carbon economy for Europe (to 2050)		
goal		**Characteristic and realization**
Developing and deploying new and sustainable fuels and propulsion systems	1.	Halve the use of 'conventionally-fuelled'cars in urban transport by 2030; phase them out in cities by 2050; achieve essentially CO2-free city logistics in major urban centers by 2030.
	2.	Low-carbon sustainable fuels in aviation to reach 40% by 2050; also by 2050 reduce EU CO2 emissions from maritime bunker fuels by 40% (if feasible 50%).
Optimizing the performance of multimodal logistic chains, including by making greater use of more energy-efficient modes	3.	30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors. To meet this goal will also require appropriate infrastructure to be developed
	4.	By 2050, complete a European high-speed rail network. Triple the length of the existing high-speed rail network by 2030 and maintain a dense railway network in all Member States. By 2050 the majority of medium-distance passenger transport should go by rail.
	5.	A fully functional and EU-wide multimodal TEN-T 'core network' by 2030, with a high quality and capacity network by 2050 and a corresponding set of information services.
	6	By 2050, connect all core network airports to the rail network, preferably high-speed; ensure that all core seaports are sufficiently connected to the rail freight and, where possible, inland waterway system.
Increasing the efficiency of transport and of infrastructure use with information systems and market-based incentives	7.	Deployment of the modernized air traffic management infrastructure (SESAR) in Europe by 2020 and completion of the European Common Aviation Area. Deployment of equivalent land and waterborne transport management systems (ERTMS, ITS, SSN and LRIT, RIS). Deployment of the European Global Navigation Satellite System (Galileo).
	8.	By 2020, establish the framework for a European multimodal transport information, management and payment system.
	9.	By 2050, move close to zero fatalities in road transport. In line with this goal, the EU aims at halving road casualties by 2020. Make sure that the EU is a world leader in safety and security of transport in all modes of transport.
	10.	Move towards full application of "user pays" and "polluter pays" principles and private sector engagement to eliminate distortions, including harmful subsidies, generate revenues and ensure financing for future transport investments.

Source: (European Commission, COM(2011) 144 final, 2011)

Negative effects, which causes transport are: (Bristow, Wardman, Zanni, & Chintakayala, 2010), (Schuitema, Steg, & Rothengetter, 2010), (Eriksson, Garvill, & Nordlund, 2008), (Ryley, Davison, Bristow, & Pridmore, 2009), congestion (Gaunt, Rye, & Allen, 2007), (Gehlert, Kramer, Nielsen, & Schlag, 2011), air pollution and noise (Eriksson, Garvill, & Nordlund, 2008), traffic accident risk (Garling & Schuitema, 2007). The elimination of the negative impact of transport on the environment can be done by using the appropriate tools, for example pricing measures (road pricing), implementations of new technologies and fuels, alternatives solution to passenger transport, which based on the car (for example train). In the assessment and measurement of negative impacts of transport a large role measurement performance has. Some of measurement systems can certainly be utilized for evaluation of green supply chain, for example: carbon intercity, land consumption, transit productivity. These measures have an impact on the transport as well on efficiency of supply chain processes. Reducing the use of fossil fuels, changes in demand for transport services and the implementation of new technologies have a strongly impact on the using of energy and climate change. These and other elements could be components of evaluation of green supply chain.

After presenting the assumptions associated with the low-carbon economy remains the question of whether these elements have an impact on the green supply chain. Particular the elements of the evaluation.

3 ASSUMPTIONS AND EVALUATION OF CONSTRUCTION OF GREEN SUPPLY CHAIN

3.1 Components and nature of green supply chain in terms of the evaluation

The essence of green supply chain has been defined in a number of scientific publications. (Beamon, 1999), (Davies & Hochman, 2007), (EPA, 2000), (Rao & Holt, 2005), (Srivastava, 2007), (Vachon & Klassen, 2006). Making trial and selection of the most adequate definition we can say that: greening the supply chain is the process of incorporating environmental criteria or concerns into organizational purchasing decisions and long-term relationships with suppliers. "Indeed, there are three approaches to GSC: environment, strategy, and logistics" (Gilbert, 2001). Furthermore, the concept of Green productivity (GP) shows, that any development strategy is sustainable, therefore it needs "to have a focus on environment, quality, and profitability, which form the triple focus of GP" (Hwa, 2001), (Nunes, Marques, & Ramos, 2004). The green supply chain is "a managerial approach that seeks to minimize a product or service's environmental and social impacts or ecological footprint". (Rettab & Brik, 2008). The environmental collaboration was defined as specifically focusing on inter-organizational interactions between supply chain members including aspects such as joint environmental goal-setting, shared environmental planning, and working together to reduce pollution. It was tried to find elements with negative impacts of the environment and tried to minimize them with participating, within individual organizations in the whole supply chain (Vachon & Klassen, 2006). The essence of these considerations is to show the process of evaluating the implementation of green supply chain strategy. Algorithm for assessing the implementation of the principles of green supply chain, including its assessment shows figure 1.

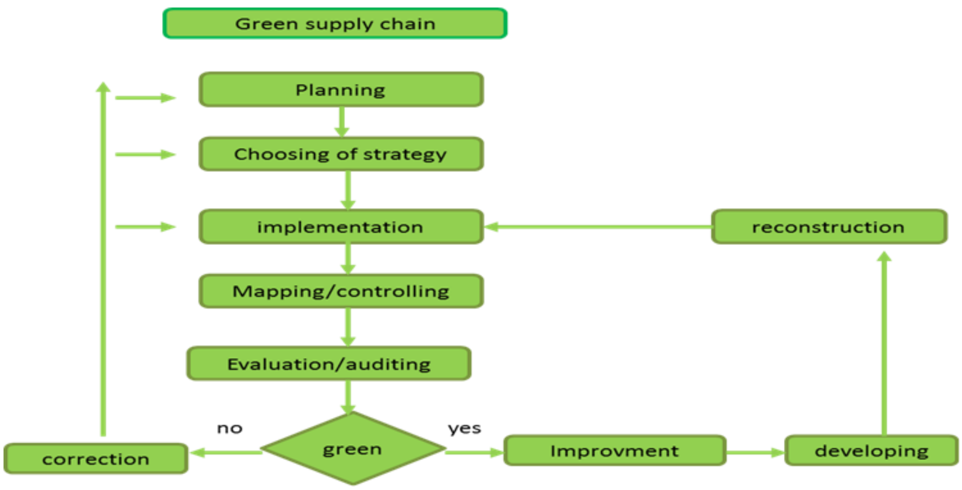


Figure 1: The algorithm of evaluation of the implementation green supply chain strategy

Source: own elaboration.

Approach in this model to the system of implementation and evaluation of assumptions of green supply chain, provides an easy way to take in a timely manner and at the appropriate stage of action, whose task is to correct or make of further development initiatives.

3.2 Assessment tools and basic model of evaluation system in green supply chain

In the process of assessing supply chains need to consider a few important items and perform specific procedures: (1) choose a product or a chain, (2) make a mapping of processes, (3) identify existing bottlenecks, (4) propose and develop alternative solutions, (5) choose the most optimal solution, (6) implement of new solutions, and after a certain time to make another review of repeating the procedure. The evaluation process should be continuous and constant, because only then you can make improvements and eliminate errors. A good way is prevention. The procedure must be presented by using appropriate tools, techniques and methods that will provide complete picture of the situation identify the versatility and the ability to customize the right tools to specific situations and supply chains.

For the evaluation of green supply chain, you can use multiple tools. The more comprehensive solution, the fewer items will be omitted. And thus it could be created a more versatile tool. Generally, it can indicate that the assessment used tools and instruments of: management, economic, legal and administrative (organizational), as well as activities within the social aspect, of which one of the most important roles to play in each category have environmental tools.

Most of them are linked and coming with the interaction with others within the closed loop. Selected Figure 2 presents tools. In the Green Supply Chain is very important the attempt to measure, analyze and improve performance among various links to ensure, that these companies are operating in environmentally friendly manner. It is important to establish green metrics and the corresponding elements, such as: carbon footprint analysis, emission from raw material sourcing, emission from inbound and outbound logistics and from manufacturing. It seems reasonable to make an evaluation of green supply chain using the best practices. It should also be pointed out that an important role is played by the flow of information and suggestions for implementation of alternatives. However to implementation, alternatives are only useful after the evaluation and auditing of the existing situation possible. Figure 2 shows a conceptual model of evaluation. Many of the indicators, measurements and areas are closely related to the transport and its impact on the environment and low-carbon economy.

It should be strongly noted that the two areas: transport and energy affect the structure of the supply chain, and thus its impact on the environment.

Figure 2: Green supply chain evaluation – areas, measurement and tools

Source: own elaboration.

The presented solution clearly shows the relationship between the elements of the assessment of the green chain and its tools and the principles of a low carbon economy. In decidedly way practical solutions should be used to supplement the general model and also assess these elements. For a full evaluation should take into account the factors directly affecting the functioning of the chain and those that indirectly affects its processes.

4 CONCLUSION

In the basic model were presented and highlighted tools, which can be used for evaluation of green supply chain. At the same time, using the presented model it can help to promote this kind of ideas. It also can be seen a clear relationship and impacts of the transport on the functioning of the chain. Using modern environmental tools leads to a reduction of negative impacts on the environment by transport. This is also useful in the evaluation of the supply chain.

It should be noted that the assumptions of the EU White Paper are very ambitious; in parts probably they are not to feasible to realization. However, the same assumptions could be some kind of guideline for implementation. Execution of the tasks associated with the use of appropriate tools and instruments (eg. sustainable transport) can be used to assess the green supply chain. Similarly situation is with the assumptions of a low carbon economy. Despite the criticism and necessity of incurring higher costs related to energy and the aims in themselves contribute to greater respect for the environment. It is known that the assumptions are not fully possible to realizations, but as in the case of transport, tools for the implementation of a low-carbon economy can be one of the elements of the assessment of green supply chain.

REFERENCES

[1] Beamon, B. (1999). Designing the Green supply chain. *Logistics Information Management, Vol. 12, No. 4,* , pp. 332-342.

[2] Bristow, A., Wardman, M., Zanni, A., & Chintakayala, P. (2010). Public acceptability of personal carbon trading and carbon tax. . *Ecological Economics 69* , pp. 1824–1837.

[3] Davies, J., & Hochman, S. (2007). The greening of the supply chain. *Supply Chain Management Review, 2007, 11 (5)* , pp. 13-14.

[4] Dendy Jr., J. E., Swartz, B., & Wendroff, B. (1977). Computing travelling wave solutions of a nonlinear heat equation. In J. H. Miller (Ed.), *Topics in Numerical Analysis* (Vol. III, pp. 447-463). London: Academic Press.

[5] EPA. (2000). The Lean and Green Supply Chain. A practical guide for materials managers and supply chain managers to reduce costs and improve environmental performance. . Washington, DC; : United States Environmental Protection Agency.

[6] Eriksson, L., Garvill, J., & Nordlund, A. (2008). Acceptability of single and combined transport policy measures. The importance of environmental and policy specific beliefs. . *Transportation Research Part A 42* , pp. 1117–1128.

[7] Euopean Commision. (2009). ROADMAP 2050, A PRACTICAL GUIDE TO A PROSPEROUS, LOW CARBON EUROPE, http://www.roadmap2050.eu/project/roadmap-2050.

[8] European Commission, COM(2011) 144 final. (2011). WHITE PAPER, Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, European Commission Brussels, 28.3.2011, COM(2011) 144 final.

[9] Garling, T., & Schuitema, G. (2007). Travel Demand Management Targeting Reduced Private Car Use: Effectiveness, Public Acceptability and Political Feasibility. *Journal of Social Issues, Vol. 63, No. 1,* , pp. 139-153.

[10] Gaunt, M., Rye, T., & Allen, S. (2007, January 2007). Public Acceptability of Road User Charging: The Case of Edinburgh and the 2005 Referendum. . *Transport Reviews Vol. 27, No 1,* , pp. 85-102, .

[11] Gehlert, T., Kramer, C., Nielsen, O. A., & Schlag, B. (2011). Socioeconomic differences in public acceptability and car use adaptation towards urban road pricing. . *Transport Policy* , p. doi:10.1016/j.tranpol.2011.01.003.

[12] Gilbert, S. (2001). Greening supply chain: enhancing competitiveness through green productivity. Tapei, Taiwan;.

[13] Hwa, T. (2001). Green productivity and supply chain management. In: Greening supply chain: enhancing competitiveness through green productivity,. Tapei, Taiwan;.

[14] Nunes, B., Marques, J. S., & Ramos, R. (2004). A Theoretical Approach for Green Supply Chain, . Gupta, S, Garg, N (Eds) "POM's Expanding Constellation", Proceedings of 2nd World POM Conference and 15th Annual POMS Conference, POM 2004, POMS,. Cancun, Mexico.

[15] Rao, P., & Holt, D. (2005). Do green supply chains lead to competitiveness and economic performance? . *International Journal of Operations & Production Management; 25 (9),* , pp. 898-916.

[16] Rettab, B., & Brik, B. (2008). *A Green supply chain in Dubai.* . Dubai: Dubai, UAE: Dubai Chamber Centre for Responsible Business;.

[17] Ryley, T., Davison, L., Bristow, A., & Pridmore, A. (2009). Public Engagement on Aviation Taxes in the United Kingdom. *International Journal of Sustainable Transportation, 4(2)* , pp. 112-118.

[18] Schuitema, G., Steg, L., & Rothengetter, J. (2010). The acceptability, personal outcome expectations, and expected effects of transport pricing policies. . *Journal of Environmental Psychology 30* , pp. 587-593.

[19] Srivastava, S. K. (2007). Green supply-chain management: A state-of - the-art - literature review,. *International Journal of Management Reviews, vol. 9 (1)* , pp. 53-80.

[20] Vachon, S., & Klassen, R. (2006). Extending green practices across the supply chain: the impact of upstream and downstream integration. *International Journal of Operations & Production Management; 26 (7),* , pp. 795-821.

[21] Vo, T. V., & Edwards, D. R. (1994). Development of In-Service Inspection Priorities for PWR. *Nucl. Technol.* , *106* (110), 253-259.

KEY PERFORMANCE INDICATORS AS ELEMENT OF ASSESSMENT AND TOWARDS THE DEVELOPMENT OF SUSTAINABLE MOBILITY

Blanka Tundys, Ph.D.
University of Szczecin
Faculty of Management and Economics of Services
Department of Logistics
Poland
blanka.tundys@wzieu.pl

ABSTRACT

The aim of this paper is to present key performance indicators (KPI`s), whose task is to assess the degree of implementation of the principles of sustainable urban mobility. Selected and presented KPI`s could serve as an example of good practice. The cities can use these indicators to assess its mobility. Connection of urban mobility with sustainable development is necessary. The main condition to the realisation of the concept of sustainable urban mobility is the pursuit of simultaneous examination on the impact of human activities: environmental, social cohesion and economic development prospects, both now and in the future. This is connected with the need to use limited resources, an attempt to improve the environment, increasing economic competitiveness and social cohesion cities. Useful elements in assessing of the negative effects of transport and logistics processes in the urban area may be indicators of urban mobility, both measurable (quantitative) and immeasurable (qualitative). It is therefore important to develop and implement appropriate measures, which will determine which of the rules and at what level in selected cities can be implemented.

Identification and selection of indicators can be used as one of the key tasks of this research. Another aim of the research is also an indication, whether the presented indicators are universal and fulfill the needs of each of the analyzed cities or every city should use a different set of indicators, if so, to what extent and what are the reasons. It was assumed, that created indicators support the assessment of urban mobility and they have a high value but their application capabilities require collecting large amounts of data, which is a costly procedure and may contribute to difficulties in implementation and realisation of the aim. Selection and choice of indicators have taken place on the basis of complexity of the proposed solutions, which have been applied and verified in the practice. The article has presented a theoretical-analytical approach.

Key words: KPI, urban mobility, indicators, sustainable mobility.

1 INTRODUCTION

Interest in scope of sustainable mobility, with particular emphasis on urban space, can be observed in the literature as a part of practical solutions and implementation in the cities. The administrative units use the different types of metrics for assessing their mobility. The interest in this subject is related to one hand with directions of cities development and to another hand as a result of observation of a multitude of solutions and indicators, which can be used to evaluate urban mobility. It should be noted, that the purpose of deliberations is to organize the knowledge in topic of indicators of urban mobility and in selected areas. The chosen indicators could be the basis for the KPI`s. The aim of the author is shown and indication of whether the indicators can be considered as universal and could be applied in all types of cities and they could have to be dedicated to each administrative unit. If so, to what extent and under what conditions taking into account the selected factors.

The main premise of the concept of sustainable urban mobility is the pursuit of simultaneous study on the impact of human activities on: environmental, social cohesion and economic development prospects now and in the future. This situation is connected with the need to use limited resources, an attempt to improve the environment, increasing economic competitiveness and social cohesion in the cities. Plans for sustainable mobility and their indicators may be one of the most effective tools to meet the needs of society in terms of freedom of movement, communication and business. It could be a useful element in the assessment of the development of the cities. The indicators of urban mobility may be: measurable (quantitative) and immeasurable (qualitative).

2 SUSTAINABLE URBAN MOBILTY

The conception of sustainable mobility can be defined in various ways. The development of the concept and related elements (including indicators) is related to the general concept of sustainable development. Sustainable urban mobility based on the movement of people and goods in urban areas, which can be done by car, as well as in other ways (e.g. by a non-motorized peoples) (Gudmundsson, 2004). The concept is developing and evolving (Szołtysek, 2011), indicating that mobility it is the state of the human mind, because mobility is a human right and give the possibility of unlimited movement. Urban mobility should be balance and equalize demand, which is associated with the implementation of individual transportation needs. And needs, that are carried out by public transport, bicycle or by foot. Sustainable urban mobility provides an alternative paradigm, which covers the complexity of cities and to strengthen the links between land use and transport (Banister, 2008).

3 METHODIC

The aim of the discussion in this paper is to analyze a set of indicators and practical implementation of sustainable urban mobility. Results of the choice of the individual elements of the system are a part of the evaluation and development trends of sustainable mobility. Used in the analysis are: a collection of the identified indicators describing and assessing the level of urban mobility, with particular emphasis on its sustainability. Selected and developed data should allow a comparison of indicators (based on case studies). In this case it is important to identify the requirements for the implementation of indicators, as well as areas, which can be compared and implemented in various cities. Created directory has to have a universal character. In this study theoretical and analytical methods have been used. Theoretical considerations are based on urban mobility indicators and their practical implementations in the cities.

4 INDICATORS OF URBAN MOBILITY

4.1 Definition

In constructing the indicators and the development of sustainable solutions for urban mobility assessment it should be take into account the general characteristics of a well-constructed index. Ingram (Ingram, 2009) identifies three principles for the selection of indicators. Namely: Validity, Availability and Reliability. Indications are so versatile that they can be successfully used in various areas. In terms of validity, there is a need to link the objectives and activities of the indicator. It must be clear and strong. Relationships between indicators and aims, such as urban policy, in the implementation of sustainable mobility must be easy to understand. Availability - indicators must be measurable and readily available from secondary data. Due to the need to ensure comparability of data and indicators they should be reliable. The significance of indicators extends beyond that which is directly obtained from observations. All informations that are availability and flow from indicator should be clear, simple, scientifically justified, verifiable and reproducible. Urban indicators cannot include only environmental indicators. Environmental performance is not the only factor in achieving a city's sustainability. Socio-economic issues play a critical role and socio-economic indicators are necessary (Mega & Pedersen, Urban Sustainability Indicators, 2012). Measurement of the performance of the operational efficiency of the system and measure the effectiveness of the transport system lead to achieving the objectives of the urban policy. Achieving the objectives and tasks, and the potential results should meet the defined objectives (Gleason, 1982).

4.2 Areas of application and types of indicators and indexes

The use of indicators to measure the sustainability of urban mobility is studied in theoretical, methodological and applied aspects (Barker, 2005), (Costa, Silva, & Ramos, 2005) (Frei, 2006) (Zhang Y., 2006). In the literature and in the research works, indicators are projected and constructed to monitor urban mobility in aspects of sustainable development (in three dimensions: economical, social and environmental. As an example in the works of: (Litman T., 2008) (Nicolas, Pochet, & Poimboeuf, 2003). Another area is the use of indicators for measurement of effectiveness of sustainable urban mobility policies (Lautso, et al., 2004). Indexes of urban mobility sholud not only serve scientific purposes. Their usefulness should have practical reflection. And their use should allow the urban decision-makers and other stakeholders to assess the level of urban mobility. The study of urban mobility can be used to make of transport policy documents, which are currently being implemented, measured and evaluated in different countries around the world. It is also important holistic approach to the subject. (Westfall & de Villa, 2001).

In the literature and in practice there are a number of indicators of urban transport. The scopes of research are extremely often performed only at the local level. And on this level activities were taken to make an evaluation of urban mobility. In most cases, in the studies appear only lists of indicators as recommended for using. This studies, which assess the usefulness as a mobility trend are focusing more on the overall performance of the city and are related with urban transport mobility. They are only a part of the whole of mobility.

Mobility indicators (index) are created for using different groups of elements. Relying on Shah et.al (Shah, Manaugh, Badami, & El-Geneidy, 2013) can be extracted the 8 areas in which the identified indicators will be useful for the construction of a model of urban mobility indices (Table 1). Selected partial indicators are presented in Table 2.

Table 1: Areas and indicators used to construct of indexes of urban mobility

Area/goal	Components	Indicator	Unit
Demand and context		Total population	
Affordability and accessibility	Improve access to daily destinations	Transit coverage by population (Percentage of people who live within 1 or 2 km of rapid transit)	%
		Average length of commute	Minutes
	Provide affordable mobility	Share of household income spent on transport	%
	Coordinate transportation and land use plans	Length of roads per 1,000 people	Km
mobility	Reduce congestion, delays and travel time	Average speed of trip	Km/h
	Encourage the use of and improve transit and active transport networks	Transport trips by mode	% by mode
	Provide for efficient freight travel	Annual volume of container traffic	Tonnes
Economic development	Facilitate economic growth through effective management of the transport network	Cost of vehicle congestion	In US$
Quality of life	Protect and promote public health	Number of noise and vibration exceedances per year	
	Respond to public expectations	Public transport customer satisfaction	%
	Addresses the mobility needs of the elderly, youth and persons with special needs	Share of transport facilities with step-free access	%
Operational efficiency	Provide an integrated public transport system		
	Provide a transportation system that is maintained, reliable and efficient	Public transport capacity	Passenger-km
	Ensure fiscal sustainability	Cost recovery from fares	Fare-box recovery ratio %
Environmental and resource conservation	Improve air quality	Greenhouse gas emission from passenger travel	Kg/capita
	Advance environmental sustainability	Annual energy consumption of transport	MJ
	Reduce dependence on nonrenewable resources	Biofuel and fossil fuel used per VKT or per capita	L
Safety	Reduce accidents	Road fatalities	
	Ensure personal security	Crime rates on public transport	%
Infrastructure conditions and performance	Maintain infrastructure in good condition	Percentage of roads in a state of good repair	

Source: own elaboration based on: (Shah, Manaugh, Badami, & El-Geneidy, 2013)

Table 2: Selected sub-indicators

Sub-indicators		
Affordability and accessibility	Average duration trip	Minutes
	Monthly income spent on transport	%
	Length of road per thousand inhabitants	m
Mobility	Average speed of trip	Km/h
	Daily trips on foot and by bicycle	%
	Daily trips by private motorized modes	%
	Daily trips by public transport	%
Operational efficiency	Annual public transport passenger-km per inhabitant	Km
	Recovery rate of public transport operating expenditure by fare box revenue	%
Environmental and resource conservation	Annual polluting emission due to passenger transport per inhabitant	Kg
	Annual energy consumption for passenger transport per inhabitant	MJ
Safty	Passenger transport fatalities per million inhabitants	Unit count

Source: own elaboration based on: (Shah, Manaugh, Badami, & El-Geneidy, 2013)

Presented and discussed will be the following measures, they were developed by EUROPEAN FOUNDATION for the Improvement of Living and Working Conditions in report: Urban Sustainable Indicators (Mega & Pedersen, Urban Sustainability Indicators, 2012), OECD (OECD, 1999), I_Sum (Silva, Costa, & Ramos, 2010), A. D. Little (1.0 and 2.0) (A.D.Little, 2014). Indicators from European Foundation presented Table 3.

Table 3: Urban Sustainable Indicators - European Foundations

Name of indicator	**Definition**	**Measure**	**Components/subindicators**	**Policy directions**
GLOBAL CLIMATE INDICATOR (GCI)	The contribution of cities to the change in the global climate.	Global Climate equivalent (GCeq) = total greenhouse gases (CO_2, CH_4, N_2O and CFCs).	Emitted total CO_2, CH_4, N_2O and CFCs and halons.	Decrease in the discharge of greenhouse gases
AIR QUALITY INDICATOR (AQI)	The number of days per year on which attention levels defined by law are exceeded in the most negative measurement.		Number of days per year on which alarm levels are exceeded and traffic circulation is stopped.	Improvement of air quality for all.
ACIDIFICATION INDICATOR (AI)	The deposition of acidic Components.	Acidification equivalents (Aeq) = total acidification caused by acidic compounds and deposited per hectare.	Deposition of SO2/hectare. Deposition of NO2/hectare. Deposition of NH3/hectare.	Drastic reduction of deposition.
ECOSYSTEM TOXIFICATION INDICATOR (ETI)	The emissions of toxic substances.	Toxic Substances equivalent (TSeq) = total emission of priority substances and radioactive substances.	Emitted quantities of cadmium, polyaromatic hydrocarbons, mercury, dioxin, epoxyethane, fluorides and copper. Emitted radioactive substances.	Reduction of the quantity of each one of the hazardous substances released by the city to a level where the risk posed by each substance is negligible.

Name of indicator	Definition	Measure	Components/subindicators	Policy directions
URBAN MOBILITY INDICATOR (UMI) OR CLEAN TRANSPORTATION INDICATOR	The use of environment-friendly means of transport, especially for enforced mobility, defined as mobility for commuting and basic Leeds	Urban Mobility equivalent (Umeq) = total number of passenger kilometres by non-environment-friendly means (private car) per inhabitant and per year. (If passenger kilometres cannot be estimated, trips can be used). Enforced Umeq (EUMeq) = total number of passenger kilometers – passenger kilometres by foot and bicycle – passenger kilometres by public transport, per inhabitant and for basic needs each year.	Enforced Urban Mobility Indicator (EUMeq, mainly for commuting). Relevant subindicators may be developed according to trip purposes (tourism, work and study, leisure, business, freight) and according to transport means.	Reduction of unnecessary use of motor vehicles, reduction of enforced mobility and improvement of accessibility. The EC's study on Car-Free Cities (EC 1992) indicates that there is a maximum number of private cars that cities can afford.
WASTE MANAGEMENT INDICATOR (WMI)	The total volume of waste disposed of.	The total volume of waste disposed of.	Waste disposed of by incineration or in controlled landfills and in uncontrolled landfills; waste reused or recycled.	Primary goal: waste minimization, i.e. prevention and avoidance, followed by reuse and recycling; drastic reduction of waste for disposal.
ENERGY CONSUMPTIO N INDICATOR (ECI)	The total amount of consumed energy.	Energy equivalent (Eeq) expressed in TOE (tonnes of oil equivalent) per inhabitant per year.	Consumed energy according to the source of production (renewable energy, electricity, petrol, gas-oil, heavy fuel oil, natural gas, carbon and wood).	Conservation and reduction.
WATER CONSUMPTION INDICATOR (WCI)	The total amount of water withdrawal.	Water equivalent (Weq) expressed in m3 per inhabitant per year	The Water Consumption Indicator is the total amount of water extracted. Indicator: Water from recycling and used mainly for maintenance of public and green spaces is to be subtracted.	Reduction of water consumption by conservation patterns and techniques; recycling, reuse.
NUISANCE INDICATOR (DI)	Nuisances created by noise, odour or visual pollution.	Nuisance equivalent (Neq) = percentage of the population affected by noise, odour or visual pollution.	It is essential to have a subindicator for the percentage of the population seriously affected by one of the above factors.	Improvement of local environments by reduction of odour, noise or visual pollution
SOCIAL JUSTICE INDICATOR (SJI)	The degree of social sustainability of a city.	Social Justice equivalent (Sjeq) expressed by the percentage of people affected by poverty, unemployment, lack of access to education, information, training and leisure.	It is essential to have a subindicator for the percentage of the population seriously affected by one of the above components. It is also essential to have subindicators for vulnerable groups of population (youth, women, the handicapped and long-term unemployed).	Reduction (ideally elimination) of the percentage of the excluded and marginalised population.

Name of indicator	Definition	Measure	Components/subindicators	Policy directions
HOUSING QUALITY INDICATOR (HQI)	The degree to which inhabitants suffer from poor housing conditions.	Housing Quality equivalent (HQeq) = percentage of people affected by lack of housing or poor housing environments.	The number of homeless in percentage of the inhabitants and of those who might become homeless	Offering all inhabitants good housing conditions.
URBAN SAFETY INDICATOR (USI)	The degree to which people suffer from lack of urban safety.	Urban Safety equivalent (USeq) = total percentage of the population affected seriously by crime or traffic accidents.	It is essential to have a subindicator for the total percentage of irreversible long-term injuries.	Fostering of urban safety. Decrease in, ideally elimination of, attacks and incidents.
ECONOMIC URBAN SUSTAINABILITY INDICATOR (ESI)	The viability of the urban economy.	Economic Sustainability equivalent (ESeq) = city income - city fiscal deficit - environmental expenditure - pollution damage per inhabitant per year.	City income (total individual incomes). City fiscal deficit (–) (city budget – taxes). Environmental expenditure (for waste collection, sewage, transport, water management). Pollution damage (air, water, land).	Increase of economic sustainability with increase of city income and city budget and reduction of pollution damage.
GREEN, PUBLIC SPACE AND HERITAGE INDICATOR (GPI)	The improvements needed for green, public spaces and heritage.	Green, Public Space and Heritage equivalent (GPSeq) = percentage of the green or public spaces and local heritage in need of improvement.	It is important for urban quality of life to have the surface of green spaces per inhabitant, the surface of heritage spaces per inhabitant and the surface of public spaces per inhabitant. They are suggested as alternative indicators.	Improvement of green and public spaces, restoring sites, forging the identity of cities.
CITIZEN PARTICIPATION INDICATOR (CPI)	The degree to which the local population participates in the decisionmaking and improvement of the local quality of life.	Citizen Participation equivalent (CPeq) = total percentage of the population participating in local elections or as active members in associations for urban improvement and quality of life.	Percentage of people participating in local elections. Percentage of people being active members of environmental, public health and cultural associations.	Co-management of cities with citizens, urban governance with all actors.
UNIQUE SUSTAINABILITY INDICATOR (USI)	Indicator to be defined by each city according to its uniqueness (i.e. unique climatic and local conditions) or the planning of a unique once-ina- lifetime event such as the organisation of the Olympic Games or a universal exhibition. This indicator should represent the degree to which unique factors or events lead to urban sustainability with its environmental, social and economic dimensions.			

Source: own elaboration based on: (Mega & Pedersen, Dublin 2012)

From another perspective, interesting to present are specific measures of sustainable urban mobility. These can include for example. I_SUM or indicator developed by OECD or A. D. Little.

Comprehensive index is presented in 2010. I_SUM. I_SUM is the acronym for Index of Sustainable Urban Mobility (Silva, Costa, & Ramos, 2010).

It was designed to combine the main domains and themes needed for urban mobility monitoring. It was meant to be a supporting tool for mobility management and for the formulation of public policies. The hierarchy of criteria of I_SUM was essentially structured on the top of an indicator set. The main characteristics of the Index are (Silva, Costa, & Ramos, 2010):

- a hierarchy of criteria based on concepts and elements identified by technicians and managers working at urban and transportation planning agencies of eleven important Brazilian cities or metropolitan regions.
- a weighing system for the criteria. It establishes the relative importance of the elements and concepts based on the judgment of a small group of experts from different countries. It takes into account the weights of the main sustainability dimensions (i.e., social, impact of any actions on the mobility system as a whole or on each separate dimension)
- a structure of criteria aggregation allows for trade-offs.
- a tool is easy to understand and to apply. It does not require specific software or complex mathematical models for practical use. A simple spreadsheet can do the entire computation job.

This indicator, despite many factors and elements that constitute their parts and it is not complicated. On the other hand, its versatility allows for accurate assessment of urban mobility[1]. The figure presents a mathematical model (1 and 2). The entire process of creating and implementing comprises 87 indicators that make up the final form of the meter.

$$I\_SUMg = \sum_{i=1}^{n} w_i^D \cdot w_i^T \cdot w_i^I \cdot x_i \ , \qquad (1)$$

where: I_SUM*g*: Global Index for *n* indicators;
w_i^D weight of the Domain that Indicator *i* belongs to;
w_i^T: weight of the Theme that Indicator *i* belongs to;
w_i^I: weight of Indicator *i;*
x_i: score (normalized value) obtained to Indicator *i.*

$$I \quad SUM_{SDi} = \sum_{i=1}^{n} w_i^{SD} \cdot w_i^D \cdot w_i^T \cdot w_i^I \cdot x_i \qquad (2)$$

with SD_j = Social, Economic or Environmental Dimensions, where:
I_SUM_{SDj}: sectorial Index to each sustainability Dimension SD_j;
w_i^{SD} weight of the Dimension SD_j in the Theme that Indicator *i* belongs to;
w_i^T, w_i^I, x_i: as defined above.

The simplest and also the oldest indicators are related to urban mobility, based on aspects of negative effects of transport, is an index developed and published in 1999 by the OECD. The criteria are indicated by WGOSE (ang. Working Group on the State of the Environmental) and include such elements as: the importance of transport and environmental policy in urban operations, the correctness of the data analysis and measurability. OECD indicator is not a mathematical description of the urban mobility. This model is expressed as a group of measurable and immeasurable elements, which were helping the integration of elements of the environmental aspects of transport policy. These elements may to lead to the development of sustainable urban mobility index. The elements which are included in these indicators are selected on three parts: (1) sectoral trends and patterns of environmental – overall traffic

[1] More see: Silva, A.N. R., Costa M.S., Ramos R.A.R., 2010. Developmentand Application of I_SUM – An Index of Sustainable Urban Mobility. Paper Presented AT the 89 th Annual Meeting of the Transportation Research Board, Washington, D.C

trends & modal split, infrastructure, vehicles and mobile equipment, energy use; (2) interaction with the environment – land use, air pollution, water pollution, noise, waste, risk and safety; (3) economic and policy aspects – environmental damage, environmental expenditure, taxation and subsidies, prices structure, trade and environment (OECD, 1999).

An interesting approach is also index, supported by empirical research, presented by A.D. Little Reports (A.D.Little, 2014). Over turn of few years, the indicators were developed and evaluated. They are very complex and could help to identify and assessment of urban mobility. Cities can receive a maximum of 100 points in the two categories: mobility maturity and performance. Both indicators presented table 4.

Table 4: Urban mobility index – A. D. Little

area	Elements			
	Points max.	Mobility urban index 1.0	Points max.	Mobility urban index 2.0
Mobility	32,5	share of public	58	financial attractiveness of public transport,
		walking and cycling in modal split		share of public transport in modal split,
		mobility strategy/vision		share of zero-emission in modal split,
		number of shared cars per citizen		roads density,
		number of shared bikes per citizen		cycle path network density,
		penetration rate of smart cards		urban agglomeration density,
				smart card penetration,
				bike sharing performance
				car sharing performance,
				public transport frequency,
				initiatives of public sector
Performance	67,5	fatalities per citizen	42	transport related CO2 emissions,
		transport related CO2 emission per capita		NO2 concentration,
		vehicles registered per citizen		PM10 concentrations,
		average travel Speer		traffic related fatalities,
		satisfaction with transport,		increase of share public transport in modal split,
		mean travel time to work		increase of share of zero-emission modes,
				mean travel time to work,
				density of vehicles registered

Source: own elaboration based on: (A.D.Little, 2014)

Presented in Table 4 the parameters are included in the mobility index to assess both parts: mobility and performance. Extending the range of indicator, a focus was emphasized on mobility in the rate of 2.0. Thus shifting the center of gravity indicates have showed a greater concentration on the elements associated by using various types of transport and also the elements related to the environment and sustainability.

As were shown, the variety and richness of indicators and the factors that enter into overall composition of indexes, have an influence to the form of measurement of urban mobility. This situation predestined to indicate, that it is an area for developing and implementation, especially in terms of practical using. Ratio analysis, also points to the fact, that some of them contain the same element, which indicates of their versatility. Presented and chosen indexes and indicators give some kind of idea how to measure urban mobility. From a theoretical point of view, both side - design (construction) and using should be not questionable. However, as practice shows - their use and practical using was implemented only in big cities. All the above described ratios are used in practice.

Around the world, a lot of cities have been tested in the context of research, either alone showed interest in the subject and create documents and research related to urban mobility. A study of mobility in Europe may be supported by large projects coordinated by the European Union, but also in area of local projects and solutions. In European cities the most frequently tested cities were capitals and the city of France, Italy and Great Britain. In South America, Brazil is the leader in implementation and practical verifications of urban mobility indexes. Also, Asian cities, which are characterized by a very large number of the population and thus have not only the transport problems, but also with mobility, often have a use the indicators to assess of urban mobility. Partial tests are performed in the USA.

Implementation of various types of research projects has permitted of the distinction of different (also dedicated) performance indicators. Extensive researches projects have helped to define the multitude of solutions and limitations of urban mobility. Their presentations have halped to shown their scope and practical implementation. The limitations of the text allowed the indication of only selected items. It is extremely interesting to make in the next part of the research a comparative analysis of the indicators, targets and objectives of the projects, which were created under the concept of EU-supported research (eg. CITEAIR, SHAPE-IT GLOBAL + 5, Actuate, Tide, Trolley, Aeneas, Bapts, Presto, Link, Niches, Niches + Matisse, Paramount, Remote control, Synaptic, Tosca, Trump, Voyager, Well-Timed, Atlantic, Cabri-Volga, Cape, the European Digital Cities, Heaven, EMTA and classic project in filed of urban mobility: CIVITAS and SUMP). The results of the projects were being implemented in urban organisms, which allows to their practical verification. So it seems to be reasonable of advancing this research area.

5 SELECTED INDICATORS (KPI) AS ASSESMENT OF DEVELOPING OF URBAN MOBILITY – FRAMEWORK OF BASIC MODEL

After the selection of indicators and the collection of data, the information is compared and evaluated.

Presented in earlier parts of the measurement an approach of mobility is a comprehensive solution, containing a lot of components. This shows that creators made a good job, as they allow for versatility and complexity. However practice shows that these indicators are used in big cities. To make a research of urban mobility it should be remembered that capitals and major cities in North or South America are characterized by other considerations as the cities in Europe (in areas of transport and mobility requirements). That what should take into consideration in creating or adapting process of the measurements, for a particular city, is certainly the specifics of the city and its structure and morphology. European city are characterized by the historical districts, where modernization and infrastructure changes are difficult. The study of urban mobility and changes in its structure must be adapted to the city and its character. Modern tools contribute to the fact that the city will be able to cope with the problems of communication. Selection of tools and thus indicators must correspond to the nature of the city. In medium-sized cities, there were not introduced car-sharing, built road bikes or do not turn the bypass and these part of indicators should not be integreted with mobility index. The indicators should be used as a base to assess and adapts to specific solutions in the city.

The presented indicators should be used as a base from which to assess a selected city and adapts to its specific solutions. Figure 1 below shows the diagram and the algorithm according to the procedure of constructing a comprehensive index of urban mobility. This comprehensive model has the features of universality and high generality. It does not contain specific measures, but indicates what level of urban mobility is located, as it sought and indicates that may be a part of sustainable development. Using of category KPIs (Key Performance Index) should be noted, that in the construction of the indicator it will be used no more than 15 elements. They can be categorized, and on the examples of results of in-depth research, already for a specific solution or city can be used more indexes. Creating a catalog of KPI`s to measure of sustainable urban mobility it should be take into account: measurability (costs, tools, accuracy, use of existing date); easy to use and communicate to public, clarity (general public, policy makers, professionals); consider individuality of cities: geographical scale (local-national-international), control (ability to change characteristics).

Urban mobility is not possible without the integration of passenger and freight transport. Enabling the movement of persons and goods included: integrated urban traffic and travel information, integrated urban network management, integrated charging policy and ticketing, integration of the infrastructure.

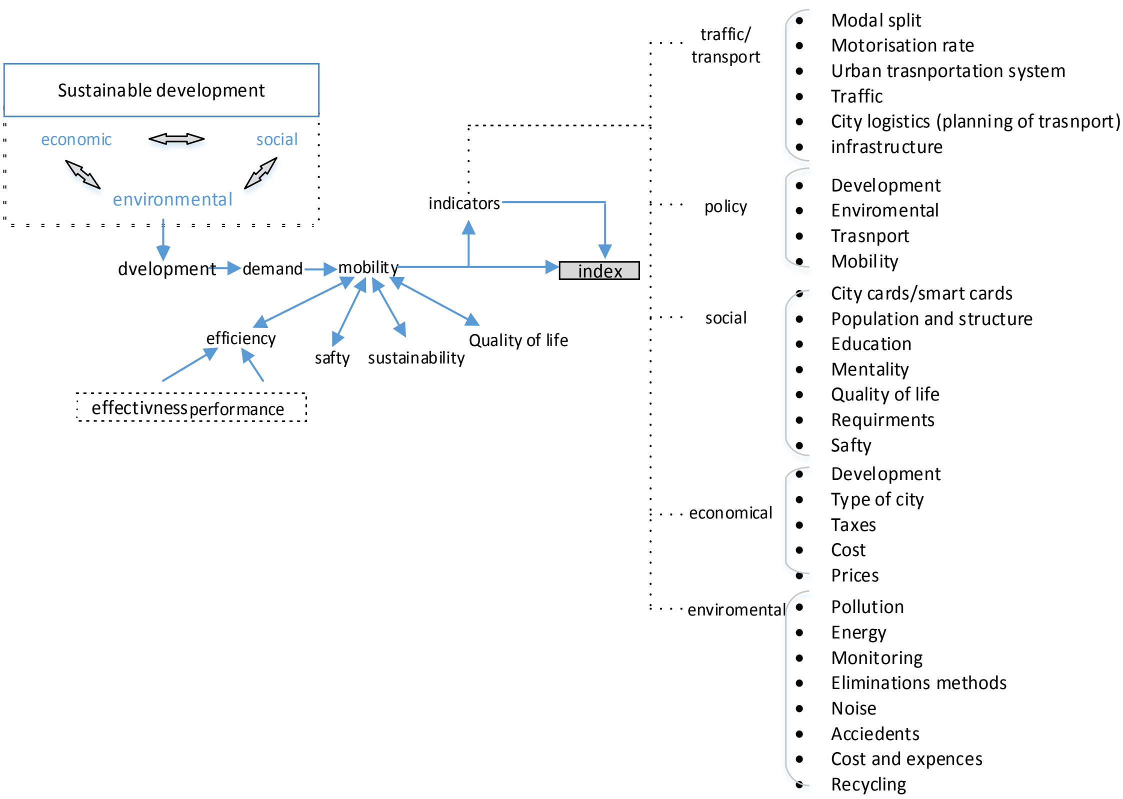


Figure 1: The procedure of constructing a comprehensive index of urban mobility

Source: own elaobration.

Before the KPIs will be used to carry out to develop of urban index it should be make a preliminary analysis. Analysis must be associated with the type of city, because this factor enters on the rate of mobility. It should be taken into account: the type of building (architecture), size of the city, the extent of territorial zoning plans and the amount and quality of transport infrastructure and the number and types of tools they are already use in city logistics projects, they are supporting the creation of urban mobility. The presented indicators may be the elements of development of the urban mobility. They should be not limited. They can provide an excellent basis for the construction of the evaluation system of urban mobility.

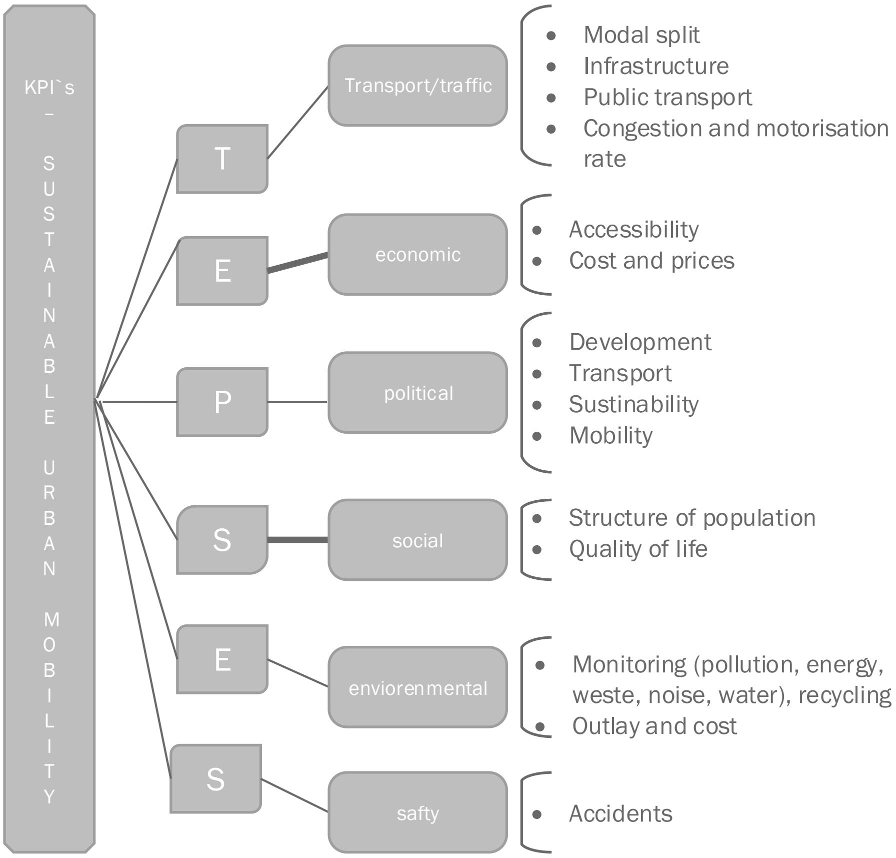


Figure 2: KPI`s for urban mobility index

Source: own elaboration.

6 SUMMARY

Indicators of urban mobility are vital and important tools for achieving the objectives of urban logistics in the cities. It is important to use properly modified and adapted indicators to the various municipal units. Not all parts of the highly complex indicators must be tested in use, for example in smaller cities. Also, urban structure, economic relations, geographical location and historical conditions affect what level of mobility at the city. The level of mobility can be a great tool for comparisons between cities, to be their element of competitiveness but also be hint what to invest in, which eventually improve, remove, or change to the city are sustainable and efficient transport. In this case it could be a way to develop a sustainable mobility for most important beneficiaries or residents in the city. The aim for this activity is satisfaction with the quality of life in the city.The proposed KPI catalog may be subject to decomposition and expansion.

REFERENCES

[1] A.D.Little. (2014). The Future of Urban Mobility 2.0, Imperatives to shape extended mobility ecosystems of tomorrow,. A.D.Little.

[2] Banister, D. (2008). The sustainable mobility paradigm. Transport Policy, Vol. 15, (2), pp. 73-80.

[3] Barker, W. (2005). Can a Sustainable Transportation System Be Developed for San Antonio, Texas? Transportation Research Record, 1924 , pp. 120-128.

[4] Barker, W.G. (2005) Can a Sustainable Transportation System Be Developed for San Antonio, Texas?. Transportation Research Record, 1924, 120-128.

[5] Costa, M., Silva, A., & Ramos, R. (2005). Sustainable Urban mobility: a comparative study and the basis for a management system in Brazil and Portugal. In L. W. eds C.A. Brebbia, Urban transport and the environment in the 21st century (pp. 323-332).

[6] Frei, F. (2006). Sampling mobility index: Case study in Assis—Brazil. Transportation Research Part A: Policy and Practice, 40, , pp. 792-799.

[7] Gleason, J. M. (1982). Toward Valid Measures of Public Sector Productivity: Performance Measures in Urban Transit. Management Science, Vol. 28, No. 4, , pp. 379-386.

[8] Gudmundsson, H. (2004). Sustainable transport and performance indicators. . In R. H. Hester, Transport and the Environment — Issues in Environmental Science and Technology, 20. Royal Society of Chemistry (pp. 35-63). Cambridge-UK.

[9] Ingram, G. K. (2009). Smart Growth Policies: An Evaluation of Programs and Outcomes. Lincoln Institute of Land Policy, Cambridge, Mass.

[10] Lautso, K., Spiekermann, K., Wegener, M., Sheppard, I., Steadman, P., Martino, A., et al. (2004). PROPOLIS – Planning and Research of Policies for Land Use and Transport for Increasing Urban Sustainability. Final Report, second edition.

[11] Litman T. (2008). Well measured – Developing Indicators for Comprehensive and Sustainable Transport Planning. Victoria: Victoria Transport Policy Institute,.

[12] Mega, V., & Pedersen, J. (Dublin 2012). Urban Sustainability Indicators,. European Foundation for the Improvement of Living and Working Conditions, .

[13] Nicolas, J., Pochet, P., & Poimboeuf, H. (2003). Towards Sustainable Mobility Indicators: ApplicationTo The Lyons Conurbation. Transport Policy, 10, , pp. 197-208.

[14] OECD. (1999). OECD. Indicators for the Integration of Environmental Concerns into Transport Policies. Environment Policy Committee, Working Group on the State of the Environment.

[15] Shah, Y., Manaugh, K., Badami, M., & El-Geneidy, A. (2013). Diagnosing Transportation, Developing Key Performance Indicators, to Assess Urban Transportation Systems. Journal of the Transportation Research Board, No. 2357, DOI: 10.3141/2357-01 , pp. 1-12.

[16] Silva, A. R., Costa, M., & Ramos, R. (2010). Developmentand Application of I_SUM – An Index of Sustainable Urban Mobility. Paper Presented AT the 89 th Annual Meeting of the Transportation Research Board,. Washington, D.C.

[17] Szołtysek, J. (2011). Kreowanie mobilności mieszkańców miast. Warszawa: Wolters Kluwers.

[18] Westfall, M. S., & de Villa, V. (2001). Cities Data Book: Urban Indicators for Managing Cities. Manila, Philippines: East Asian Development Bank,.

[19] Zhang Y., G. B. (2006). Using satellite remote sensing to survey transport-related urban sustainability – Part 1: Methodologies for indicator quantification. International Journal of Applied Earth Observation and Geoinformation, 8, pp. 149-164.

EFFECTS OF NEW TECHNOLOGIES ON HUMAN ERRORS

Pero Vidan, PhD
University of Split
Faculty of Maritime Studies, Split, Croatia
pvidan@pfst.hr

Mihaela Bukljaš-Skočibušić, PhD
University of Zagreb
Faculty of Traffic and Transport Scineces
Vukelićeva 4, Zagreb, Croatia
mihaela.bukljas@fpz.hr

Jure Rubić, student
University of Split
Faculty of Maritime Studies, Split, Croatia
jure.rubic@pfst.hr

ABSTRACT

Modern vessels are fitted with sophisticated equipment and highly automated navigation systems. Investigations of maritime accidents confirm that a series of events may occur within a ship's system, contributing to the hazard. The results produced by investigations and studies increase the awareness of causation of maritime accidents and reduce their incidence. This paper discusses the human error causation with particular focus on elements that considerably contribute to human failure that eventually results in a marine accident. Given the complexity of this issue, it is important that the future efforts of competent maritime organisations, experts developing modern ship operation systems, and seafarers as the end users of these systems, are directed towards creating systems, i.e. working environments, where the risk of human error would be reduced to a minimum.

Key words: Human error, maritime technology, safety.

1 INTRODUCTION

According to the research conducted by *British Marine Accident Investigation Board* (MAIB), *Canadian Transportation Safety Board* (TSB), and A*ustralian Transportation Safety Board* (ATSB), which carefully studied 350 cases of maritime accidents, 82 to 85% of all accidents were either directly initiated by human error or were associated with human error by means of inappropriate human responding to threat situations [1]. The incidence of human error in maritime shipping industry does not arise exclusively from the operator's failure. There is a wide range of factors contributing to the occurrence of human error. One of them is modern technology. It is considered that inadequately designed equipment causes 1/3 of major sea accidents [2]. Another aspect affecting the human error is the interaction between the technology and human beings i.e. lack of training and familiarization with equipment's operation procedures. A study performed by R. Ziarati and M. Ziarati reveals that inadequate use of navigation equipment causes 28% of accidents [3].

Another project dealing with the impact of technology on human error has been conducted by Finnish applied research organization VTT and Rolls-Royce. They present their vision of seafaring ten years from now, projecting current technology to the near future. According to their vision, the ship's navigation bridge of 2025 will feature heads-up displays and high-tech workstations (Figure 1).

Figure 1: Design of the navigation bridge in the near future

Source: http://www.gizmag.com/future-ship-bridge-2025/31250/pictures#2

The conventional helm is replaced by a workstation that identifies different users and adjusts the helm station to custom presets for chair adjustment, and control and display configurations. The windows form an adjustable heads-up display that enables the master and the officers to "see through" the deck, so a crewman is visible on the augmented display even if the deck or equipment is in the way. The screen can also show the route of one's own ship and other vessels, obstacles hidden by fog and other weather conditions, sea ice conditions along the planned route, share information with deckhands and share information in real time between vessels. At night, thermal night vision would enhance visibility to such an extent that conditions would not differ much from conditions during daylight. VTT and Rolls Royce believe that this technology could be a step towards the development of fully automated vessels.

It is true that the cost of a ship's crew is the single largest item in the total costs over the ship's life cycle, and that companies continuously try to find ways to reduce it. Therefore it is not unusual to hear announcements that the vessels will become fully automated and crewless in the future. The importance of these visions and trends has been confirmed by the European Union by allocating 8.4 million US dollars to the project MUNIN (Maritime Unmanned Navigation through Intelligence in Networks) engaged in research on the development of crewless ships.

2 HUMAN ERRORS IN SEAFARING AND THE IMPACT OF NEW TECHNOLOGIES

If a device is intended to serve the operator as an aid in safe ship operation, its technical and technological features have to ensure optimal applicability. This is achieved through finding quality ergonomic solutions in the process of designing both a piece of equipment and a whole system such as the navigation bridge.

The maritime system is a system involving people, and human errors are dominant in casualty situations. About 75-96% of marine casualties are caused, at least in part, by some form of human error. Studies have shown that human error contributes to [4]:

- 84-88% of tanker accidents,
- 79% of towing vessel grounding,
- 86-96% of collisions,
- 75% of allisions, and
- 75% of fires and explosions.

In most cases, incidents are not caused by a single action; they rather result from a series of wrong actions that make a causation chain. A Dutch study of 100 marine casualties found that the number of causes per accident ranged from 7 to 58, with an average of 23.

The most important factors that affect the performance of an individual include organisational factors, i.e. the factors associated with the nature of the workplace:

- the quality of tools and equipment, i.e. the technology the operator is in interaction with,
- whether or not the managing staff (masters, managers, inspectors, supervisors) turn a “blind eye” and pretend they do not see the rules being breached, in order to get the job done,
- the quality of the rules, regulations and procedures, and
- the organisation’s overall safety culture.

Here are examples of some situations that operators deal with (the degree of risk depends on a particular situation):

- lack of standardised equipment,
- lack of applicability of the equipment (including the information overload issue),
- new devices that are essentially irrelevant for the task they are intended for,
- inadequate design of the equipment – ergonomic problems,
- ignoring human factors when designing and implementing technologies,
- operator’s excessive reliance on technology,
- fast changes in technology development and lack of full integration,
- degradation of operator’s individual skills due to the introduction of new equipment, etc.

Most of regulations and standards applying to ships do not address complex issues such as cognitive activities associated with implementing new technologies on board ships. The number of standards and regulations that exclusively deal with the relationship between onboard automation and human beings are relatively low. Almost 80% of the regulations in maritime shipping industry refer to technical rules, whereas the remaining 20% refer to humans. For instance, SOLAS Chapter V, regulation 15, lays out the principles relating to bridge design and design of navigational systems and equipment. Operators have to cope with the equipment produced by various manufacturers applying their own standards, which makes the overall bridge system inconsistent. The equipment installed on ships of the same type and purpose may greatly vary from vessel to vessel, so that operators have to adjust to a new equipment layout, differing specifications etc., which represents a potential source of failure. The American National Transport Safety Board states that almost one out of three failures is caused by inadequate equipment design, where the lack of standardisation is the key contributing factor.

According to British psychologist Lissiane Banbridge, the core of the problem is that equipment manufacturers and their designers often tend to displace a human being out of the system wherever possible but keep on requiring an operator to carry out the tasks for which they have not found adequate solution. One of the problems that may arise in automated systems is undoubtedly the poorly designed technology that does not allow an adequate interaction between the human being and the equipment. If the interaction between a device and an operator is not ergonomic, it is likely that the operator will be overloaded and confused by the information provided by the device. For example, in case that a number of alarms are given at the same time, it is possible that critical warnings remain unnoticed.

One of the most important aspects of the effect of new technologies on the operator is his/her workload. Officers that operate a vessel are exposed to a large number of simultaneous information from various sources:

- the ship’s environment, especially in dense traffic areas,
- verbal instructions received from the superiors or subordinates,
- various devices, tools, alarm and communication systems, etc.

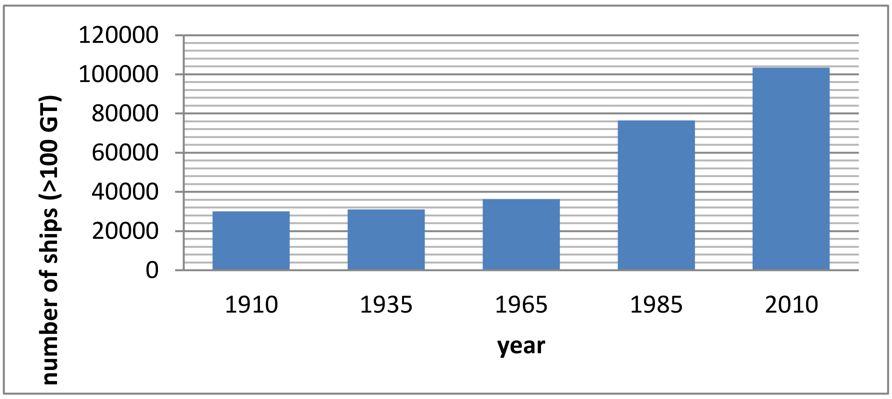
The workload control when using new technologies is a very important factor in achieving optimum working performance of operators. Too much workload may lead to a situation where the requirements can exceed operators’ capacities whereas, on the other hand, low workload may result in boredom and neglecting the control loop.

Technologies may cause the degradation or loss of skills. In the long run, the removal of the operator from the direct process management or bringing him/her in the position of a passive observer may decrease both the abilities and skills of the operator. This may particularly become tricky when it is necessary to identify a problem and act in case of emergency. In other words, the introduction of new technologies may cause undesired phenomena such as an operator’s over-reliance on technology or shifting an operator’s knowledge and skills from the area of active assets towards the area of passive assets, eventually making these assets insufficient or unavailable in emergencies [2].

It is essential that the operators are aware of the constraints of the new technologies. If their expectations regarding the performance of a new piece of equipment are erroneous or too high, they might expect that the system will warn them of potential threats or take action in lieu of them although the system is not capable of doing it. Also, when crew members adjust to new systems on board ship, they may become over-dependent on them [5].

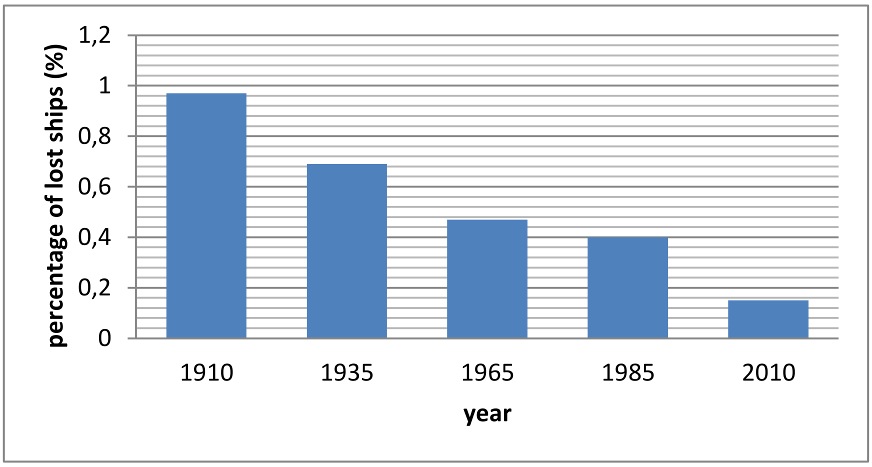
Humans’ actions may directly result as accidents. A large number of active failures arise from certain human actions but not all active failures are human actions. Physical failure of controls and defences may occur due to conditions such as over-stress, fatigue, etc. These are often referred to as *unsafe conditions*. There are an almost infinite number of possible active failures and an equally large number of combinations of circumstances in which accidents can happen.

Maritime shipping industry has experienced dramatic changes over the last hundred years, largely due to various innovative technologies that have been continuously implemented aboard ships. The fact is that these technologies have considerably contributed to the overall enhanced safety of the maritime systems. Consequently, as the world fleet grows (Graph 1), the relative percentage of lost vessels decreases (Graph 2).



Graph 1: Growth of world fleet size by number of ships

Source: Safety and Shipping, An insurer's perspective from Allianz Global Corporate & Specialty

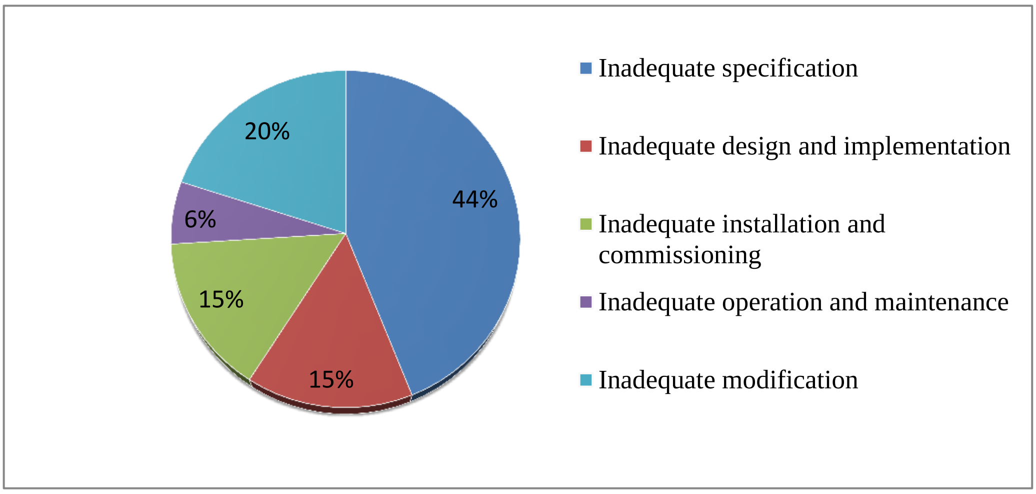


Graph 2: Percentage of lost ships

Source: Safety and Shipping, An insurer's perspective from Allianz Global Corporate & Specialty

While the implementation of technologies has reduced the number of sea accidents, human factor remains the main cause of incidents. People are in the interaction with the technology, environment and organisational factors. This interaction forms a specific working environment and a system where, in most cases, a human being represents the weakest link in the chain. If people were not different, the technology would easily eliminate human deficiencies and create an almost ideal system where no human error would ever occur. However, everyone has their own various mental and physical abilities. Technology cannot change human performance.

The problem of insufficient usage of the equipment still exists. Some of the primary causes of failures resulting in poor exploitation of modern systems are shown in Graph 3. One of the essential aspects of this issue is the fact that the equipment often differs considerably from vessel to vessel, and seafarers rarely serve the same or similar vessels throughout their career. The end result is the superficial familiarisation with the system. Although every device has a user's manual offering certain information and guidelines to the operator, the latter is often unable to read the manual thoroughly upon joining the ship, due to the lack of time. Consequently, this leads to a situation where the operator is forced to handle the devices he/she is not entirely familiarised with. The operator improvises, relies on the previous experience and transfers it from the previous devices to the new ones that do not necessarily have the same mode of operation. These situations open up huge potential for misinterpreting the information that is provided by automated systems.



Graph 3: Primary causes of failures in modern exploitation systems

Source: Foord, A., G., and Gulland, W. G., Can technology eliminate human error?, available at: http://wildeanalysis.co.uk/system/downloads/371/original/Can_Technology_Eliminate_Human_Error.pdf?

In order to reduce the share of human error in maritime accidents, it is necessary to create the environment and the system that will benefit from the advantages of human beings and neutralise their drawbacks in various ways. The prevailing public and legislative standpoint is that, in the end, the ultimate person in the failure chain is to take the responsibility. However, investigation of maritime accidents, carried out by objective and qualified experts, almost always reveal that unwanted events result from a series of events and contributing factors.

The key elements (Table 1) in the introduction of such as system may be latent failures, i.e. deficiencies within the system itself. Identification and elimination of these deficiencies will have a far greater effect on the maritime system safety than focusing on operators' active failures.

Table 1: Causes and consequences of technology to human errors

Hardware	Failures occur due to inadequate quality of materials or construction, or non-availability or obsolescence of the hardware. This category does not include failures due to poorly designed equipment or hardware failures caused by inadequate maintenance.
Design	Deficiencies in design or layout of facilities, plant, equipment or tools that lead to their misuse, or to the creation of unsafe acts, increasing the chance of potential errors and violations of rules or procedures.
Maintenance management	Failures occurring in the systems for ensuring technical integrity of facilities, plant, equipment and tools are often caused by poor maintenance. No matter how good the hardware might be, it constantly requires proper maintenance, otherwise it will be prone to errors and failures.
Procedures	Unclear, unavailable, incorrect, out-of-date or otherwise unusable standardised task information that have been established to achieve a desired and safe result.

Error-enforcing conditions	Factors such as time pressure, changes in work patterns, physical working conditions (heat, cold, noise etc.), affect an individual and may promote, or make more likely, the performance of unsafe acts, errors or violations of any type.
Incompatible goals	Failure to manage conflict: between organisational goals such as safety and production; between formal rules such as company written procedures and the rules generated informally by a work group; between the demands of individuals' tasks and their personal preoccupations or distractions.
Communication	Failure in transmitting information necessary for the safe and effective functioning of the organisation to the appropriate recipients in a clear, unambiguous or intelligible form. This element is fundamentally important to every aspect of the business, especially in maritime shipping. Analyses often reveal that insufficient communication was a contributory factor in the incident.
Organisation	Deficiencies, either in the structure of a company or in the way it conducts its business, which allow the safety responsibilities to become ill-defined or neglected. In a wider sense, the issue is whether an organisation is able to perform its stated intentions safely and efficiently, i.e. is it able to fulfil its purpose.
Training, education	Deficiencies in the system for providing the necessary awareness, knowledge or skill to an individual. In this context, training includes various forms of courses where an individual can develop skills, particularly of a technical or regulatory nature, that are necessary for safe and efficient implementation of corporate goals.
Defences	Failures in the systems, facilities and equipment for the control or containment of hazards or for the mitigation of the consequences of either human or component failures.

3 PROPOSALS FOR ENHANCED SAFETY WITH REGARD TO MODERN TECHNOLOGIES

Modern integrated systems of shipping management have considerably contributed to the increased safety of sea traffic. Yet it is necessary to introduce changes within these systems in order to reduce the share of human error in accident causation. For instance, SOLAS regulations define the layout of the bridge but do not define its precise design. This allows substantial room for the manufacturers who, apart from meeting SOLAS requirements, frequently install additional options to the equipment in order to build their price and competitiveness on the market. In this way the seafarers are moved in a less-favoured position as the design of the technologies forming a modern operating system has not been developed on the basis of the seafarers' needs and is likely to lead an operator to make a mistake. In order to use the available technology in a fast and efficient way, the operator has to be thoroughly familiar with all the equipment specification and modes of use and operation. To achieve this, the operator has to complete adequate training and familiarisation which will help him/her to identify all advantages and drawbacks of the equipment. Proficiency and familiarisation are the key factors in the prevention of failures and safety hazards. However, although a large number of seafarers employed by forward-thinking maritime companies attend various forms of training in order to acquire certificates of competence in operating specific systems, this does not guarantee that a seafarer will perform his/her duties using the very device and the very model that he/she familiarised with during training.

International Maritime Organization (IMO) organisation has recognised the importance of creating systems and working environments where certain procedures are defined and certain standards are met, with the purpose of reducing failures. Important steps have been made through the introduction of the International Safety Management (ISM) Code, aimed at defining who is in charge of the safety on board ship and reducing human errors through creating organisations committed to safety [6].

It is suggested that the special norms be adopted by SOLAS. These norms would propose the construction of several types of bridges which would be ergonomically acceptable for various types of vessels [7]. Special STCW training should be offered to enable navigators to attend specialized courses for a particular bridge type. Such specialization would be recognized by the issuance of certificates and it would certainly have effect on reduction of time needed for getting familiar with the bridge. Also, there is a proposal for unification of the main navigation instrument menus. Their use should not be too demanding. Simplification of functional keys is especially useful for instrument tuning. These often contain settings which are not used in navigation. A proposal for instrument layout to be regulated by SOLAS is also considered. [7]. The quality as regards the period of exploitation could be subject to different prices, but the outlook and usage methods should be unified by all manufacturers. This would enable competition amongst producers with regard to the price, reliability and quality but the outlook would be unified as well as the instrument options that are most used in navigation. Warning alarms on the bridge should use various types of sound warnings. Having the alarm with voice message explaining the cause of alarm ought to be considered. Such demand becomes important if alarm is activated at the critical moment such as the manoeuvre, anchoring, sailing in bad weather, collision avoidance etc. In this way the time for alarm cancellation is reduced and the time saved is used for decision making which adds to the quality of the decision. Modern integrated systems in maritime shipping management involve cutting-edge technologies in the area of ship operation. They have been created through merging a number of ship's systems that used to be separate components. The equipment fitted to the ship may be older or more modern, supplied by various manufacturers, having different design, look, layout etc. [8]. When dealing with new equipment, a seafarer may be familiar with some of its basic principles of operation but is unlikely to be familiar with all its features and possibilities. It takes some time to adjust his/her knowledge and skills to the new devices. Therefore, the problem mainly arises from the fact that the onboard equipment is not standardised. Technology standardisation would require less training for the crew and would ensure easier and safer operation.

4 CONCLUSION

A probability of human error can be reduced primarily through certain changes introduced to the education systems. This implies considerable savings for the company, both in terms of time and money.

Changes in the equipment design might considerably contribute to reducing the risk of human error. In order to achieve this, equipment designers should pay more attention to the analysis of human factor and the studies of human capabilities and limitations in maritime systems, instead of focusing their efforts on meeting specific technical design requirements. Understanding of human capabilities and limitations and application of this information in equipment design, working environments, procedures and policies would allow the development of systems that are compatible with human abilities. Such systems would work *with* people, enhancing their performance, instead of working *against* people, thus degrading their performance.

Certain changes within the human resources policies of maritime companies could foster easier and faster familiarisation of the crew with new equipment. Safe operation of highly automated systems such as integrated navigation systems requires a very high degree of familiarisation with all elements of the system and automation. Careful selection of trained crew would allow better maintenance of a ship, increased adaptability and familiarisation, better task organisation and more effective teamwork.

Combination of better training, use of standardised equipment, design of ergonomic equipment aimed at better and safer applicability of technology and improved methods of allocating human resources aboard ships, can contribute to reducing human errors in operating modern onboard systems.

REFERENCES

[1] Baker, C. C.; McCafferty, D. B.: *Accident database review of human element concerns: what do the results mean for classification?*, ABS Technical papers, presented in London, 2005.

[2] Bielić, T.: *Utjecaj ergonomskih čimbenika na upravljanje brodom / Influence of Ergonomic Factors on Ship Managing,* Naše More, Dubrovnik, No. 51 (5-6)/2004, pp. 172-177

[3] Ziarati, R.; Ziarati, M.: *Review of Accidents with Special References to Vessels with Automated Systems – A Way Forward*, Turkish Maritime Education Foundation, Institute of Maritime Studies, Turkey and Marine Education (MarEdu), United Kingdom

[4] Rothblum, A., M.,: *Human error and marine safety*, www.1insaat.com/uploads/TrbBlogs/pdfs_1/13239_1187781746_917.pdf (accessed: 28/02/15)

[5] UK P&I Club: *Getting to grips with the human factor* – A guide for trainers

http://www.merikotka.fi/julkaisut/Lappalainen_maritime_personel.pdf

[6] http://www.merikotka.fi/julkaisut/Lappalainen_maritime_personel.pdf

[7] Vidan, P.; Stanivuk, T.; Bielić, T.: *Effectiveness and Ergonomics of Integrated Navigation System*, Transactions on Maritime Science, Split, No. 1 (2012), pp. 17-21

[8] Bielić, T.; Vidan, P.; Mohović, R.: *Podložnost kao bitan čimbenik pomorskih nezgoda*, Pomorstvo: Scientific Journal of Maritime Research, No. 24/2(2010), pp. 247-260

SAFETY ASSESSMENT OF PASSENGER SHIP

Peter Vidmar, D.Sc.
Marko Perkovič, M.Sc.
University of Ljubljana
Faculty of Maritime Studies and Transport
Pot Pomorščakov 4, 6320 Portorož, Slovenia

ABSTRACT

Cruise ships arriving in ports carry approximately 1000 to 3000 passengers and crewmembers. Such a concentration of people presents a high degree of risk in the event of a major disaster. To avoid the possibility of hazard events, the safety assessment is a mandatory document for every cruise ship. One of the methodologies for the systematic assessment of risk is a Formal Safety Assessment, a tool to determine and evaluate the risk of potential hazards. Deviations from predicted events could occur underway as well as at a port. Passenger terminals located in close proximity to other cargo terminals are additionally influenced by risks that are not manageable by the cruise ship safety management system. Possible accidents on cargo terminals, oil spills or fires could influence the safety of other ships and environment. A general approach is presented and discussed with particular focus on the specifics of the particular port, where the passenger terminal is close to other cargo terminals. The paper discusses the diverse aspects of safety analysis and methods for evaluation of individual and social risk.

Key words: Safety assessment, cruising, safety in port.

1 INTRODUCTION

The Mediterranean and its seas is an area of great interests for the cruise industry in the last decades. It emerged to be the world’s second most popular cruising area behind the Caribbean. In 2012, more than 120 million cruise bed days were available worldwide and the Mediterranean area accounted for almost 20% of the global cruise market. The Cruise Lines International Association (CLIA), which is the largest cruise industry association, reported the significant increase of the cruise industry. Demand for cruises increased for more than 77% worldwide in last decade, the growth of 136% in evidenced in Europe including Russia, Central and Eastern Europe [24].

In 2004 P. Lois and authors [1] have conducted a research regarding a safety assessment of cruise ships and correctly indicated the tendency of a cruising industry growth. According to studies like Cruise Industry News, 2000 to 2014 [3], World cruise ports and shipping to 2025 [4] and Stojanović [5] there are great potentials in the cruising industry and by the year 2017 at least 26 million passengers will take cruise holidays. The forecast for 2025 is to reach 36 million passengers. Figure 1 shows the estimated world cruise fleet until the year 2019 (Cruise Industry News, 2014). The trend is to build bigger ships that can accommodate more than 1500 passengers. Cruising has proved to be a very safe method of taking a vacation. Although most critics the cruise industry in general has an excellent safety record, however serious losses can and do occur. The last and most noticed is the loss of Costa Concordia in 2012, where 32 passengers died. Considering EMSA reports from 2007 until 2012, [6] fire may be the biggest danger to a cruise ship but collision and grounding may also have serious consequences. The research presented in the article exposes that the most elevated risk belong to the collision accidents.

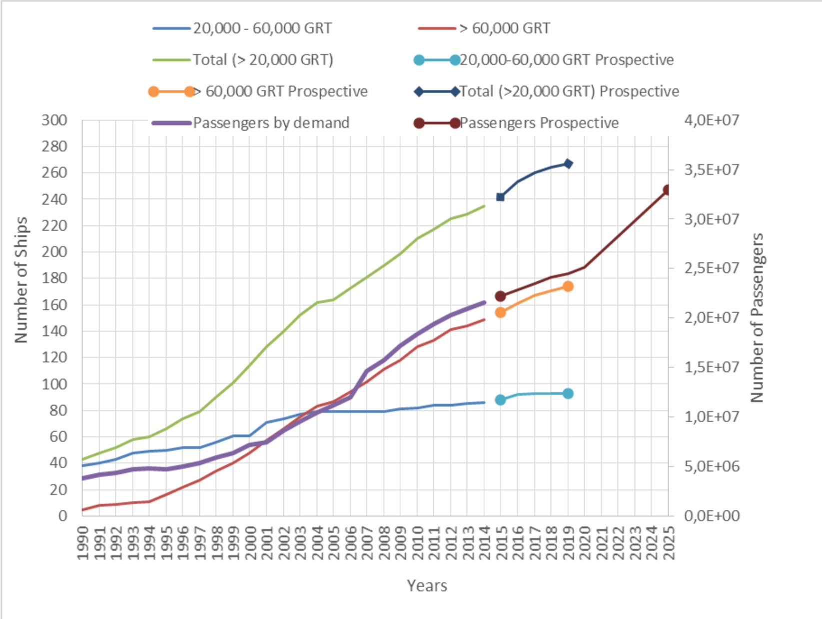


Figure 1: Cruise ship world fleet and accommodation demand

For the international shipping community, the safety of ships has always been a priority. Disasters such as the 'Titanic' sinking in 1912, 'Scandinavian Star' fire in 1990 and 'Moby Prince' collision in 1991 have changed the rules of safety relative to ship abandon equipment and procedure, fire safety and navigation. The most recent ferry dramatic accident of "MV Sewol" in 2014 has been attributed to the sharp turn, being overloaded, having unsecured cargo and being affected by past renovations, all things and procedures that are ordinarily regulated. However there is a clear expert distinction between ferry and cruise ship related to construction, stability and operation. On the other side the grounding and sinking of Costa Concordia is, by many experts and aspects, considered as an anomaly in cruise shipping. The accident has pointed out more rigorous consideration of: muster drills, bridge access and procedures, life jacket availability and location, lifeboat loading drills, recording of passenger nationalities for on-shore emergency, mandatory passenger muster drill prior to departure from port, updating the evacuation analysis, additional safety measures for passenger ships, a so called 'No Salute' decree, issued by the Italian government and other considerations. Procedures already known by ships and operators but not followed as procedures request or not followed as maritime education and practice requests.

1.1 Focus on risk assessments

Authorities are struggling with the need to adapt to the growing cruise ship trade, which includes the need to accept larger ships. Safety analysis is also necessary, for while in general cruising offers a safe vacation and has a good overall safety record, hazards do exist: from fire, collision, and grounding.

While the international shipping community has long been concerned with maritime safety, in the last decade or so the safety of cruise ship has become more of a concern. Cruise ships must also comply with the safety standards set by the International Maritime Organization (IMO) enforced through the International Convention for Safety of Life at Sea (SOLAS).

The Formal Safety Assessment (FSA) is a tool for risk evaluation developed by IMO to enhance the safety of ships, passengers and crews, and the environment. The FSA uses five steps: hazard identification (HAZID), risk assessment, risk control options, cost benefit assessment and decision-making recommendations. Its goal is a systematic approach to safety in all aspects regarding particular vessels. This paper examines the FSA in relation to a cruise terminal and the existing safety plan of a cargo seaport and is finally compared with several experts' opinions (cruise shipmasters, terminal operators, harbour masters, tugboat masters, researchers and other experts). We should add that the US Coast Guard and Passenger Vessel Association published a manual for safety risk assessment of passenger ships at sea and in ports (PVA Risk Guide – A Guide to Improving the Safety of Passenger Vessel Operations by Addressing Risk) [7]. This manual helps improve the process of risk (hazard) identification, to plan how to reduce risk levels and protect ship or ports from possible hazards. Further, the combination of both procedures is used.

Definitely, the use of statistics and expert opinion is a valuable information for the evaluation of probability rather than the evaluation of consequences. The magnitude of these lasts is more a matter of physics and consequence analysis. In ports where cargo terminals are in a close neighbour to passenger terminals, any possible accidental situation should be considered and its influence to the cruise ship safety. The following chapters are going to present the proposed methodology and results are going to be validate and discussed for wider application.

2 RISK EVALUATION CRITERIA

Risk evaluation begins with the conception of appropriate risk acceptance criteria. Port and terminal operators identify potential hazards strictly related with ship hazards, when the ship is approaching or leaving the port or is moored at a terminal. The following quote is taken from MSC 72/16: "The term risk acceptance is established in many industries and regulations [18]; however, it is worth noting that the term itself can be misleading. The risk is not acceptable, but the activity might imply the risk to be acceptable because of the benefits." One reason for explicitly mentioning Risk Acceptance is the need to focus management's attention to this issue, which would otherwise be only superficially treated. "Risk evaluation" is the official term at IMO (FSA Guidelines MSC 72/16) and reflects organization's position that risks are not acceptable; yet decisions involving risks are accepted because their benefits are deemed to outweigh the risks. During the last decade the terminology difference between evaluation and acceptance became more evident, and is clearly distinguished in recent EMSA report [11]. The risk evaluation process in EMSA report in used to evaluate risk acceptance criteria. The evaluation in mainly based on accident statistics and risk based damage stability, provided by GOALDS project report [12]. The maritime sector has widely accepted ALARP risk criteria, the British risk acceptability framework, widely recognized in Norway and other countries. It uses the following categories: unacceptable, tolerable and broadly acceptable risk. Risks inside the ALARP region are tolerable up to the "As Low as Reasonably Practicable". If tolerable risks shall be reduced as long as the risk reduction is not disproportionate to the costs or implement cost beneficial Risk Control Options (RCOs).

Undoubtedly, the term risk acceptance could easily be use in business not directly related with persons and their lives. Risk Acceptance has been included in the assessment of methods and tools, as it might be a decision criterion for certain kinds of organizations (e.g. in the financial and insurance sector, in critical infrastructure protection etc.). One reason for explicitly mentioning Risk Acceptance is the need to draw management's attention to this issue, which would otherwise merely be a communicative activity [13]. The risk criteria should reflect organization's values, policies, and objectives, should base on its external and internal context, should consider the views of stakeholders, and should derive from standards, laws, policies, and other requirements [4]. Considering the IMO FSA cruise ship guidelines to define the ALARP region one can understand the reasons of a risk acceptance levels, based on cost benefit computations. However depending on country and company policy on risk acceptance level, risks treatment could and should be a continuous challenge, independently on results of risk evaluation or cost benefit equilibrium. The Risk management process has its own deviations inside the process chain that could lead unexpected causalities. As already said the accident of Costa Concordia was, by many, defined as an anomaly. Most probably, the anomaly has arisen inside the risk management process of the owner company and his conviction that the cost benefit equilibrium in risk evaluation is the appropriate process to assure "enough safety".

In the following, the modelled risk level for cruise ships and ship terminal will be evaluated using risk evaluation criteria concerning individual risk and societal risk.

2.1 Cruise ships accident statistics

In order to perform safety analysis, whether qualitative or quantitative, it is essential to obtain reliable failure data. Qualitative risk analysis requires less detailed statistical failure data compared to Quantitative Risk Assessment (QRA). A ship year is defined as one ship sailing for one year. Given the increase in the number of large ships in recent years it is necessary to distinguish between "smaller" cruise ships and "large" cruise ships; the following tables have been split into two groups (20000-60000 GRT and > 60000 GRT).

The review takes in account high-risk accident only; contact-collision, fire, grounding and sinking. The detailed review of any accident reported would show about 300 reported accidents in 2014, with less or more severe consequences, but not processed as high-risk causalities. Among the large number of reported accidents, about 20 are classified as high-risk, and at least four passengers were died because of these 20 accidents. The graph shows an increase of the average accident frequency from 2005. A very important consideration is the reliability of data before this year. Only from 2005 EMSA has started the systematic collection of accident data. The data takes into account the significant increase in the number of cruise ships that have entered the market during the previous decade – particularly for vessels > 60000 GRT.

The influence or potential consequences of external accidents to a cruise ship and its passengers is not mentioned in reports and references. The risk analysis presented below shows how the risk may be quantified on the basis of the simulation of different accident scenarios.

2.2 Accident frequency calculation

The exposure during the 1990-2014 period has been 3390 ships years and will be used for the accident frequency calculations. The frequency calculations can be summarized as the fraction of accident per accident type and the total number of accidents. However the number of accidents with fatalities is too few to represent any significant accident trend.

Table 8: Accident frequency calculations for cruise ships between 1990-2004 and 1990-2014

Cruise ship	Collision/Contact	Sinking	Grounding	Fire/Exp.	Other	SUM
Ships >20,000 GRT						
LMIS accidents recorded 1990-2004	10	-	17	16	34	77
Ship years 1990-2004 [ship years]	1742	-	1742	1742	1742	1742
Cruise ship accident frequency [per ship year]	**5,74E-03**	**-**	**9,76E-03**	**9,18E-03**	**1,95E-02**	**4,42E-02**
Return period [no. of ship years per accident]	174	-	102	109	51	23
Number of fatalities, 1990-2004	0	-	0	21	1	22

Cruise ship	Collision/Contact	Sinking	Grounding	Fire/Exp.	Other	SUM
Ships >20,000 GRT						
LMIS accidents recorded 1990-2014	52	1	25	25	60	163
Ship years 1990-2014 [ship years]	3390	3390	3390	3390	3390	3390
Cruise ship accident frequency [per ship year]	**1,53E-02**	**2,95E-04**	**7,37E-03**	**7,37E-03**	**1,77E-02**	**4,81E-02**
Return period [no. of ship years per accident]	65	3390	136	136	57	21
Number of fatalities, 1990-2014	7	2	34	4	10	57

The table shows the significant increase of frequency for the collision/contact accidents when others have reduced slightly. The average ship accident frequency remains the same in both period. The general information is therefore that a cruise ship accident can occur every 21 ship-years, or calculated for the current fleet, about once a month. The obtained frequency of accidents could give a general information on global risks issues but for risk assessments, of a particular port, could not be used as absolute. When assessing a singular port or cruise terminal the likelihood of an accident should consider the sopping time of a ship in a port or the sum of all days when cruise ships were moored on terminal pier. In 2014 the treated port received 56 cruisers with an average staying time of 2,5 days, that means 140 ship days, compared to the 85775 ship days of a world fleet in 2014, gives about 0,163% of a cruise market. In last ten years the same port counts 1187,5 ship days with moored cruisers. Taking in account the global statistic of accidents the particular port takes its proportionate share of the global probability. Calculated values are presented in Table 9.

Table 9: Accident frequency calculations for cruise ships in one port

No. of days in port 2005-2014		Collision/Contact	Sinking	Grounding	Fire/Exp.	Other	SUM
1187,5	**Cruise ship accident frequency [per ship year]**	1,47E-05	2,83E-07	7,08E-06	7,08E-06	1,70E-05	**4,61E-05**

Ports without a particular past statistics on accidents have a demanding job to estimate both the probability and consequences of an accident. The US Coast Guard PVA assessment method [7] is an expert based method, simply applicable in practice and give a direct qualitative expert answer of a risk level for a considered terminal or operation.

The consequence of an accident is defined as the expected number of fatalities, if such accident occurs. In order to perform consistent and comparable consequence assessments, fixed bands of expected numbers of fatalities is defined. As proposed by MSC 85/INF.2 [8], bands are defined to suit the reference vessel of 110000 GRT with a total capacity of 4000 persons. Ten fatality bends cover the full range of accident severities, from a minor scenario to a catastrophic accident resulting in a large number of fatalities. For purposes of accuracy concerning the current world fleet, the estimated number of fatalities was also estimated for ships of 75000 GRT and 40000 GRT.

It is important to note that the identified fatality bands only apply to the reference vessels defined for this study. Each final event is connected to an estimated number of fatalities. The expected number of fatalities is selected from one of the ten possible bands, as defined before. The event tree and probabilities for each event have been carried out together with other participants involved in the Hazard Identification process. The assumption of fatalities is based on the review of the calculated consequences for each event. The event tree for an oil spill occurring near a cruise ship is presented in Figure 2.

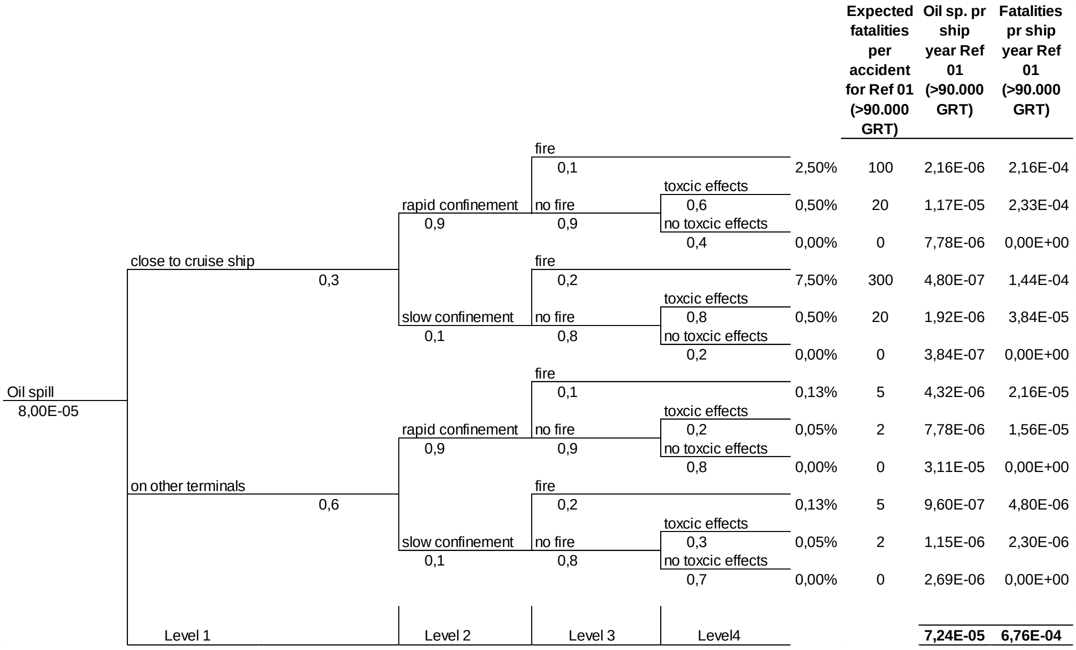


Figure 2: Cruise ship neighbour oil spill event tree

The percent value represents the share of the total number of passengers on the analyses ship brand. Most important are levels 2 and 3, which consider intervention by the containment group from the port. Without containment the slick could spread uncontrollably and reach zones with a higher probability of ignition. In the proposed event tree the percent of fatalities on each event is predicted on a qualitative basis, proposed by the HAZID group of expert, in our case authors and port safety department. Those values could therefore be enhanced.

The most recent EMSA Repot [11] is an upgrade of IMO FSA Guidelines [18], [8], based on most recent data on cruise ship accidents. Similarly as for event frequency calculation also the magnitude of consequences cannot be directly used for a particular port. One is because the order of magnitude of events and the second the specifics of a particular port. As for events probability calculation the estimated consequences are obtained from expert assessment.

Table 10: Estimation of events consequences for the assessed port

	Estimation of consequences (from 1-Insignificant to 5-Catastrophic) for local population 10.000 person 1 - Insignificant event = 0,28 fat 2 - A smaller event = 1,57 fat 3 - An important event = 6,64 fat 4 - Critical event = 32,42 fat 5 - Catastrophic event = 81,42 fat	Score	Frequency
1	Small collision between two ships	**1,93**	1,61
2	Large collision between two ships	**3,29**	12,73
3	Small fire in engine room/galley/cabins/otfer spaces	**1,93**	1,57
4	Large fire in engine room/galley/cabins/otfer spaces	**3,00**	7,64
5	Explosion on ship	**3,50**	14,30
6	Accident with environmental consequences on other ships	**2,86**	2,69
7	Accident with environmental consequences on terminal with dangerous cargo	**3,93**	25,14
8	Explosion on terminal	**3,64**	5,76
9	Fire on terminal	**2,86**	28,84
10	*Viral infection of passengers*	**4,00**	*21,83*

Similar as for the event frequency evaluation the number of population is a reference frame for decision. It mostly depend on port and terminal location and should consider the ship passengers, crew and neighbour citizens. Several European cruise terminals are located in a direct vicinity of city borders and accident could influence the close neighbour area.

3 RISK LEVEL

Individual risk levels can be derived from the ship risk level when the number of crew and passengers is known. Following the basic methodology of IMO FSA passengers and crew are divided in three different reference vessels. An estimated number of persons on board the world cruise fleet (1990-2014) can be calculated and an estimated number of persons on an average size cruise ship can be derived.

For the cruise industry this number was firstly gathered from the aviation industry due to its large statistical database. From 2000 to 2008 IMO MSC reports used the EV value equals to 4.8 fatalities / billion USD [8]. The most recent review of a cruise market has reduced the EV value to about 1,5 fatalities / billion USD [11], which is also based on the revenue per passenger-year about 0.05 MUSD. The review of a cruise market gives also interesting relations between number of passengers and risk criteria, Figure 3.

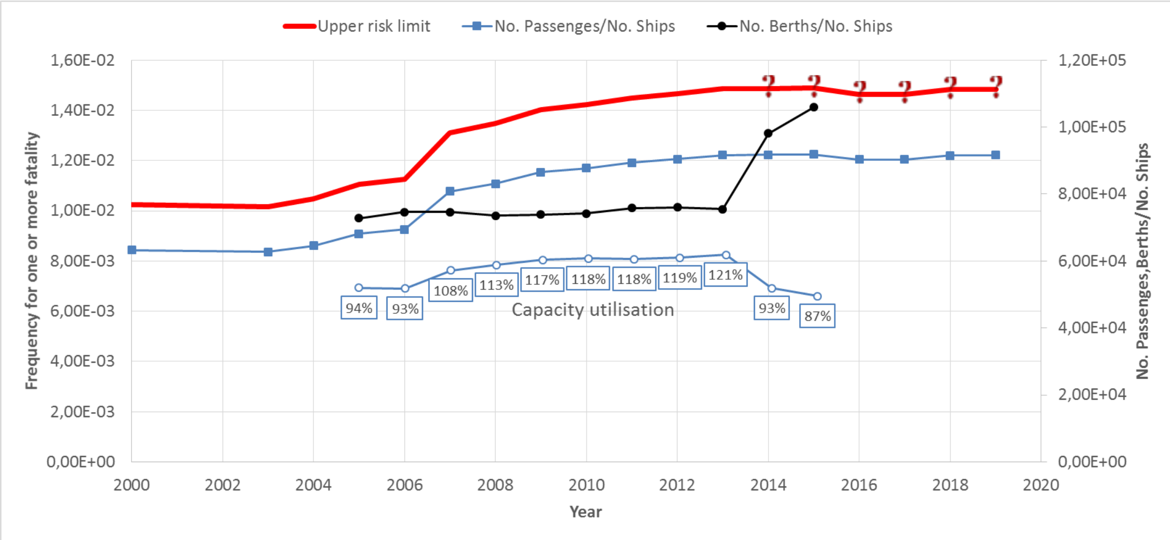


Figure 3: Relation between passengers and risk criteria

The upper risk criteria represents the tolerable limit for the PLL based on the economic value or the revenue for the average ship. The global revenue of cruise industry is obtained from economics and cruise industry reports like CLIA [19], BREA [24] and UK P&I Cub reports [20]. The dynamics of the tolerable risk is therefore proportional to the number of passengers. In past eight years we can see an important overbooking of cruisers what, considering forecasts, is going to change. New deliveries of cruise ships will reduce the average revenue per passenger and relieve the reduction of risk criteria. It mostly depends on the cruise industry on how they will balance the revenue and expenses. The trend of the relations between the number of passengers/No. of ships and No. of Berths/No. of ships show at least the possibility for the reduction of upper tolerable risk.

The fatality frequencies, calculated from the event-tree(s), as proposed by IMO MSC guidelines, are used as input to calculate the individual fatality frequencies for crew and passengers. Risk for crew and passengers have been modelled in a similar way except for the fact that crew is on board for a longer period (higher exposure).

Table 11: Individual risk per accident for period 1990-2014

Hazard	Fatalities* [per ship year]	Individual Risk of Pax & Crew** [Fatalities Per Year]	Individual Risk for Pax*** [Fatalities Per Year]	Individual Risk for Crew**** [Fatalities per year]	Return period for passengers in years	Return period for Crew in years
Collision/Contact	6,95E-02	3,49E-05	1,34E-06	1,75E-05	746289	57250
Grounding	3,33E-02	1,67E-05	6,42E-07	8,36E-06	1558683	119570
Fire/Explosion	9,15E-03	4,60E-06	1,76E-07	2,30E-06	5670413	434991
Oil spill	4,95E-04	2,49E-07	9,54E-09	1,24E-07	104814217	8040543
Sum of all incident causes	**1,12E-01**	**5,65E-05**	**2,17E-06**	**2,83E-05**	**461377**	**35393**
Return period in years	8,89	17697	461377	35393		

From Table 11 it can be seen that the individual risk exposure to a crew member is 5.67 E-5 fat/year, that is less then 7.5E-5 calculated by IMO MSC [8] in 2008. Similarly, the individual risk exposure to a cruise ship passenger is 2.17 E-6 fat/year, less 5.77E-6 fat/year in 2008. The individual risk level for crew and passengers is inside the ALARP area, which means that according to the IMO guidelines the risk for crew and passengers should be reduced as long as the risk reduction is not disproportionate to the costs; i.e., only cost beneficial RCOs (Risk Control Options) need to be implemented.

3.1 Societal risk

Based on the calculated individual risk frequencies the societal risk in computed. Integrate the probability of death for each event over the population specified N_u, represents the number of people killed by a given event. Figure 4 illustrates the modelled risk level for cruise ships in the F-N diagram. The risk level is calculated as the sum of the frequency per ship year for analysed accidents. Although notable accident occurred in last years, they did not influenced the statistics of accidents so much. The consequent Risk control options taken in consideration by the international community allowed the reduction of the tolerable risk for the factor 3, from 4.9xE-2 to 1,57xE-2 fat/year. Figure 4 shows the calculated tolerable risk limit for 2014, based on the calculation procedure of IMO FSA. Assuming this limit as a total risk limit the societal risk would be to elevate and would require additional control actions. As noticed above the risk limit is not only a calculated value, but also a matter company and country policy.

The overall risk level for cruise ships is within the ALARP region. The most important is the influence of the collision/contact events, because of majority in number, though consequences for passengers are not high.

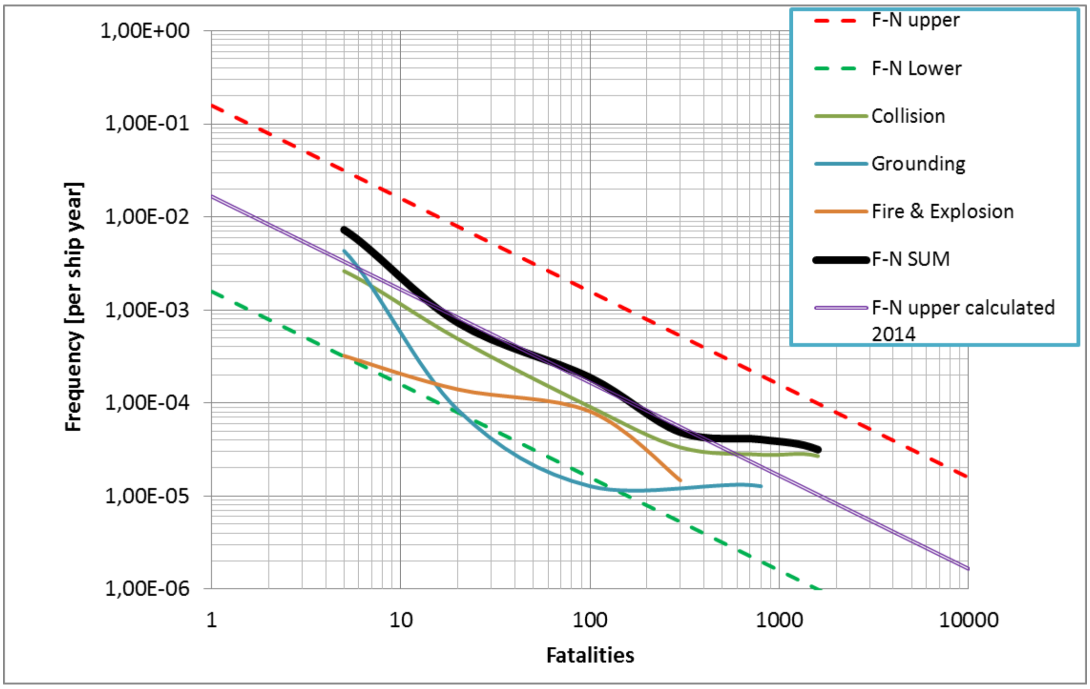


Figure 4: Societal risk level based on accident type

Considerations for a one-port assessment, without reliable statistical data, could be qualitative in respect to the global safety frame. The risk evaluation from estimated frequencies and estimated consequences

Table 10 give the risk F-N curve. Figure 5 presents risks inside a boundary frame as understood for a single port area. Frequencies of events are in relation with a global frequency frame depending on a share of a cruise market for the assessed port. Consequences are and could not be on a same relation, because a singular event with severe consequences, no meter where happens, has a global impact on safety issues. This can be observed by the most events are located in a central part of the F-N diagram.

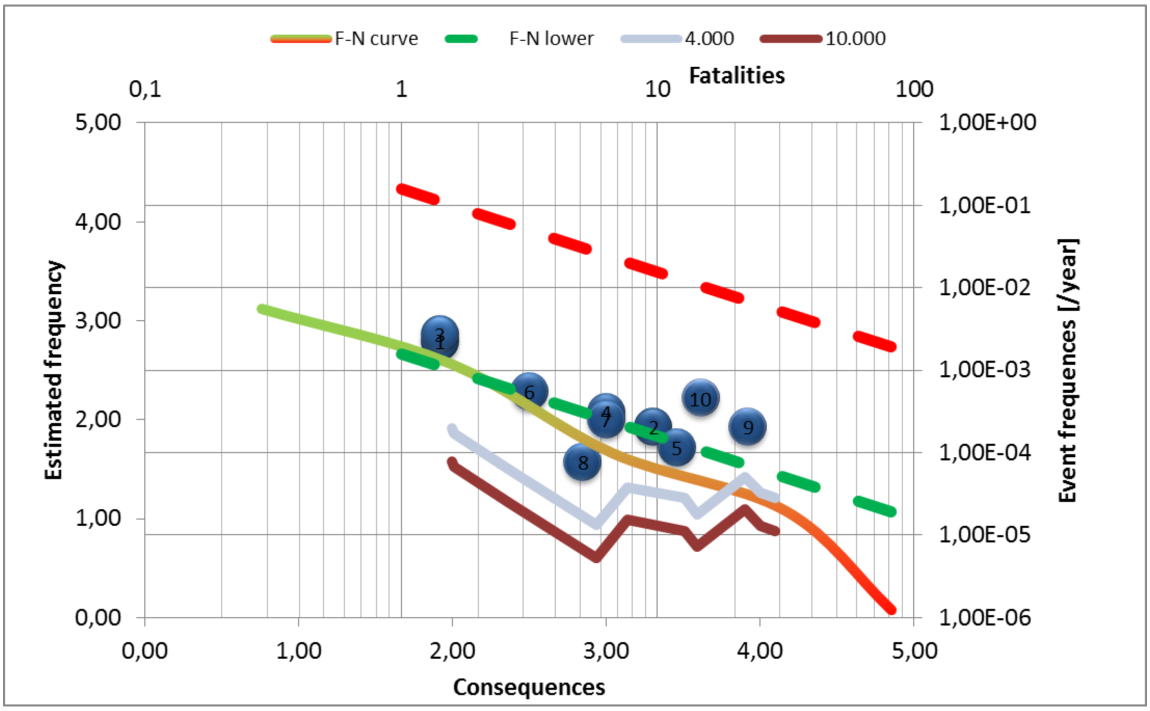


Figure 5: Societal risk level for one port consideration

According to event numbers (1-10) in

Table 10 all events stays inside the ALARP boundaries. From experts point of view the highest risk belong to fire event on terminal (9), explosion on a ship (5) and large collision (2) that are treated as technical (operational) accidents. High risk is expressed also for viral infection (10), but similarly as security issues events, these cannot be treated as an operational event and in therefore not discussed here.

The maximum expected risk is represented by the F-N cure on Figure 5, located on the lowed border of the ALARP area. The estimated risk is also presented, based on a different number of persons (pax+crew, citizens) used in the model. Considering a larger group (10.000 persons) the risk is lower then considering a smaller group (4.000 person). The number of person in a model is estimated based on accidents consequence models, that includes persons inside the individual risk area below 1xE-8.

4 CONCLUSION

The paper presents the methodology applying different approaches, probabilistic, deterministic, qualitative, estimations and others to obtain more reliable answers regarding transportation risks. Operational (technical) risks are analysed and discussed for further improvement in their management. Risks for different kind of accidental events, like collision, grounding, fire, accidents inside a port, are analysed statistically on a global scale and mirrored to a local scale of a single port, applying a proposed approach of risk scaling. It is proved that the frequency of accidental events could be scaled from global to local, by the share of the local revenue of cruise market compared to a global. Consequences, fatalities could not be scaled the same, but the “local” societal risk is strongly related with a population number taken in account for safety assessment. For ports with a direct contact with city borders, the civil population have to be included, depending on the maximum area size of accident consequences.

REFERENCE

[1] Lois P., Wang J., Wall A., Ruxton T., Formal safety assessment of cruise ships, Tourism Management 25 (2004) 93–109

[2] Wild, P., & Dearing, J. (2 000). Development of and prospects for cruising in Europe, Maritime Policy and Management, 27(4), 315–337.

[3] Cruise Industry News, International guide to the cruise industry, Annual Report 2014, New York.

[4] Ocean Shipping Consultants, World cruise ports and shipping to 2025, 2013, England (http://www.maritime-rh.com/maritime_docs/osc_press_releases/press-release2-world-cruise-ports-and-shipping-to-2025.pdf (13/03/2014)

[5] Stojanović M., Poletan J. T., Jugović A., Indicators of passenger flows movements on the world and mediterranean cruise market, Scientific Journal of Maritime Research 28 (2014) 40-48, Faculty of Maritime Studies Rijeka, 2014

[6] EMSA, Maritime Accident Review (2007 – 2012), European Maritime Safety Agency, (http://www.emsa.europa.eu/)

[7] United States Coast Guard, Passenger Vessel Association (2007). PVA Risk Guide: A Guide to Improving the Safety of Passenger Vessel Operations by Addressing Risk.

[8] Maritime Safety Committee (2008). MSC 85/INF.2, Formal Safety Assessment – Cruise Ship, IMO.

[9] Institution of Chemical Engineers. 1992. Nomenclature for Hazard and Risk Assessment in the Process Industry Rugby.

[10] Trbojevic, V. M. (2005). Risk criteria in EU, ESREL'05, Poland, 27-30.

[11] Papageorgiou S., Risk Level and Acceptance Criteria for Passenger Ships. First interim report, part 1: Risk level of current fleet, European Maritime Safety Agency, Norway 2014

[12] GOALDS (2009-2012). "Goal-based Damage Stability", Project funded by the European Commission, FP7- DG Research, Grant Agreement 233876, http://www.goalds.or

[13] Bottelberghs, P. H. (2000). Risk analysis and safety policy developments in the Netherlands. Journal of Hazardous.

[14] European Union Agency for Network and Information Security (ENISA), Risk Management: Implementation principles and Inventories for Risk Management/Risk Assessment methods and tools, June 2006 (https://www.enisa.europa.eu/activities/risk-management)

[15] Cornwell J.B., Meyer M.M., Risk acceptance criteria or "How safe in safe enough", Risk Control Seminar, Venezuela 1997

[16] Lohansen I. L., Foundations and Fallacies of Risk Acceptance Criteria, Norwegian University of Science and Technology (NTNU), Department of Production and Quality Engineering, Norway 2009

[17] Raj, P. K., Lemoff, T. (2009). Risk analysis based LNG facility sitting standard in NFPA 59A, Journal of Loss Prevention in the Process Industries 22, 820–829.

[18] International Maritime Organization (2000). MSC 72/16, Formal Safety Assessment – Decision parameters including risk acceptance criteria –Submitted by Norway".

[19] Cruise Lines International Association, CLIA Cruise Market Overview (http://cruising.org/regulatory/clia-statistical-reports)

[20] UK P&I Club (1999). Press release, UK club's analysis: Two per cent of claims incur 72% of the costs. London.

[21] Bottelberghs, P. H. (2000). Risk analysis and safety policy developments in the Netherlands. Journal of Hazardous Materials, 71.

[22] Gucma L. (2007). Evaluation of oil spills in the Baltic Sea by means of simulation model and statistical data. International Maritime Association of Mediterranean, Balkema.

[23] Macdonald, D. (2004). Practical Hazops, Trips and Alarms, IDC Technologies, imprint of Elsevier, ISBN: 0750662743.

[24] Business Research & Economic Advisors, The Global Economic Contribution of Cruise Tourism 2013, September 2014 (http://www.cruising.org/sites/default/files/pressroom/Global_Cruise _Impact_Analysis_2013.pdf)

VIBRATION SIGNAL ANALYSIS AS SHIP'S DIAGNOSTIC'S TOOL

Igor Vujović, D.Sc.
Joško Šoda, D.Sc.
Zlatan Kulenović, D.Sc.
Ivica Kuzmanić, M.Sc.
Slavica Vujović Kežić, M.Eng.
University of Split
Faculty of Maritime Studies
Zrinjsko-Frankopanska 38, Split, Croatia
ivujovic@pfst.hr

ABSTRACT

Condition monitoring is an invaluable measure of modern engine diagnostic tool techniques. Vibration signal is a basic signal source, which is analyzed by signal analysis techniques. This paper presents an overview of wavelet application in ship's engine condition monitoring. Due to a nature of the vibration signal (non-stationary in origin), wavelet and related transforms seems ideally suited to vibration signal analysis. The paper deals with cutting-edge technologies in this research field, as integrated vehicle health monitoring, Bayesian networks approach (which became superior to both the fault tree analysis and the event tree analysis), wavelet learning techniques, etc. Examples of typical failures are shown, as well as the effect of the failures to the vibration signal. These effects make possible to develop and use an identification procedure, which leads to the localization of the failure.

Key words: Condition monitoring, wavelet transform, vibration signal.

1 INTRODUCTION

Condition monitoring (CM) is essential technique supplemented with others, such as video monitoring, for monitoring various systems and elements of systems. CM enables a good planning of maintenance, order/shipping of spare parts, etc. CM in engine room is a modern approach to engine monitoring addressed in many manuals and references and incorporated in ship systems worldwide, since it is very reliable into obtaining conclusions about the state of monitored system. One of signals that can be used in CM is the vibration signal. Vibration signal is non-stationary signal and using time-frequency analysis techniques such as wavelet transform (WT) makes it perfect for condition monitoring. Continuous monitoring research goal is to save money, resources and make ship's engine room systems operational as much as possible. Also by using and applying various modern signal processing algorithms there are further gains in condition monitoring.

This paper is organized as follows. The second section presents an overview of literature in the field. Subsection 2.1 deals with wavelets in CM. Section three presents wavelets in signal analysis and explains how and when to use wavelets in the vibration signal analysis. Paper is finalized with conclusion section.

2 LITERATURE OVERVIEW

Before we begin review, it should be noted that there are two classes of references. The first one is the low level software, which is used for data processing. The second one is the high level software, which is used to make decisions of higher level. It is almost the rule that WT is used in the low-level processing to detect changes in the vibration signal. Bayesian methods, event tree analysis, fuzzy approach, etc are methods to decide based on results of low level processing. These methods needs extracted features to be useful, and such features can be obtained by different transformations, such as WT. Hence, high level applications decide weather is necessary to replace some component/part of the system.

CM is already widely used in practice, which can be seen by the possibility to find firms, which offers seminars, workshops, videos and textbooks on the subject or provide information from experience [1 - 5]. Integrated vehicle health monitoring (IVHM) is also introduced [1].CM is used to monitor the states of motors and generators [2, 3], ship's automation [4], propulsion monitoring [5], etc. Among other concepts, Advanced Condition Monitoring (ACM) [6] has submerged. This concept was developed for usage aboard merchant vessels. ACM presents an ability to integrate algorithmic capabilities into data-stream to identify whether the monitored system operates with normal parameters or perhaps some of the system's parts need to be replaced.

The source signal for CM of ship's engines is vibration signal. Since the signal exhibits non-stationary characteristics by using time-frequency techniques, such as wavelet transform, it is easily to identify in which operating state is monitored system. Wavelet packets as a further upgrade of wavelet analysis were used [7] to diagnose diesel engine condition. Frequency content of a vibration signal was described by wavelet maps in [8]. Faults in a gearbox were detected by WT in [9]. Another approach is usage of Bayesian Networks to make decisions in maritime industry [10]. Decisions are made mainly in maintenance planning, risk-related issues. Bayesian networks are also used for combing uncertain evidences. This approach is also superior to both the FTA (fault tree analysis) and the ETA (event tree analysis).

Due to its increasing importance, different advanced and novel techniques are applied to CM. One technique is to apply neuro-fuzzy diagnostic system, such as in [11]. Authors concluded that this approach can be used to detect faults.

A complete solution for fault diagnostics is proposed in [12]. They used accelerometers for condition monitoring and fault diagnostics (CMFD) of input devices. Independent component analysis (ICA) was used to isolate sources. STFT was used for fault feature extraction. Principal component analysis (PCA) was used to reduce dimensions of a featured space. After all, a fuzzy neural network classifies (FNN) was used to identified faults.

Condition monitoring of large marine diesel engines were analyzed in [13]. However, it is based on known thermodynamical model. Diagnosing faults of marine propulsion systems was presented in [14]. This research used vibration parameters analysis.

2.1 Wavelets in CM

A research of wavelet application in the analysis of the vibration signal was presented in [15]. However, this research used experimental data obtained in turning machine, not a ships' engine, so it can be of interest in the industry applications also.

Adaptive wavelet analysis (AWA) is proposed in [16]. AWA uses linear combination of wavelets adapted for particular vibration signal. AWA incorporates parametric optimization by generic algorithm. It is shown that characteristics of signal's energy in Hilbert space can be used for fault diagnosis of water hydraulic motor.

A non-destructive method to assess damage in [17] is based on wavelet analysis of modal shapes in the vibration signal. It was found that the effectiveness of an algorithm depend greatly on the type of applied wavelet. The paper proposes a combination of a multiobjective meta-optimization to select wavelet parameters for optimal solution in order to be able to have real time condition monitoring. It is well known that some advanced techniques, such as complex wavelet analysis, that maybe could produce better results are not applicable in some applications since they are time consuming i.e. they are not useful in real time monitoring.

Paper [18] investigates the use of wavelets for the control of multi-frequency rotor vibration in real time. An adaptive wavelet is used for time-varying signals. Experiments are used to deduce the best wavelet basis for evaluation of operating conditions. An interesting result is that rotor impact test at 20 Hz resulted in detection in details in the second level of decomposition of the measures vibration signal in x-axis direction. It was the attention to design a control algorithm that would measure the vibration response of the rotor during a cycle and then produce the required control force to minimize the response during the following cycle. Authors analyzed the vibration signal with several wavelets. They concluded that the rate of convergence that can be achieved decreases with decreases of wavelet order and length of the wavelet support. However, the lower order wavelets are not accurate enough to approximate the measured vibration signals using fewer scale levels. So, the optimal solution should be found in further research.

Selection of wavelets for vibration signal analysis of a rotational mechanical system is presented in [19]. The proposed selection method was successful in a way that selected wavelets are better in sense of structural defect detection. Complex wavelet transformation in combination with the wavelet packet approach is used for the vibration signal analysis in [20]. They concluded that wavelets are very suitable for finding unbalance, misalignment, mechanical looseness, rubs, shaft crack and etc. due to the fact that the vibration signal is non-stationary.

Authors in [21] have shown that wavelets are valuable and effective in detection of the health status of bridge structure. Vibration signal was again a media from a real system to the signal analysis. Wavelet packet energy flow of the vibration signal was used in [22] with manifold learning technique. The proposed method was confirmed in case studies of fault classification of machines. It is stated in the reference [23] that the WT is especially suitable for non-stationary vibration measurements obtained from accelerometer sensors. If the input is the accelerometer, FT analysis is not suitable. WT detects abnormal change in the measured data. The authors found out that for their purposes the best wavelet was Daubechies wavelet of 4th order (db4). Approximation coefficients at the 4th level of decomposition were used to the vibration signal of the mass unbalance at speed 1200 rpm.

An efficient technique is proposed in [24] for wavelet spectrum analysis on truncated vibration signals. The proposed technique is tested in two experimental setups. It was found that the proposed technique is efficient for incipient machine fault detection. Wavelet method for fault diagnosis of the wind turbine planetary gearbox components was proposed in [25]. Emphasis was given on the signal processing of the acquired vibration signal to extract features of value to the diagnostics. It was proposed that the best wavelet for fault detection is

Morlet wavelet. It is the best for matching behaviors of hidden impulses. Kurtosis was used for detection of fault symptoms, because it is sensitive to sharp variant structures. This measure is defined as:

$$Kurt(x) = E\left(x^4\right) - 3\left[E(x^2)\right]^2 \tag{1}$$

where x is the sampled time series, E the mathematical expectation of the series and $Kurt\ (x)$ is the kurtosis of the signal. The procedure to find adaptive wavelet filter is to vary the parameters of the Morlet wavelet to produce different daughter wavelets. The value of the kurtosis for each daughter wavelet is compared to find the best kurtosis. Kurtosis is a parameter that is sensitive to the shape of the signal. To determine where the defect is, time-domain features were used, such as crest factor.

All presented research show popularity of wavelets in the vibration signal analysis. The next section describes wavelets and how to use them to the analysis of the vibration signal.

3 WAVELETS AND VIBRATION SIGNAL

Wavelet transform is a type of the integral transform defined with the following definition.

Definition 3.1. Let $\psi\ (t) \in \mathbf{L}_2(\mathbf{R})$ be the wavelet in the time domain and $\Psi\ (\omega)$ the same wavelet in the frequency domain. If and only if exists the integral:

$$CWT_f\,(a,b) = \frac{1}{\sqrt{|a|}} \int_{-\infty}^{\infty} f(t)\psi^*\left(\frac{t-b}{a}\right)dt = \left\langle \psi_{a,b}(t),\, f(t) \right\rangle \tag{2}$$

the following rules apply:

1° $\int \psi(t)dt = \Psi(\omega = 0) = 0$

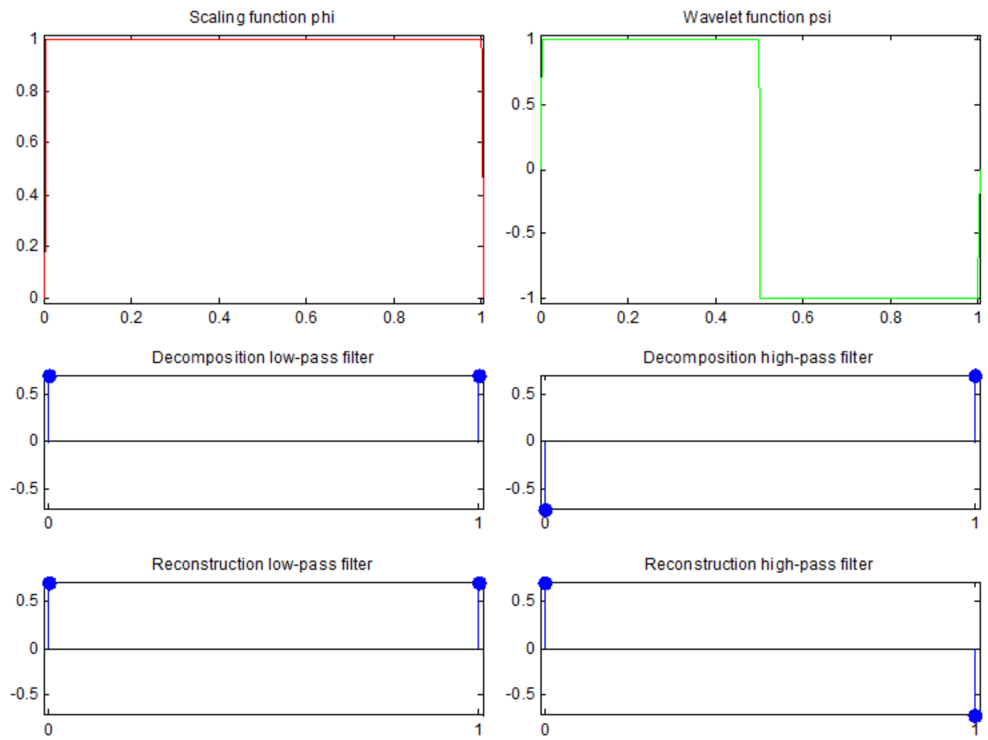
2° Translated (which is presented with parameter b) and scaled (which is presented with parameter a) function of $\psi(t)$ is described as $\psi_{a,b}(t) = \frac{1}{\sqrt{|a|}} \cdot \psi\left(\frac{t-b}{a}\right)$ where $a, b \in \mathbf{R}$ and $a \neq 0$. Function $\psi(t)$ is called mother wavelet, and $\psi\left(\frac{t-b}{a}\right)$ is dilated version of mother wavelet at given scale a. In practical applications, scale parameter is always $a \leq 1$.

3° Normalization rules apply: $\|\psi_{a,b}(t)\| = \|\psi(t)\|$ and

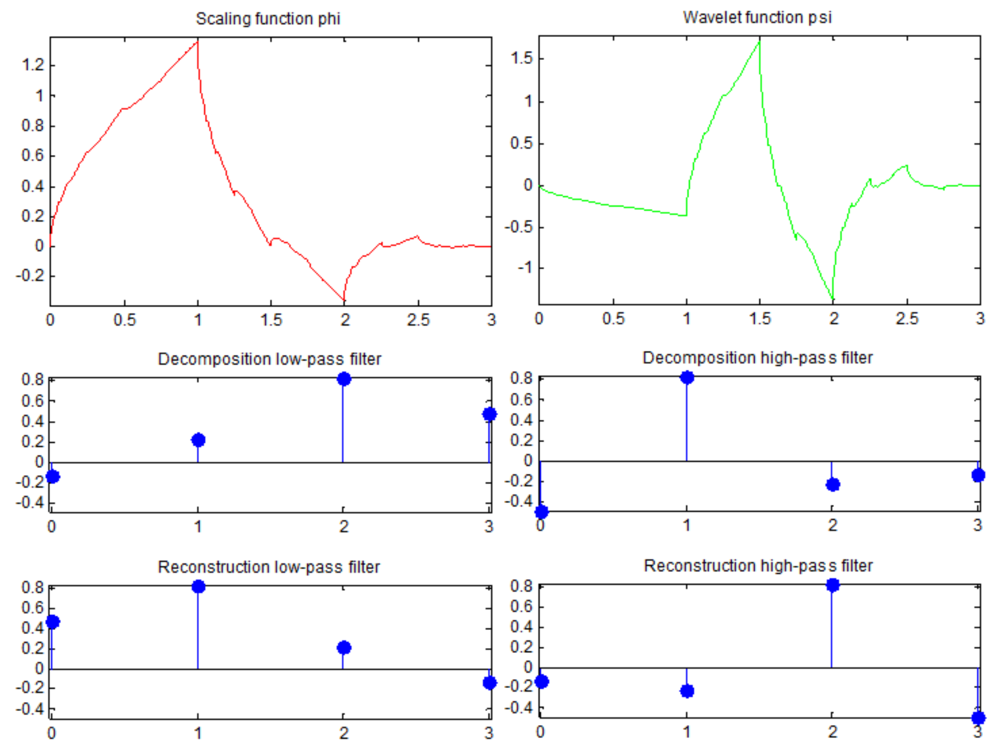
4° $\|\psi(t)\|^2 = \int_{-\infty}^{+\infty} |\psi(t)|^2\, dt = \frac{1}{2\pi} \int_{-\infty}^{\infty} |\Psi(\omega)|^2\, d\omega = 1$

Then the CWT satisfies the sufficient and necessary conditions and it is called Continuous Wavelet Transform (CWT) [26].

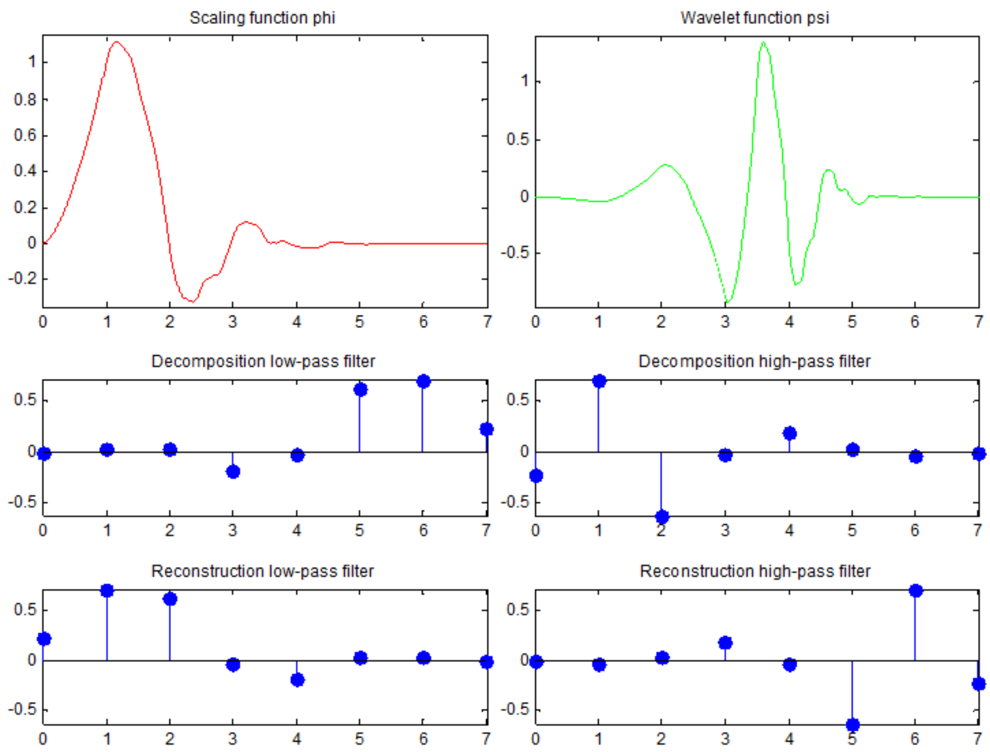
Most of wavelets have a so called scaling function and a so called wavelet function. Figure 1 shows some wavelets' scaling and wavelet function with decomposition and reconstruction filters. Figure 2 shows Morlet and Gauss wavelets, which do not have scaling function.


Scaling function phi
Wavelet function psi
Decomposition low-pass filter
Decomposition high-pass filter
Reconstruction low-pass filter
Reconstruction high-pass filter

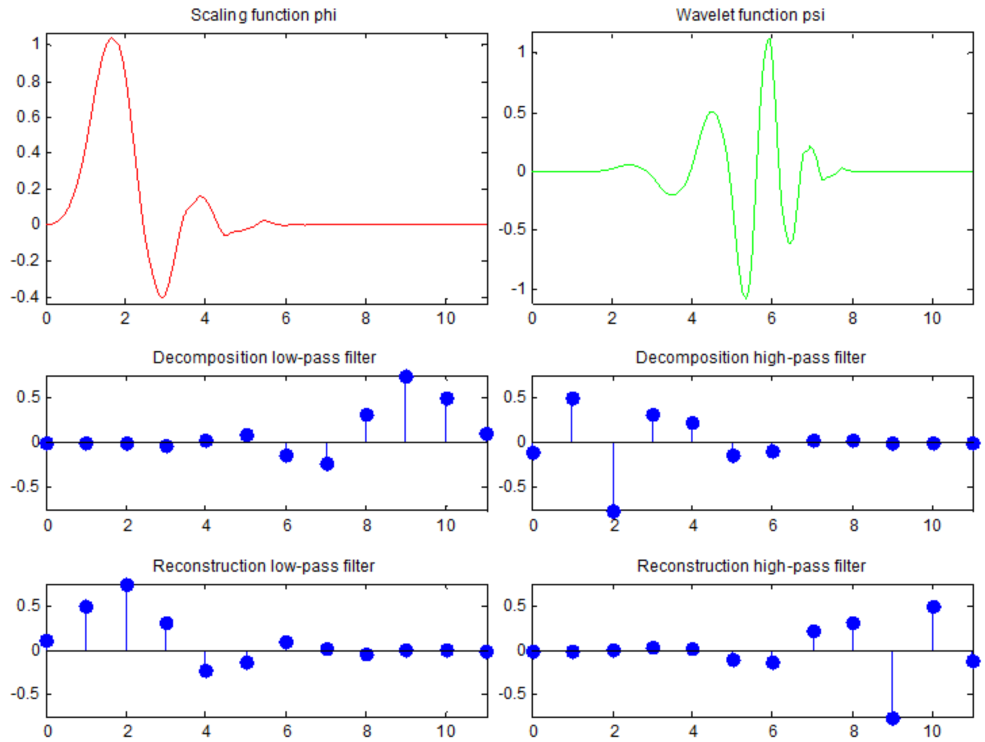
a)


Scaling function phi
Wavelet function psi
Decomposition low-pass filter
Decomposition high-pass filter
Reconstruction low-pass filter
Reconstruction high-pass filter

b)



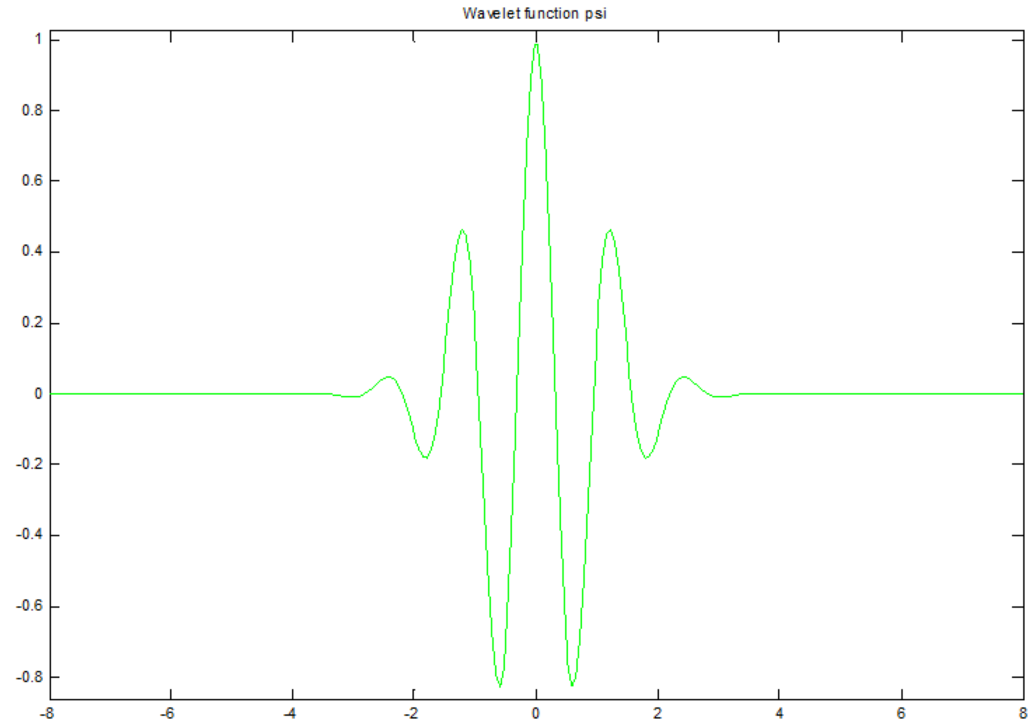
c)



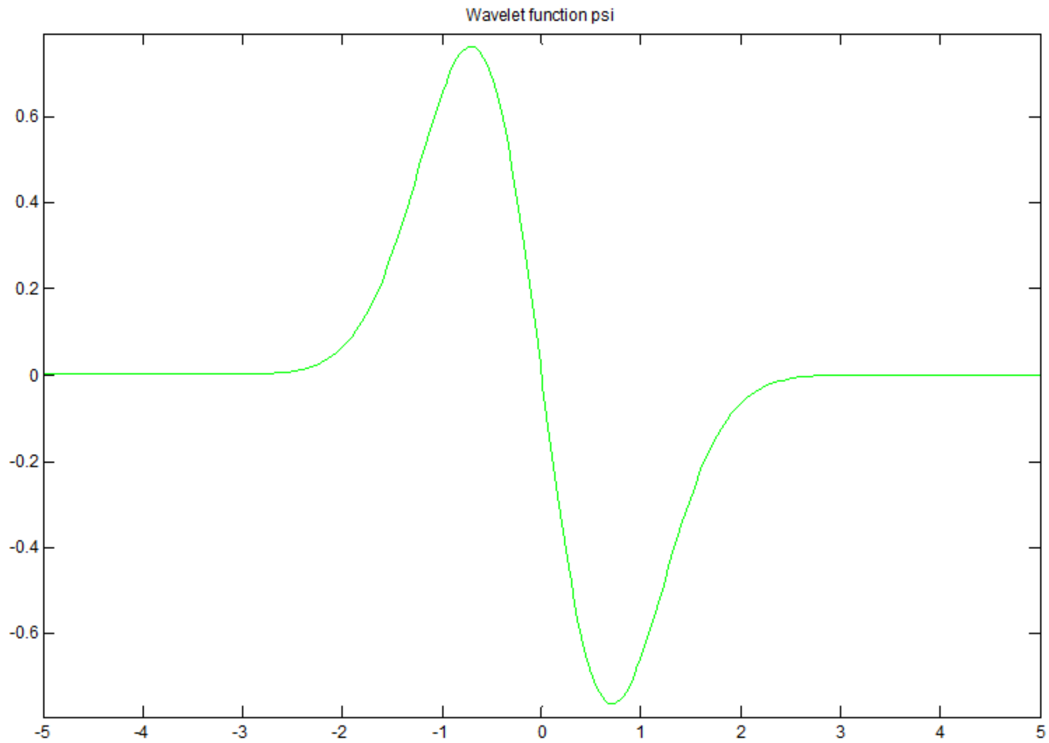
d)

Figure 11: Wavelet and scaling function, reconstruction and decomposition filter coefficients for: a) Haar, b) Daubechies db2, c) db4, d) db6

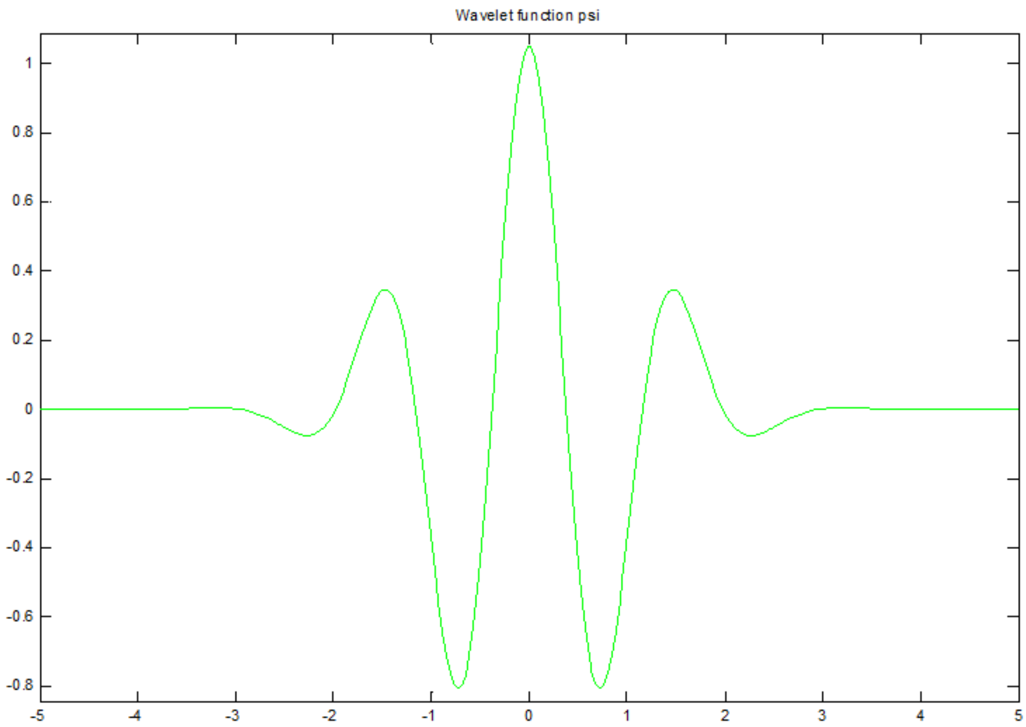
Figure 2 shows Morlet and Gauss wavelets, which do not have scaling function. Figure 3 shows how the WT works. The chosen signal is non-stationary, because wavelets are ideal for non-stationary signal analysis. For stationary signals, Fourier transform (FT) can be used.



a)



b)



c)

Figure 2: Some wavelets without scaling function: a) Morlet, b) Gauss 1, c) Gauss 8

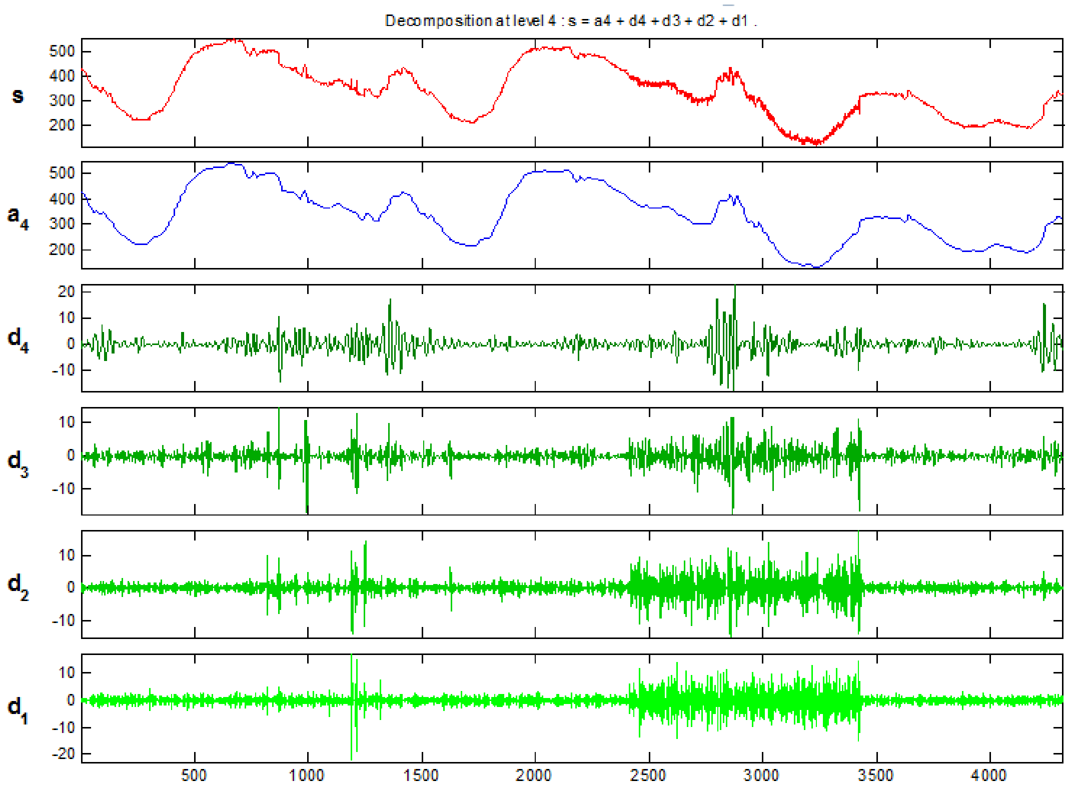


Figure 3: Wavelet (db4) decomposition at the 4th level of decomposition; original signal (upper), approximation at the 4th level of the decomposition, details at the 4th, 3rd, 2nd and the 1st level of the decomposition

Figure 3 shows that the approximation can be used for trends in the original signal, and approximations can be noise, disturbance, unbalance, etc.

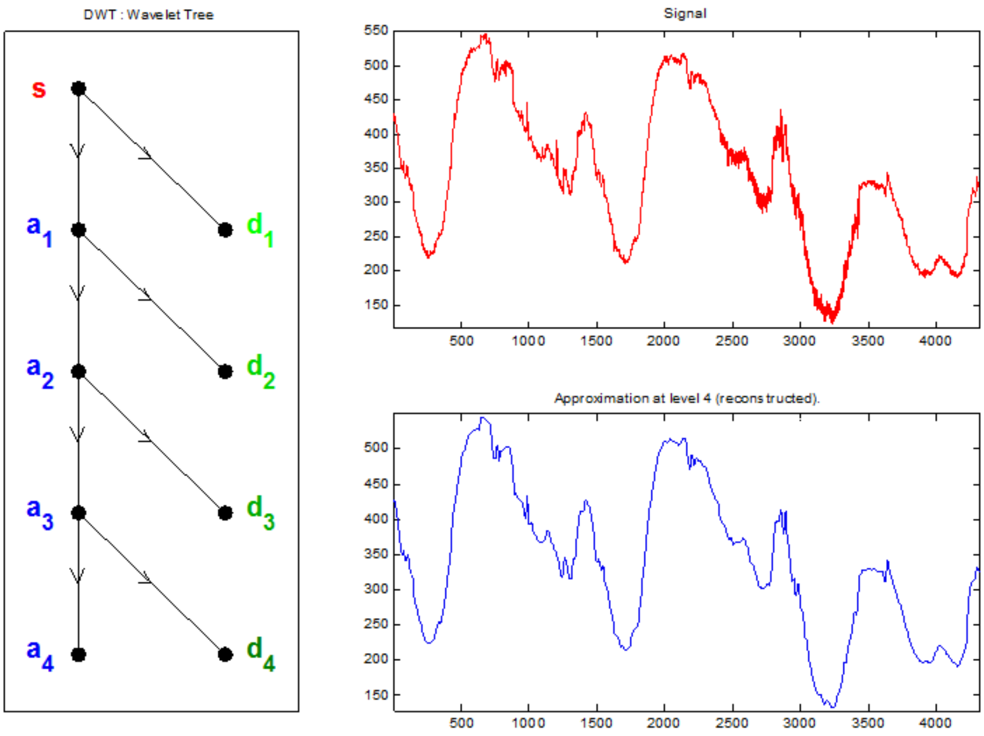


Figure 4: Wavelet tree (db4)

Figure 4 shows the wavelet decomposition tree and the comparison between the original signal and the approximation at the 4th level of the decomposition.

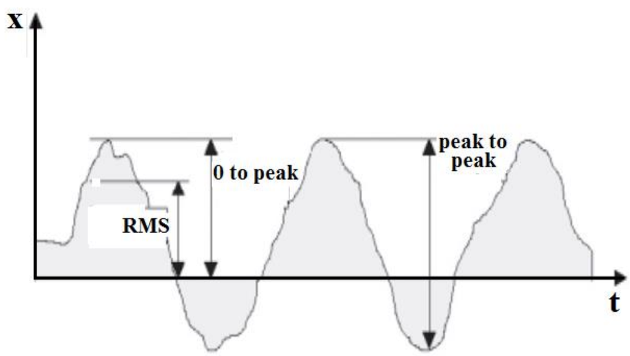


Figure 5: An example of the vibration signal

Figure 5 shows an example of the vibration signal obtained aboard ship. It can be seen that it has periodic harmonic trend and fluctuations, which should be captured by WT.

Table 12: Time and frequency domains representation of some usual failures

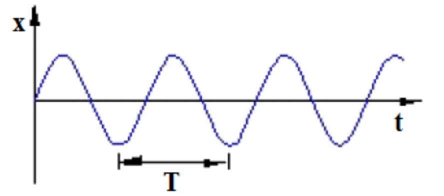
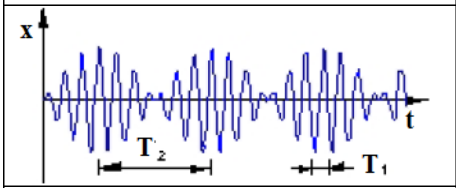
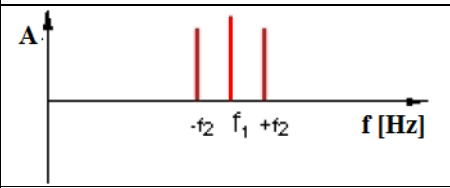
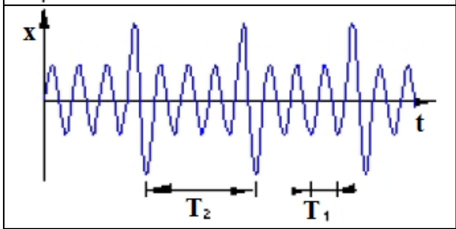
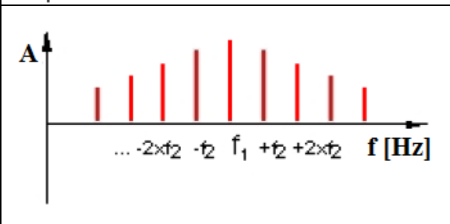
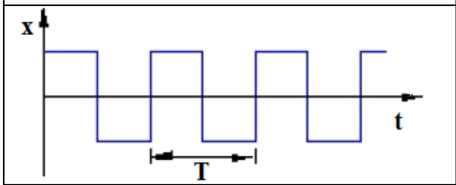
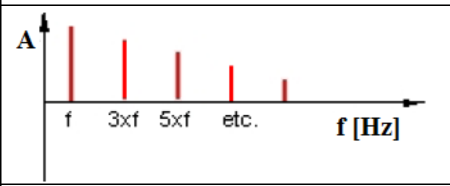
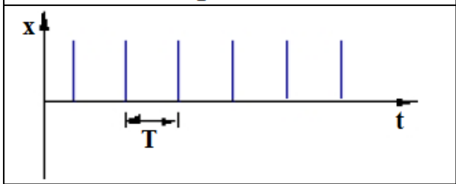
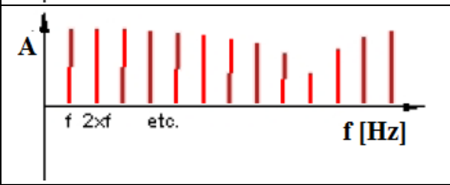
Time-domain signal	Signal's type	Frequency-domain signal	Comment
	Sin wave		Unbalance
	AM sin wave		Eccentricity of gear
	AM sin wave		Broken gear (local problem)
	Rect-angle vibration		Mechanical lability
	Impact imp. of the same f		Rubbing of rotor

Table 1 shows time and frequency representation of the vibration signal for some usual failures. It can be seen that different failures leave different influences to the vibration signal.

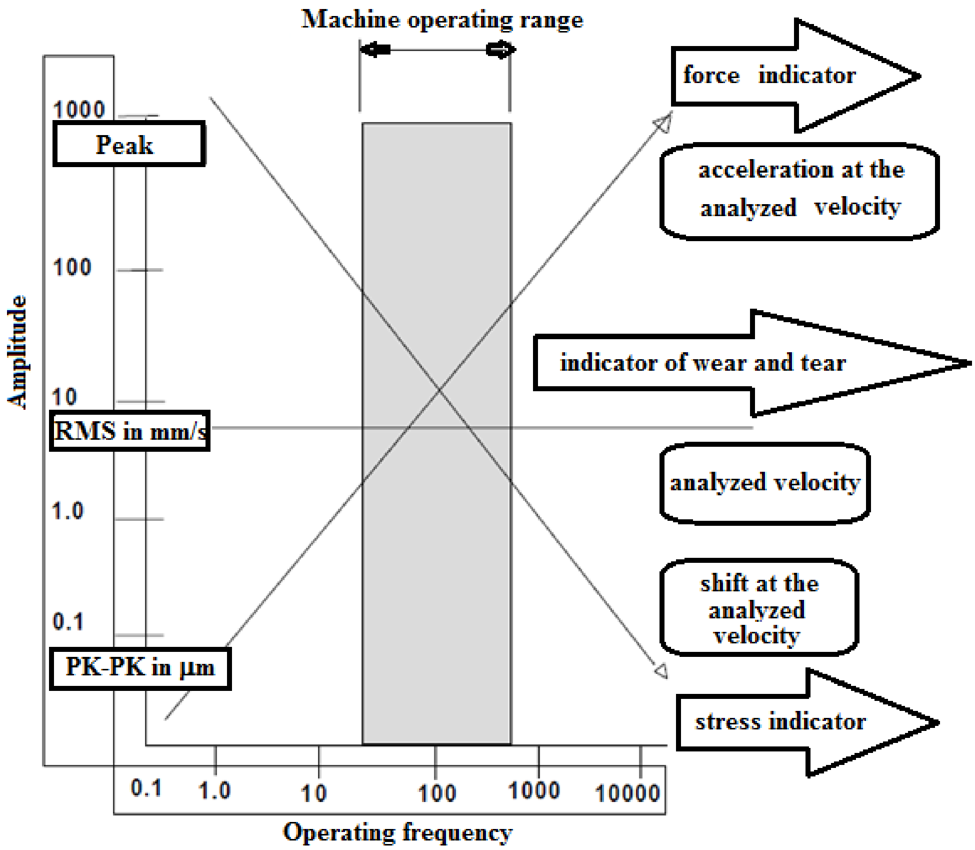


Figure 6: Position, velocity and acceleration as indicators of force, wear and tear and stress

Figure 6 shows the procedure how to choose sensor. It can be seen that the choice of the measurement sensor depends on the operating frequency and the indicator we are interested in, i.e. stress or force.

4 CONCLUSIONS

The time-frequency techniques such as Wavelet Transform are well suited for analysis of the vibration signal in condition monitoring. Due their compact support they are especially useful in dangerous and hardworking areas such as ship's engine room.

The main reason for using wavelets is to obtain monitoring in real time. So some advanced techniques, such as complex wavelet analysis, that maybe could produce better results are not applicable in some applications since they are time consuming i.e. they are not useful in real time monitoring.

Also it should be noted that in order to have successful condition monitoring it is necessary to distinguish between so called low level processing in which feature extraction has been used and so called higher lever processing in which Bayes, fuzzy and similar algorithms are used in order to use low lever data and determine the state of monitored system. The better feature extraction techniques are used the better and reliable analysis is.

Further research should include distinguishing and the diagnostics of multiple failures. It is supposed that wavelet ability to analyze non-stationary signals can be vital advantage in comparison to standard FT.

A final goal of the further research should be to develop computer diagnostic tool, which diagnosis a fault based on vibration signal spectra in real time. Furthermore, such a tool should report faults and suggest necessary actions.

REFERENCES

[1] Meggitt PLC – Engine Health Monitoring. http://www.meggitt.com/?OBH=108&ID=587&OP=Y

[2] Condition monitoring solutions for motors and generators - Enabling the right maintenance at the right time, ABB. http://www05.abb.com/global/scot/scot234.nsf/veritydisplay/96786057818e047bc12579e900695aaf/$file/condition%20monitoring_lr.pdf

[3] ExxonMobil-Marine Fuels & Lubricants, MobilGard™ Cylinder Condition Monitoring – monitor liner wear and safely optimise feed rates. http://www.exxonmobil.com/MarineLubes-En/Files/mobilgard-cylinder-condition-monitoring.pdf

[4] Santala, M.-M. Condition Monitoring provides key to ship automation. Wärtsilä article, http://www.wartsila.com/en/condition-monitoring-provides-key-to-ship-automation

[5] Performance Monitoring and Condition – Based Maintenance. Transmarine Propulsion Systems INC., http://www.shipserv.com/ShipServ/pages/attachments/55618/TMPS-Performance-Monitoring.pdf

[6] Tetrault, P. J. The future of Marine Engine Remote Monitoring in Marine Applications. http://pdf.cat.com/cda/files/3327305/7/The+Future+of+Remote+Monitoring+in+Marine+Applications+FINAL.pdf

[7] Shuzi, L. S. D. R. Y. Fault Diagnosis for Diesel Engines by Wavelet Packets Analysis of Vibration Signal Measured on Cylinder Head. J Vib Eng, 2000(04), http://en.cnki.com.cn/Article_en/CJFDTOTAL-ZDGC200004010.htm

[8] Newland, D. E. (1999). Wavelet Analysis of Vibration: Part 2 – Wavelet Maps. J. Vib. Acoust., 116(4), 417-425.

[9] Wang, W.J., & McFadden, P. D. (1996). Application of Wavelets to Gearbox Vibration Signals for Fault Detection. J Sound & Vib., 192(5), 927-939.

[10] Friis-Hansen, A. (2000). Bayesian Networks as a Decision Support Tool in Marine Applications. PhD Thesis, Technical University of Denmark, Department of Naval Architecture and Offshore Engineering.

[11] Esmail, O. E. M. (2009). An Intelligent Engine Condition Monitoring System. PhD Thesis, School of Mechanical and System Engineering, Newcastle University, UK.

[12] Li, Z., Yan, X., Guo, Z., Zhang, Y., Yuan, C., & Peng, Z. (2012). Condition Monitoring and Fault Diagnosis for Marine Diesel Engines using Information Fusion Techniques. Electronic & Elect Eng, 123(7), 109-112.

[13] Watzenig, D., Sommer, M. S., & Steiner, G. (2013). Model-Based Condition and State Monitoring of Large Marine Diesel Engines. In S. Bari (Ed.), Diesel Engine – Combustion, Emissions and Condition Monitoring (pp. 217-230). Intech.

[14] Grządziela, A. (2014) Diagnosing Faults of Marine Propulsion Systems by Means of Vibration Parameters Analysis. International Maritime Science Conference (pp. 124-130). Solin, Croatia: Faculty of Maritime Studies.

[15] Šoda, J., Beroš, S. M., Kuzmanić, I., & Vujović, I. (2013). Discontinuity Detection in the Vibration Signal of Turning Machines. In: A. Öchsner & H. Altenbach (Eds.), Experimental and Numerical Investigation of Advanced Materials and Structures (pp. 27-54), Springer-Verlag.

[16] Chen, H. X., Patric, S. K., Chua, G. H. L. (2006). Adaptive wavelet transform for vibration signal modelling and appliacation in fault diagnosis of water hydraulic motor. Mech Syst & Sig Proc, 20(8), 2022-2045.

[17] Katunin, A., Przystałka, P. (2014). Meta-optimization method for wavelet-based damage identification in composite structures. Proceedings of the 2014 Federated Conference on Computer Science and Information Systems (vol.2, pp. 429–438), Warsaw, Poland: Polish Information Society. http://dx.doi.org/10.15439/2014F268

[18] Cole, M. O. T., Keogh, P. S., Burrows, C. R., Sahinkaya, M. N. (2006). Adaptive Control of Rotor Vibration Using Compact Wavelets, J. Vib. & Acoust, 128, 653-665.

[19] R. Yan, R. X. Gao (2009). Base Wavelet Selection for Bearing Vibration Signal Analysis. Int. J. Wavelets Multiresolut Inf. Process, 07(2009), 411.

[20] Pricop, M., & Pricop, C. (2009). Signal Processing Wavelet Techniques in Vibration Analysis. Analele Universitatii Maritime Constanta, 10(12), 131-136.

[21] Xiang-jun, C., Zhan-feng, G., & Yue-e, M., Qiang, G. (2010). Application of Wavelet Analysis in Vibration Signal Processing of Bridge Structure. 2010 International Conference on Measuring Technology and Mechatronics Automation (ICMTMA), (vol.1, pp. 671-674), Changsha City, China.

[22] He, Q. (2012). Vibration signal classification by wavelet packet energy flow manifold learning. J Sound & Vib, 332(7), 1881-1894.

[23] Bendjama, H., Bouhouche, S., & Boucherit, M. S. (2012). Application of Wavelet Transform for Fault Diagnosis in Rotating Machinery. Int J Mach Learn & Comp, 2(1), 82-87.

[24] Liu, J. (2012). Shannon wavelet spectrum analysis on thuncated vibration signals for machine incipient fault detection. Meas Sci Technol, 23(5), 055604.

[25] Abouel-seoud, S. A., & Elmorsy, M. S. (2012). Enhancement of Signal Denoising and Fault Detection in Wind Turbine Planetary Gearbox Using Wavelet Transform. Int J Sci Adv Technol, 2(5), 120-132.

[26] Kingsbury, N. G., &Magarey, J. F. A., (1997). Wavelet Transforms in Image Processing. Proc. First European Conference on Signal Analysis and Prediction (pp. 23 – 24). Prague, Czech Republic, Birkhäuser.

ANALYSIS OF CARBON DIOXIDE EMISSIONS BY ROAD TRANSPORT IN EU USING KUZNETS CURVE APPROACH

Aneta Włodarczyk, PhD
Częstochowa University of Technology
Dąbrowskiego 69, 42-201 Częstochowa, Poland
aneta.w@interia.pl

ABSTRACT

Empirical studies devoted to the development of transport sector in the EU countries indicate the negative environmental impacts caused by transport activity. Increase of traffic, caused inter alia by such factors as the economic growth, urbanization, change in the life standards, enlarge of road infrastructures, leads to increase of energy consumption and degradation of air quality. Hence, this paper studies the long-run relationship between GDP, road transport-related energy consumption and CO2 emissions from transport for chosen European countries. The background of empirical research constitutes the environmental Kuznets curve (EKC) approach. Annual data are downloaded from the World Development Indicators database. Additionally, according to Enders and Siklos (2001) work, the existence of threshold cointegration and asymmetric relationship are tested. Such approach allows for a different speed of adjustment to the long-run equilibrium level depending on the direction of the short-run deviations of CO2 emission from the long-run EKC. The results of empirical research presented in this paper suggest that the traditional EKC model should be extended about the additional variables such as energy consumption in transport and technological progress, explaining the relationship between CO2 emission in the transport sector and economic growth.

Key words: Road transport sector, carbon dioxide emission, energy consumption, Environmental Kuznets Curve.

1 INTRODUCTION

Recently the quality of natural environment has been considered in terms of public good, the value of which is decrease, among others, through emission of pollutions connected with growing energy demand on the side of various groups of stakeholders in the society. More and more often the relationship between the quality of the natural environment and the quality of human life and the health of whole societies is emphasized. Ang (2009) proved that growing energy consumption and economic growth contribute to the growth of CO_2 emissions to the atmosphere and moreover, the level of natural environment pollution is negatively correlated with the economy capacity in the scope of implementing new technological solutions in the process of production and services [Ang, 2009]. Growing degradation of natural environment and the greenhouse effect have become recently ones of the most important issues considered at the level of the European Commission as well as the Organization of the United Nations. More and more attention is devoted to the transport impact on the greenhouse effect.

While implementing market mechanisms to limit greenhouse gases emission within implementation of the Kyoto Protocol (1997) has contributed to the control and limiting CO_2 emission in the energy sector, constantly growing CO_2 emission in the transport sector has remained a global problem. A growing demand for transport services (connected with the growing economic activeness or the change of people's standard of life), division of the transportation assignments among individual branches of transport partially neutralize results of the research concerning improved efficiency of fuel consumption, which concern inter alia modifying engine operation, construction of vehicles or an increased share of bio-fuels as compared to conventional fuels.

In the subject literature one can find papers which concentrate on studying mutual long-term relationships among energy consumption, greenhouse gases emission, economic growth and growth of demand for transportation services at the whole economy level [Saboori et all, 2014; Abdallah et all, 2013]. The basis of these papers constitutes the EKC hypothesis which verifies the non-linear nature of relationships between natural environment degradation and level of economic growth [Grossman&Krueger,1995; Stern, 2004]. To be more precise, it has been proved that the relation between greenhouse gases emission and GDP is of an inverted U shape. This means that environment pollution grows in case of developing countries, but after achieving a certain level of economic growth greenhouse gases emission decreases despite the fact that the GNP per capita still grows (developed countries start investments into environment protection). Some researchers modelled the environmental curve EKC including in the analysis additional variables in the form energy consumption [Fosten et all**,** 2012], trade [Halicioglu**,** 2009] or urbanization ratio [Farhani et all, 2013]. There are few papers devoted to verifying the EKC hypothesis in the transport sector, and in particular ones that check the occurrence of threshold cointegration and asymmetric relationship adjustment to the long-run equilibrium level determined by the EKC curve.

The aim of this paper is to verify the environmental Kuznets curve (EKC) hypothesis in both the traditional and the modified version for the road transport sector in chosen EU countries. The inclusion of the additional variables such as trend or energy consumption of the transport sector into the EKC model may allow for testing the robustness of the results. These hypothesis are tested using threshold autoregressive (TAR) and momentum threshold autoregressive (MTAR) cointegration techniques proposed by Enders and Siklos (2001). Such approach enables for a different speed of adjustment to the long-run equilibrium depending on whether the CO_2 emissions derived from road transport are above or below the EKC level. The empirical studies are conducted on the basis of the following variables: transport value added, road transport-related energy consumption and road transport-related CO_2 emission for chosen European countries. All data sets are taken from the World Development Indicators (WDI). The rest of the paper is organized as follows. Section 2 briefly presents the negative impact of the transport sector on the environment and the feedback relationship between the transport development and economic growth. In Section 3 both the EKC hypothesis and the econometric tools used for its verification are described. Section 4 describes the data and presents empirical results. And finally, Section 5 concludes the paper.

2 TRANSPORT INFLUENCE ON ECONOMY AND ENVIRONMENT

Transport is one of the most vital factors determining economic development of the country, and modern transport infrastructure contributes to the increase of social, economic and spatial integrity of the country and strengthening given country's competitiveness on the international scene. Direct and indirect effects of transport's influence on economy include inter alia [Witkowski, 2004; Neider, 2008]:

- increased efficiency of logistics processes in enterprises,
- increase in logistics service efficiency,

- creating favorable conditions for development of logistics centers,
- increased spatial range of markets for the goods,
- creating conditions aiming at decreasing prices, through inter alia mitigating negative impact of space on the cost level of goods manufacturing and services,
- integration of central and peripheral areas, and thus, limiting the phenomenon of social exclusion,
- creating new workplaces in the transport, shipping and logistics sector,
- mobilizing innovative activities in the scope of renewable energy sources use and an increase of fuel efficiency in the transport sector,
- satisfying communication needs of people, as illustrated also by development of tourism.

It is worth stressing the complementarity of transport for other branches of national economy, due to the lack of a substitute for transport activity, as well as occurrence of a feedback loop between transport development and economic conjuncture. The place and role of transport in the management process are determined by factors shaping the size and rate of changes of demand for transport services, that is: size of production potential, production structure, activeness level of social life, level of specialization and cooperation of work sharing, preferences of individual sectors of the economy, economic cycle phase [Rydzykowski & Wojewódzka-Król, 2009]. Transport system may contribute to the growth of competitiveness of a given economy, if it is able to guarantee inter alia: an increased access in time and space to transport services for various profiles of users, limiting the cost and time of performing transport services, energy efficiency improvement and decreasing unit emission benchmarks, eliminating congestion and multimodality [Strategy of transport development until 2020, Ministerstwo Transportu, Budownictwa i Gospodarki Morskiej, 2013].

An undeniable problem and at the same time a barrier for transport development in the light of The United Nations Framework Convention on Climate Changes is its dependence on fossil fuels and therefore high benchmarks of greenhouse gases emission into the atmosphere. The adopted during the summit of the European Union in 2008 energy and climate package assumes with regard to transport (included into the economy sectors not covered by the European Emission Trading System, EU-ETS) performing the following goals: reducing greenhouse gasses emission by 10% by 2020 at a simultaneous decrease of CO_2 emission limits by new vehicles to the level of 95g/km, achieving at least a 10% share of renewable fuels in transport fuels use [Sanderski, 2008]. In order to limit a negative impact of the transport sector on environment the following solutions are recommended [Strategy for decreasing the demand of heavy goods vehicles for fuel and CO_2 emission reduction, 2014; Skowron-Grabowska, 2014]:

- increase of energy efficiency in the transport sector through development of intermodal transport in cargo transport, increase of the share of environmentally-friendly means of transport (vehicles and buses using fuel cells and hydrogen and the ones propelled by electricity, gas, hybrid, compressed air), implementing innovative systems of traffic and transport management in particular branches of transport (ITS – road transport, ERTMS – rail transport, SESAR – air transport, VTMS – sea transport, RIS – inland waterway transport);
- investments in low-emission solutions through inter alia decarbonisation of fuels and supporting development of alternative fuels infrastructure, stimulating works on constructing vehicles of lower CO_2 emission, supporting purchases of more environmentally-friendly vehicles by public subjects;

- organizational and system solutions which aim at decrease of transport congestion, particularly in urban areas (inter alia through development of municipal collective transport, promoting pedestrian and bicycle traffic, optimizing municipal and regional systems of passenger transport).

Klooster and Kampman (2006) in turn suggest implementing market mechanisms in order to limit CO_2 emission in the transport sector, similar to the ones functioning in the energy sector. The authors evaluate in their paper the possibility of introducing two types of CO_2 emission allowances trading: Cap&Trade or Baseline &Credit in the whole transport sector or in its particular branches (road, railways, maritime shipping or aviation). Briefly describing, the essence of the Cap and Trade scheme is setting of a fixed ceiling for CO_2 emissions level in combination with tradable emission rights. Each source must hold emissions allowances in order to cover its emissions level, and the saved rights may be sold to the another source. The main feature of Baseline &Credit scheme is that the baseline emission standard in combination with bankable /tradable emission credits is set. The difference between these two type of schemes is that in the B&C scheme the absolute level of CO_2 emissions are not regulated directly, only the relative emissions (the CO_2 emissions per vehicle kilometer) are respected. [Klooster & Kampmann, 2006]. Mraihi (2012) indicated for some policy options which may reduce energy intensity from transport sector and in consequences may lead to increase energy efficiency of transport activity. The following policy options are described: logistics solutions, modal shifting, economic structure change, transport planning, fiscal and economic instruments, technological instruments, in order to underline the meaning of decoupling the transport energy consumption from economic growth [Mraihi, 2012]. The problem of negative impact of the reduction of transport-related energy consumption on economic growth is also underlined by Abdallah et al. (20013). The subject literature also stresses the fact that transport processes generate highest costs within reverse logistics [Mesjasz – Lech, 2012].

The above presented issues of transport impact on environment degradation and occurrence of mutual dependencies among energy consumption, economic growth and transport development indicate the relevance of the research problems and importance of econometric analyses conducted in this scope. The next part of the paper will present the environmental Kuznets curve analysis and econometric tools which enable testing non-linear dependencies among CO_2 emission, added value in the sector transport and energy consumption.

3 EKC MODELS AND THRESHOLD COINTEGRATION APPROACH

In classical approach to modelling the relationship between environmental degradation and economic growth the following quadratic function with the turning point occurring at a maximum pollutant level is used [Stern, 2004]:

$$ln(CO_2)_t = \alpha_0 + \alpha_1 ln(GDP)_t + \alpha_2 (ln(GDP))_t^2 + u_t \tag{1}$$

where: CO_2 – carbon dioxide emissions (per capita), GDP – real gross domestic product (per capita), α_0, α_1, α_2 – estimated parameters, u_t – error term (disturbance term) that may be serially correlated.

It is worth stressing that on the basis of the parameters value one may conclude about the shape of environmental degradation and income linkage. If $\alpha_1 > 0$ and $\alpha_2 < 0$, an inverted U-shape describes the situation when the pollution level increase as a country develops until this development reaches a turning point ($GDP_{TP} = \exp\left(-\frac{\alpha_1}{2\alpha_2}\right)$) and after that the rising incomes are accompanied by decreasing environmental degradation. This quadratic function indicates the symmetry in the shaping of environmental pollution – income relationship, for example when income pass the turning point, the environmental degradation decreases at the same rate as income increases.

In order to capture the effect of technological progress on pollution emission level one may include the deterministic time trend into the EKC model [Fosten et all, 2012]:

$$ln(CO_2)_t = \alpha_0 + \alpha_1 ln(GDP)_t + \alpha_2(ln(GDP))_t^2 + \beta t + u_t, \tag{2}$$

where: t – time variable, β –trend parameter.

In EKC literature the more sophisticated functional form, which enables for the capturing of the impact of energy consumption on environmental degradation, is also taken into consideration [Fosten et all, 2012; Abdallah et all, 2013]:

$$ln(CO_2)_t = \alpha_0 + \alpha_1 ln(GDP)_t + \alpha_2(ln(GDP))_t^2 + \gamma ln(E)_t + u_t, \tag{3}$$

where: E – energy consumption (per capita), γ – model parameter.

According to literature studies, the higher level of energy consumption causes the greater economy activity and CO_2 emissions, so $\gamma > 0$ [Fosten et all, 2012; Abdallah et all, 2013; Saboori et all, 2014]. It is also possible to join together these two approaches in order to modify the traditional EKC model (1) as follows:

$$ln(CO_2)_t = \alpha_0 + \alpha_1 ln(GDP)_t + \alpha_2(ln(GDP))_t^2 + \gamma ln(E)_t + \beta t + u_t. \tag{4}$$

Recently studies devoted to verification of EKC hypothesis proved that linear cointegration methods are not suitable for describing the empirical dependencies between environmental – economic factors [Fosten et all, 2012]. Enders and Siklos (2001) modified the original Engle and Granger (1987) test for linear cointegration by allowing for regime-behavior of error term from the long-run regressions (1)-(4). They proposed two types of nonlinear models: threshold autoregressive (TAR) and momentum-threshold autoregressive (M-TAR) for capturing possible differences in cointegration relationship across two regimes [Enders & Siklos, 2001]:

$$\Delta u_t = H_t \rho_1 u_{t-1} + (1 - H_t)\rho_2 u_{t-1} + \sum_{i=1}^{r} \theta_i \Delta u_{t-i} + \varepsilon_t, \tag{5}$$

where: ε_t – white noise error term, ε_t is independent on u_t, θ_i, ρ_1, ρ_2 – estimated parameters, H_t – Heaviside indicator function, which is determined by one of the following formulas:

$$H_t = \begin{cases} 1 \ if \ u_{t-1} \geq \tau \\ 0 \ if \ u_{t-1} < \tau \end{cases} \tag{6}$$

or

$$H_t = \begin{cases} 1 \ if \ \Delta u_{t-1} \geq \tau \\ 0 \ if \ \Delta u_{t-1} < \tau \end{cases}. \tag{7}$$

where τ - threshold value, which is estimated by means of the Chan's (1993) methodology.

The main difference between TAR and M-TAR model is that in the first model ((5)-(6)) the Heaviside indicator depends on the level of u_{t-1}, while in the second model ((5) - (7)) the threshold value is approximated on the basis of the previous period's change in ut-1. This specification is particularly useful in the case of asymmetric adjustment to the long-run equilibrium level when in time series may be observed more rapid changes in one direction than in the other [Yau & Nieh, 2009]. Both the necessary and the sufficient conditions for stationarity of the EKC residuals $\{u_t\}$ are that $\rho_1 < 0, \rho_2 < 0, (1+\rho_1)(1+\rho_2) < 1$ for any τ value [Enders & Siklos, 2001].

On the basis of estimation results obtained from TAR and M-TAR models two different hypotheses are tested. The first null hypothesis H_0: $\rho_1 = \rho_2 = 0$ helps to verify the first two conditions of disequilibrium error stationarity jointly. It is worth noting that the F-statistics for this null hypothesis has a non-standard distribution and the appropriate critical values were computed by Enders and Siklos (2001). The rejection of null hypothesis means the existence of the cointegration relationship between environmental degradation, energy consumption and income and fulfillment of the stationarity assumptions. After confirmation of the presence of cointegration between analyzed variables one may investigate whether the adjustment process to the long-run equilibrium has an asymmetric character. The second null hypothesis H_0: $\rho_1 = \rho_2$ about symmetric adjustment is tested by using a standard F-test. In the situation that the adjustment parameters in each regime do not statistically significantly differ from each other, the Enders and Siklos (2001) procedure comes down to traditional Engle and Granger (1987) cointegration test. Rejecting this set of null hypothesis simultaneously means the threshold cointegration with asymmetric adjustment effect [Enders & Siklos, 2001; Fosten et all, 2012].

4 VERIFYING THE EKC HYPOTHESIS FOR SELECTED EU COUNTRIES

Empirical research presented in the paper have been conducted for four selected countries of the European Union: France, Great Britain, Finland and Spain. Two first countries are characterized by the greatest share of transport value added created jointly by 27 countries of the European Union (EU-27 value added) (France - 18.1% in the land and pipeline transport sector, Great Britain - 21% in the air transport sector)[1]. Spain and Finland in turn belong to the group of EU countries working intensively on establishing an efficient certifying system of bio-fuels use (the level of bio-fuels consumption in the EU increased from 1.1mln Toe in 2002 to 13.6 mln Toe in 2011)[2].

1http://ec.europa.eu/eurostat/statistics-explained/index.php/Land_transport_and_transport_via_pipelines_services_statistics_-_NACE_Rev._2 (accessed 21.03.2015).
2 http://www.globenergia.pl/aktualnosci/podsumowanie-rynku-biopaliw-w-unii-europejskiej-raport (accessed 21.03.2015).

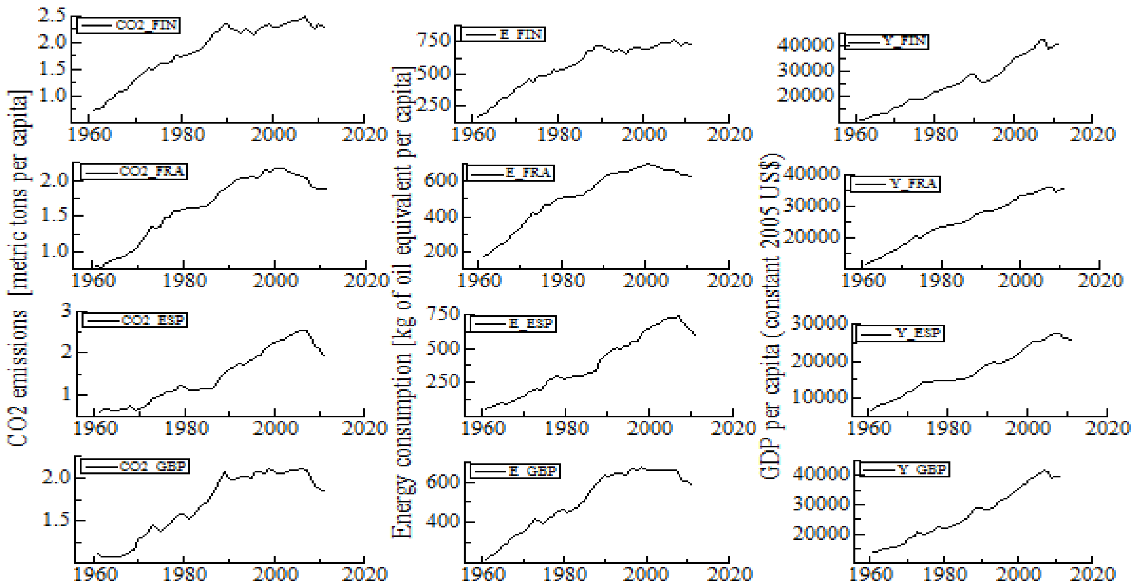


Figure 12: Shaping of CO_2 emissions, energy consumption in transport sector and real GDP per capita in Finland (first panel), France (second panel), Spain (third panel) and the United Kingdom (fourth panel) from 1961 to 2011

Source: own elaboration.

Annual data for this analysis was collected from World Development Indicators (WDI)[3] and for the reason of the time series availability, the sample period ranges from 1961 to 2011. Following Sabori et all (2014), the data used in this study consist of CO_2 emissions from transport (CO_{2t}; in metric tons per capita), real gross domestic product (GDP_t; constant 2005 US dollars per capita) and energy consumption from road sector (E_t; in kg of oil equivalent per capita). As it is described in WDI database, CO_2 emissions from transport contain emissions from combustion of fuel for all transport activity, regardless of the sector, except for international marine bunkers and international aviation. In turn, road sector energy consumption is the total energy used in the road sector including petroleum products, natural gas, electricity, combustible renewable and waste. All analyzed time series are shown in Fig.1.

All variables are expressed in natural logarithms to conduct the analysis. In order to establish the order of integration of the analyzed time series the author used unit roots tests (Augmented Dickey-Fuller Generalized Least Squares (ADF-GLS) and Schmidt-Phillips) for logarithms of the variables and their first differences (comp. Tables 1-4). Moreover, a very important issue while evaluating time series stationarity is identifying occurrences of potential structural breaks. For this reason the author also conducted the structural break unit roots test of Zivot and Andrews (1992), in which the null hypothesis on unit roots occurrence was verified against an alternative one on the stationarity with a structural break in the intercept and trend coefficient (comp. Tables 1-4).

[3] http://data.worldbank.org/indicator (accessed 03.12.2014).

Table 13: The results of unit root tests for Finland

Variables	Levels				Differences	
	ADF-GLS	Zivot-Andrews	Break date	Schmidt-Phillips	ADF-GLS	Schmidt-Phillips
CO_{2t}	-0.778 [3]	-3.882 [3]	1996	-2.988 [3]	-2.192 [2]**	-58.345 [2]***
GDP_t	-2.316 [1]	-3.122 [1]	1975	-8.797 [1]	-4.378 [0]***	-26.745 [0]***
GDP^2_t	-2.536 [1]	-3.111 [1]	1975	-9.821 [1]	-4.441 [0]***	-26.999 [0]***
E_t	-1.247 [2]	-5.539 [2]***	1996	-2.273 [2]	-2.373 [1]**	-57.119 [1]***

Note: (***), (**), (*) in ADF-GLS , Schmidt-Phillips and Zivot-Andrew tests respectively indicate the rejection of the null hypothesis that series has a unit root at 1%, 5% and 10% levels of significance. The numbers inside the brackets are the optimum lag lengths determined using Akaike information criterion. Tests includes intercept and trend for variables levels and only intercept for variables differences.

Source: own calculation.

Table 2: The results of unit root tests for France

Variables	Levels				Differences	
	ADF-GLS	Zivot-Andrews	Break date	Schmidt-Phillips	ADF-GLS	Schmidt-Phillips
CO_{2t}	-1.166 [3]	-1.632 [2]	1994	-3.881 [3]	-2.484 [2]**	-24.259 [1]**
GDP_t	-0.807 [1]	-2.856 [2]	1973	-1.783 [1]	-3.053 [0]***	-37.678 [1]***
GDP^2_t	-0.841 [1]	-2.754 [2]	1973	-2.165 [1]	-3.265 [0]***	-37.813 [1]***
E_t	-1.255 [3]	-3.137 [2]	2001	-2.676 [3]	-2.110 [1]**	-24.683 [1]**

Note: see Table 1.

Source: own calculation.

Table 3:The results of unit root tests for Spain

Variables	Levels				Differences	
	ADF-GLS	Zivot-Andrews	Break date	Schmidt-Phillips	ADF-GLS	Schmidt-Phillips
CO_{2t}	-0.954 [1]	-3.420 [1]	2008	-4.022 [1]	-4.617 [0]***	-28.927 [0]***
GDP_t	-1.133 [1]	-3.019 [1]	1972	-1.233 [1]	-1.766 [0]*	-15.646 [0]*
GDP^2_t	-1.259 [1]	-2.984 [1]	1972	-1.949 [1]	-1.916 [0]*	-15.126 [0]*
E_t	-0.681 [1]	-2.256 [1]	2004	-3.593 [1]	-4.357 [0]***	-41.911 [0]***

Source: own calculation.

Table 4: The results of unit root tests for the United Kingdom

Variables	Levels				Differences	
	ADF-GLS	Zivot-Andrews	Break date	Schmidt-Phillips	ADF-GLS	Schmidt-Phillips
CO_{2t}	-0.873 [1]	-3.252	1996	-2.924 [1]	-3.679 [0]***	-31.343 [1]***
Y_t	-2.588 [1]	-3.392	2009	-10.813 [1]	-4.730 [0]***	-35.108 [1]***
Y^2_t	-2.829 [1]	-3.472	2010	-10.865 [1]	-4.705 [0]***	-35.028 [1]***
E_t	-0.482 [1]	-3.396	1996	-1.848 [1]	-3.272 [0]***	-40.543 [1]***

Source: own calculation.

The results of ADF-GLS and Schmidt-Phillips tests indicate that all analyzed variables are first order integrated. The Zivot-Andrews test provides grounds for concluding that in case of majority of variables the structural change does not occur, the only exception being the time series of energy consumption for Finland (the Zivot-Andrews test indicates an occurrence of the structural break in energy consumption in Finland in 1996 at significance level 0.01).

The first stage of the analysis was to estimate the long-term relationship between CO_2 emission and economic growth in the context of the EKC hypothesis and verifying the occurrence of the effect of the threshold cointegration with asymmetric adjustment to the long-run equilibrium. Parameters of the traditional EKC model (1) were estimated with the ordinary least squares (OLS) method and then in accordance with the Engle-Granger approach (1989), residuals of the long-term equation were tested for stationarity (comp. Table 5).

Table 5: Estimated parameters of the traditional EKC model

Country	α_0 (t-Stud)	α_1 (t-Stud)	α_2 (t-Stud)	ADF (residuals)	Signs of EKC parameters
Finland	-74.35 (-18.57)***	14.16 (17.67)***	-0.67 (-16.64)***	-2.393**	appropriate
France	-51.652 (-6.268)***	9.484 (5.741)***	-0.428 (-5.172)***	-0.623	appropriate
Spain	25.384 (3.213)***	-6.439 (-3.916)***	0.396 (4.636)***	-1.743*	inappropriate
United Kingdom	-62.49 (-8.51)***	11.814 (8.124)***	-0.552 (-7.672)***	-1.982**	appropriate

Note: (***), (**), (*) indicate significance at 1%, 5% and 10% level. t-statistics for parameters in parentheses.

Source: own calculation.

The EKC hypothesis verification was unfavourable for France (residuals of the EKC equation are not stationary which makes it impossible to use this model for further analysis due to the possibility of spurious regression effect occurrence) and for Spain (parameters signs in the long-term equation are not consistent with theoretical assumptions, according to which the long-term dependence between environment degradation and economic growth is of an inverted U shape) [Fosten et all, 2012]. Such shape can be observed in case of Finland and Great Britain (comp. Fig. 2), which is additionally confirmed by the results of the classic Engle-Granger procedure (1989) (stationarity of residuals from the EKC model verified with the ADF test, significance of parameter estimates and their signs: α_0 <0, α_1 > 0 and α_2 < 0).

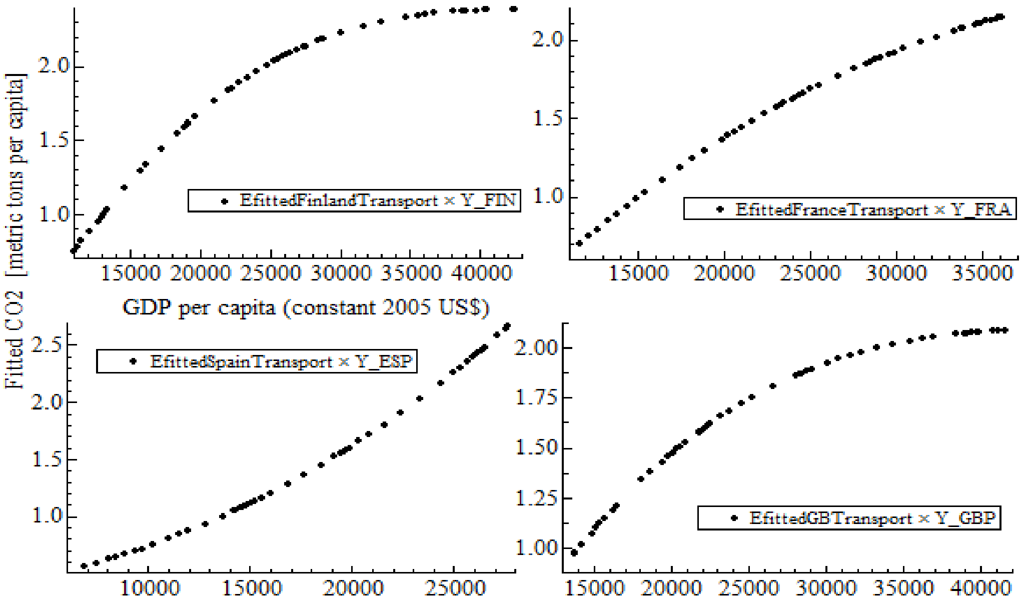


Figure 2: Fitted values for the estimated EKC relation for CO_2 emissions in Finland, France (upper panel), in Spain and the United Kingdom (lower panel)

Source: Own elaboration.

The turning points are located at US$ 38838 (Finland, in 2009) and at US$ 44404 (the United Kingdom, in 2007). It is worth noting that the estimated value of the turning point for France (64825 US$) has not been reached so far and the shape of EKC plot may suggest that this value may be realized in the future. However, this result should be treated with caution because of the quality of the estimated EKC model for France.

Then the Enders and Siklos methodology was used in order to test if a more sophisticated form of cointegration dependence occurs between environment pollution and economic growth in the form of the threshold cointegration with asymmetric adjustment to the long-run equilibrium. The TAR and MTAR threshold autoregressive models (5)-(7), at 0 threshold value and estimated one with the use of the Chan method (1993) were estimated on the basis of the traditional EKC model residuals for each analyzed country (comp. Table 6). In the case of each TAR or MTAR model the autoregressive order was selected on the basis of the Schwarz Bayesian information criterion (BIC) and the Ljung-Box statistics (LB (4)), and then a set of two null hypotheses was verified: on lack of cointegration between the variables (H_0:ρ_1=ρ_2=0) and on occurrence of symmetric adjustment to the long-term equilibrium level (H_0:ρ_1=ρ_2) in the situation when CO_2 emission level will be significantly higher or lower than the determined by the EKC model.

Table 6: Results of threshold cointegration test – the traditional EKC approach

Parameters/ Statistics	Finland				France			
	TAR τ=0	MTAR τ=0	TAR τ= -0.006	MTAR τ= -0.004	TAR τ=0	MTAR τ=0	TAR τ= 0.057	MTAR τ= -0.017
ρ_1	-0.223	-0.203	-0.231	-0.180	-0.083	-0.080	-0.047	-0.055
	(-1.751)*	(-1.571)	(-1.816)*	(-1.517)	(-0.876)	(-0.849)	(-0.382)	(-0.738)
ρ_2	-0.271	-0.310	-0.261	-0.407	-0.004	-0.007	-0.036	-0.00006
	(-1.931)*	(-1.967)*	(-1.858)*	(-2.26)**	(-0.050)	(-0.091)	(-0.497)	(-0.001)
Φμ	3.398	2.967	3.375	3.470	0.385	0.363	0.193	0.273
F	0.064	0.294	0.024	1.191	0.386	0.343	0.005	0.163
	[0.801]	[0.590]	[0.877]	[0.281]	[0.537]	[0.561]	[0.942]	[0.688]
Lag	0	1	0	1	1	1	1	1
BIC	-206.3	-197.4	-206.2	-198.3	-216.8	-216.7	-216.4	-216.6
LB(4)	1.70	1.42	1.73	1.45	4.59	4.57	4.67	4.90
	[0.790]	[0.840]	[0.785]	[0.832]	[0.331]	[0.334]	[0.323]	[0.298]
Parameters/ Statistics	Spain				United Kingdom			
	TAR τ=0	MTAR τ=0	TAR τ=0.031	MTAR τ=0.041	TAR τ=0	MTAR τ=0	TAR τ=0.020	MTAR τ= -0.008
ρ_1	-0.240	-0.108	-0.231	0.042	-0.158	-0.049	-0.147	-0.062
	(-1.757)*	(-0.874)	(-1.669)	(0.235)	(-1.78)*	(-0.419)	(-1.69)*	(-0.678)
ρ_2	-0.100	-0.220	-0.109	-0.223	-0.046	-0.127	-0.060	-0.148
	(-0.847)	(-1.657)	(-0.933)	(-2.17)**	(-0.50)	(-1.76)*	(-0.666)	(-1.694)*
Φμ	1.823	1.701	1.743	2.409	1.696	1.453	1.530	1.672
F	0.632	0.403	0.481	1.732	0.780	0.320	0.465	0.466
	[0.431]	[0.529]	[0.491]	[0.195]	[0.382]	[0.574]	[0.499]	[0.498]
Lag	1	1	1	1	2	2	2	1
BIC	-137.0	-136.7	-136.8	-138.1	-230.5	-230	-230.1	-231.8
LB(4)	2.32	2.16	2.25	1.71	1.91	2.09	2.03	5.01
	[0.677]	[0.706]	[0.690]	[0.790]	[0.753]	[0.719]	[0.730]	[0.286]

Note: (***), (**), (*) indicate significance at 1%, 5% and 10%. Critical values for Φμ statistics from Enders and Siklos (2001) work. t-statistics for ρ terms in parentheses. In brackets are p-values for F-statistics and Ljung-Box statistics (LB(4)). The lag length is selected such that the BIC is minimized.

Source: own calculation.

In case of Finland the TAR model with the 0 threshold value best describes the dynamism of long-term equation residuals which is confirmed by the lowest value of the BIC criterion, negative and statistically significant evaluations of ρ_1 i ρ_2 parameters, the fulfilment of the necessary and sufficient conditions for EKC residuals stationarity. Moreover, $|\rho_1|$ is lower than $|\rho_2|$ what may suggest that CO_2 emissions are adjusted to the EKC level slower (at the rate of 22.3%) in the case when CO_2 emissions exceed the equilibrium level than when CO_2 emissions fall below the equilibrium level (the rate of adjustment equals 27.1%). Also in case of the rest of EU countries the TAR model with 0 threshold value proved to be the best one. However, the results presented in Table 6 show that the occurrence of the threshold cointegration with asymmetric adjustment to the long-run equilibrium cannot be confirmed in case of any country (at the significance level of 10% there were no reasons to reject any of the null hypotheses: (H_0:ρ_1=ρ_2=0) and (H_0:ρ_1=ρ_2).

The next step of the analysis is connected with the examination of the modified EKC specification which concerns the inclusion of the additional variables in order to investigate the complex nature of the relationship between environmental degradation and economic growth. In this work two additional variables are proposed, namely time trend and energy consumption what enable to verify the impact of technological changes and changes in energy consumption on CO_2 emissions. In the first specification (I) only time trend is added (2), in the second specification (II) only energy consumption is included (3) and in the third specification (III) simultaneously time trend and energy consumption are involved (4). Parameter estimates for each of the three modified EKC models are shown in Table 7.

Table 7: Estimated parameters for the modified EKC models

Country	α_0 (t-Stud)	α_1 (t-Stud)	α_2 (t-Stud)	γ (t-Stud)	β (t-Stud)	ADF (residuals)
Finland I	-78.0 (-17.79)***	15.0 (16.34)***	-0.72 (-14.7)***	-	0.005 (1.84)*	-2.524**
Finland II	-9.69 (-2.104)**	1.01 (1.082)	-0.043 (-0.962)	0.71 (15.1)***	-	-1.393
Finland III	-11.23 (1.316)	1.355 (1.316)	-0.062 (-1.222)	0.07 (14.4)***	0.0009 (0.809)	-1.434
France I	7.791 (0.457)	-3.292 (-0.909)	0.259 (1.346)	-	-0.022 (-3.851)***	-2.466**
France II	76.121 (6.944)***	-16.203 (-7.355)***	0.776 (7.445)***	1.418 (12.519)***	-	-3.280***
France III	86.989 (7.587)***	-18.675 (-7.924)***	0.922 (7.835)***	1.309 (11.114)***	-0.007 (-2.335)**	-3.189***
Spain I	21.606 (2.062)**	-5.539 (-2.387)**	0.343 (2.648)**	-	0.003 (0.554)	-1.672*
Spain II	62.303 (9.112)***	-13.549 (-9.834)***	0.688 (10.422)***	0.795 (8.170)***	-	-5.280***
Spain III	69.895 (7.873)***	-15.286 (-8.074)***	0.786 (7.973)***	0.829 (8.296)***	-0.005 (-1.326)	-5.600***
United Kingdom I	-59.362 (-7.989)***	10.889 (7.137)***	-0.489 (-6.148)***	-	-0.008 (-1.707)*	-1.96**
United Kingdom II	-1.867 (-0.124)	-0.395 (-0.131)	0.025 (0.174)	0.613 (4.432)***	-	-3.083***
United Kingdom III	-2.310 (-0.155)	-0.512 (-0.171)	0.044 (0.307)	0.587 (4.239)***	-0.006 (-1.382)	-3.033***

Source: own calculation.

For each country the author chose the of additional explanatory variables in the EKC model on the basis of the BIC criterion, significance parameters estimates and stationarity of residuals from the long-term equation. One can notice that considering technological progress or energy consumption in the EKC model has influenced the stability of the long-term equilibrium between CO_2 emission and economic growth (see ADF test results in Table 5 and 7). Energy consumption, as it had been expected, in case of each analyzed country turned out to be a significant factor determining CO_2 emission size. The last stage of the analysis consists in verifying the occurrence of the effect of the threshold cointegration with asymmetric adjustment to the long-run equilibrium, which is described by the best out of three specifications of the EKC model (see Table 8).

Table 8: Results of threshold cointegration test – the modified EKC approach

Parameters/ Statistics	Finland I				France II			
	TAR τ=0	MTAR τ=0	TAR τ=0.010	MTAR τ= -0.003	TAR τ=0	MTAR τ=0	TAR τ= -0.021	MTAR τ= 0.009
ρ_1	-0.242 (-1.77)*	-0.268 (-1.82)*	-0.219 (-1.59)	-0.229 (-1.68)*	-0.283 (-2.34)**	-0.274 (-2.57)**	-0.322 (-2.85)***	-0.242 (-1.93)*
ρ_2	-0.317 (-2.11)**	-0.300 (-1.86)*	-0.345 (-2.31)**	-0.377 (-2.12)**	-0.232 (-2.37)**	-0.229 (-2.06)**	-0.196 (-1.93)*	-0.258 (-2.63)**
Φμ	3.786	3.131	3.933	3.385	5.330*	5.317	5.699*	5.270
F	0.134 [0.716]	0.023 [0.880]	0.388 [0.536]	0.469 [0.497]	0.109 [0.743]	0.087 [0.769]	0.709 [0.404]	0.010 [0.920]
Lag	0	1	0	1	1	1	1	1
BIC	-203.6	-194.3	-203.7	-194.7	-260.8	-260.76	-261.4	-260.7
LB(4)	1.33 [0.856]	1.46 [0.834]	1.39 [0.847]	1.49 [0.830]	6.92 [0.154]	7.89 [0.096]	6.89 [0.167]	8.13 [0.087]
Parameters/ Statistics	Spain II				United Kingdom II			
	TAR τ=0	MTAR τ=0	TAR τ= -0.055	MTAR τ=0.008	TAR τ=0	MTAR τ=0	TAR τ=0.007	MTAR τ=0.009
ρ_1	-0.940 (-5.06)***	-0.925 (-4.76)***	-0.831 (-4.62)***	-0.958 (-4.20)***	-0.267 (-2.75)***	-0.243 (-2.49)**	-0.257 (-2.64)**	-0.036 (-0.26)
ρ_2	-0.565 (-3.19)***	-0.606 (-3.54)***	-0.635 (-3.27)***	-0.656 (-4.17)***	-0.126 (-1.63)	-0.154 (-2.25)**	-0.133 (-1.72)*	-0.203 (-3.30)***
Φμ	15.676***	15.098***	14.15***	14.788***	5.381*	5.024	5.218*	5.448
F	2.555 [0.117]	1.830 [0.183]	0.640 [0.183]	1.441 [0.236]	1.214 [0.276]	0.621 [0.435]	0.942 [0.337]	1.326 [0.255]
Lag	1	1	1	1	1	1	1	1
BIC	-148.6	-147.8	-146.6	-147.4	-257.9	-257.6	-258.3	-258.2
LB(4)	3.61 [0.462]	1.88 [0.757]	3.49 [0.480]	3.25 [0.516]	4.68 [0.322]	6.21 [0.184]	4.77 [0.312]	4.60 [0.331]

Source: own calculation.

As it can be observed while analyzing the results in Table 8 considering technological progress in case of Finland and energy consumption for the rest of the countries improved the significance of ρ_1 i ρ_2 parameters estimation in the threshold models TAR and MTAR and influenced the change of decision in the test verifying the occurrence of threshold cointegration (values of Φμ statistics**)**.

It is worth noting that the short-run adjustments towards the EKC equilibrium revert more quickly when the CO_2 emissions from transport activity are below the threshold value (τ=0 or τ=0.01 for TAR specification as the better than MTAR) and tend to persist more when the CO_2 emissions are above the threshold. It means that CO_2 emissions from transport sector in Finland converge to their long-run equilibrium at the rate of 31.7% with a deviation below the threshold and at a lower rate of 24.2% with a deviation above the threshold. The opposite situation one may observe in the case of France (TAR with τ= -0.021), Spain (TAR with τ=0) and the United Kingdom (TAR with τ=0.007), where the more permanent regime relates to the CO_2 emissions from transport activity below the threshold value. The rate of CO_2 emissions convergence to the EKC equilibrium, when they are above this level, is about 94% for Spain, 32.2% for France and 25.7% for the United Kingdom. Moreover, the results showed that the inclusion of energy consumption into the EKC model caused the changes in the threshold cointegration test results. At the 0.1 (France, the United Kingdom) and at the 0.01 (Spain) significance level the null hypothesis of no threshold cointegration (H_0:ρ_1=ρ_2=0) is rejected (see Table 8). However, there is no reason to reject the null hypothesis about the symmetric adjustment (H_0:ρ_1=ρ_2) to the long-run equilibrium level for each analyzed country.

5 CONCLUSION

The paper presents mutual conditionings occurring among the demand for transport services, economic growth, energy consumption in the transport sector and CO_2 emission. The author also indicates instruments of climate policy of the European Union which may contribute to limiting to some extent CO_2 emission in the transport sector. In accordance with the environmental Kuznets curve hypothesis after a certain level of economic growth is achieved a decoupling between CO_2 emissions and GDP can be observed, which means that CO_2 emission growth is slower than economic growth. The EKC hypothesis was verified for the transport sector in four selected countries of the EU of different level of economic growth using the Enders and Sikols methodology. The results of the initial research presented in this paper suggest the necessity to extend the traditional EKC model with a set of additional variables (energy consumption in transport, technological progress) explaining the relationship between CO_2 emission in the transport sector and economic growth. It is also worth stressing that analyzing and describing the complex nature of this relationship by means of non-linear econometric models will provide vital information with regard to selecting proper instruments of climate policy, individually adjusted for each of the countries, limiting the emission of pollution in the transport sector.

REFERENCES

[1] Abdallah, K.E., Belloumi, M., & Wolf, D.D. (2013). Indicators for sustainable energy development: A multivariate cointegration and causality analysis from Tunisian road transport sector. Renewable and Sustainable Energy Reviews, 25, 34-43.

[2] Ang, J. (2009). CO2 emissions, research and technology transfer in China. Ecological Economics, 68 (10), 2658–2665.

[3] Chan, K.S. (1993). Consistency and limiting distribution of the least squares estimator of a threshold autoregressive model. The Annals of Statistics, 21 (1), 520-533.

[4] Enders, W., & Siklos, P.L. (2001). Cointegration and threshold adjustment. Journal of Business and Economic Statistics, 19 (2), 166–176.

[5] Engle, F. R., & Granger, C. W. J. (1987). Co-integration and Error Correction: Representation, Estimation, and Testing. Econometrica, 55 (2), 251–276.

[6] Farhani, S., Shahbaz, M., & Arouri, M. (2013). Panel analysis of CO2 emissions, GDP, energy consumption, trade openness and urbanization for MENA countries. MPRA Paper No. 49258, http://mpra.ub.uni-muenchen.de/49258/1/MPRA_paper_49258.pdf (accessed 12.11.2014).

[7] Fosten, J., Morley, B., & Taylor, T. (2012). Dynamic Misspecification in the Environmental Kuznets Curve: Evidence from CO2 and SO2 Emissions in the United Kingdom. Ecological Economics, 76, 25–33.

[8] Grossman, G., & Krueger, A. (1995). Economic environment and the economic growth. Quarterly Journal of Economics, 110 (2), 353–377.

[9] Halicioglu, F. (2009). An econometric study of CO2 emissions, energy consumption, income and foreign trade in Turkey. Energy Policy, 37(3), 1156-1164.

[10] Klooster, J.,& Kampmann, B.(2006). Dealing with transport emissions. An emission trading system for the transport sector, a viable solution. Swedish Environment Protection Agency. www.naturvardsverket.se/Nerladdningssida/?fileType=pdf&downloadUrl=/Documents/publikationer/620-5550-X.pdf (accessed 10.01.2015).

[11] Mesjasz – Lech, A. (2012). Efektywność ekonomiczna i sprawność ekologiczna logistyki zwrotnej (Economic effectiveness and ecological efficiency of reverse logistics). Częstochowa: Wydawnictwo Politechniki Częstochowskiej.

[12] Mraihi, R.(2012).Transport intensity and energy efficiency: Analysis of policy implications of coupling and decoupling. In M. Eissa (Ed.), Energy Efficiency – The Innovative Ways for Smart Energy, the Future Towards Modern Utilities. INTECH. http://www.intechopen.com/books/energy-efficiency-the-innovative-ways-for-smart-energy-the-future-towards-modern-utilities (accessed 18.01.2015).

[13] Neider, J. (2008). Transport międzynarodowy (International transport). Warszawa: PWE.

[14] Rydzykowski, W., & Wojewódzka-Król, K. (2009). Transport. Problemy transportu w rozszerzonej Unii Europejskiej (Transport. Problems of transport in the enlarged European Union). Warszawa: PWN.

[15] Saboori, B., Sapri, M., & Baba, M. (2014). Economic growth, energy consumption and CO2 emissions in OECD (Organization for Economic Co-operation and Development)'s transport sector: A fully modified bi-directional relationship approach. Energy, 66, 150-161.

[16] Sanderski, A. (2008). Parlament Europejski zatwierdził pakiet klimatyczny (European Parliament accepted the climate package). www.ure.gov.pl/pl/urzad/wspolpraca-miedzynarod/2829,dok.html (accessed 12.01.2015).

[17] Skowron-Grabowska, B. (2014). Problems of Managing Transportation Systems in Urban Areas. Logistyka, 5, 25-27.

[18] Stern, D.I. (2004).The rise and fall of the environmental Kuznets curve. World Development, 32 (8), 1419–1438.

[19] Strategia na rzecz zmniejszenia zapotrzebowania pojazdów ciężarowych na paliwo oraz redukcji emisji CO2 (Strategy for decreasing the demand of heavy goods vehicles for fuel and CO2 emission reduction). The Commission Communicate to the European Council and Parliament, COM, Brussels 21.05.2014. www.ec.europa.eu/transparency/regdoc/rep/1/2014/PL/1-2014-285-PL-F1-1.Pdf (accessed 12.01.2015).

[20] Strategia rozwoju transportu do 2020 roku (Strategy of transport development until 2020). Ministerstwo Transportu, Budownictwa i Gospodarki Morskiej, Warszawa 22.01.2013. www.mir.gov.pl/Transport/Zrownowazony_transport/SRT/Documents/Strategia_Rozwoju_Transportu_do_2020_roku.pdf (accessed 12.01.2015).

[21] Witkowski, J. (2004). Polityka logistyczna nowym rodzajem polityki państwa (Logistic Policy as a New Type of Government's Economic Policy). In M. Sołtysik (Ed.), Kierunki rozwoju logistyki w Polsce w świetle tendencji światowych (Trends of Logistics in Poland against the Global Background). Katowice: Wydawnictwo Akademii Ekonomicznej.

[22] Yau, H-Y., & Nieh C-C. (2009). Testing for cointegration with threshold effect between stock prices and exchange rates in Japan and Taiwan. Japan and World Economy, 21, 292-300.

[23] Zivot, E., & Andrews, D.W.K. (1992). Further evidence on the great crash, the oil-price shock and the unit-root hypothesis. Journal of Business & Economic Statistics, 10 (3), 251–270.

MODEL OF APPLICATION OF UNMANNED AERIAL VEHICLES IN SLOVENIA

Aleš Zupančič, B.Sc.
Beli Grič 25, 8230 Mokronog, Slovenia
alesh78@gmail.com

ABSTRACT

Until recently, we imagined unmanned aerial vehicles (UAV) as destructive military flying machines. Although the idea to build UAV is over 100 years old, the development and deployment of UAV is a new chapter in the history of aviation. Using UAV for military purposes is very diverse and massive today and has recently increased significantly, but the civilian use has not received these trends so far. By increasing the supply and affordability of high-tech components for the manufacture of UAV, they are emerging as low-cost flying toys, such as robotic devices working in different industries. They can be found in energetics, agriculture, geodesy, meteorology, commerce, delivery, police, for media and entertainment purposes, etc.

The paper is based on the idea of optimizing the use of UAV in Slovenia. Before the widespread use of different types of UAV in all areas occurs, it is necessary to establish standards, with the adoption of which we will achieve optimal, secure, and affordable way to use these modern devices. If we want to set the standard, we need to have a vision for what the system is designed, so this paper is about the optimal use of modular model of UAV in Slovenia. UAV uses airspace, which is very crowded in many places; thus it must meet the prescribed requirements for inclusion in this space. This paper focuses on the use of UAV for the surveillance of ground communication infrastructure, which includes road, railway, energetics, water, gas, public utilities and other infrastructure. We could say that the paper describes the model of area surveillance from the air.

Key words: Unmanned aerial vehicle, UAV, airspace, modular model, surveillance.

1 INTRODUCTION

UAVs may be employed for a wide range of operations: inspecting oil and gas pipelines, checking wind turbines for defects, pinpointing malfunctioning solar panels, incident response, monitoring road conditions, emergency vehicle guidance, tracking vehicle movements, measurement of typical roadway usage, monitoring parking lot utilization, power line inspection. Because movement of UAV is not limited with poor, jammed and damaged roads it can move with higher speed than ground vehicles. That fact is crucial in time sensitive situations where lives depend on minutes. In these times human resources should be managed so that people are not exposed to danger if it is really not necessary. In case of conditions to dangerous to fly with manned aircraft we could use UAV and perform task not only safer but faster and cheaper. In comparison with ground operation UAV is able to review much larger area in same time and automatically forward findings about accidental sites to base stations. The base station can then choose the best way to act and inform service with jurisdiction.

With this model I would like to demonstrate in a small but rugged area similar to the entire state of Slovenia, how to develop a system of use of the UAV in an economical and useful way that exploits the small size of the country.

I decided that in the paper I will use the title UAV, because it is generally more recognizable term, although it would be technically more appropriate to use the term UAS (Unmanned Aerial System) or even legally more appropriate term RPAS (Remotely Piloted Aerial Systems), as applicable in documents of European Commission.

2 UAV IN SLOVENIA

The essence of the idea to set up an UAV system in Slovenia is not, on which flying device these or other type of camera will be attached, but how to utilize the system effectively to be highly exploited, well maintained and always available. Always available does not mean that we will have an UAV airborne and then just wait for the event and redirect it to the scene. No, my idea is to have an established network of UAVs, which would be exhibited throughout the country according to the needs. Each UAV would have an attached camera in the basic configuration, as at the scene, firstly, an image is necessary almost always, with the help of which, the assessment of the situation would be done. This assessment of the situation would happen, by using the UAV, even before the first rescuers arrived on the scene. The assessment of the situation is very important for a general overview of the magnitude of the event itself and the associated trigger of different number of rescue services.

Slovenia has 20,273 km^2 of total area. If our system would use a small UAV with a mission radius of 5-25 miles, and 1-4 hour of endurance, the entire territory of Slovenia would need approximately 200 systems to be covered. As soon as we hear of such number we think that this is not possible, that the number is too high. But if we know that the price of these systems declined significantly in recent years and that we may acquire an appropriate basic system already for a few 1.000 EUR, this would no longer be a large amount, if the country embarked on this project. Given the fact that most communication systems, from highways to power lines, are state-owned enterprises, it is most appropriate that the transition to the new technology, which will yield optimization, greater speed of intervention and simplification, addresses the state itself.

2.1 The current regime in case of event

The regional notification centres (ReCO) operate 24/7 and are usually the first to know about the event. The centres then trigger various emergency services that are needed. The services have different times of export and usually have very limited information about the intervention on which they go. In any event, the fire departments, ambulance and police intervention groups are usually activated. On the spot of the event, a firefighter - the Chief of intervention, is responsible for the entire intervention. He is responsible for coordination of the work of all people, who were called to intervene. Firefighters protect the scene and carry out the necessary intervention, rescuers provide the necessary care, and police officers help deal with traffic and other police tasks, and at the end they make a record. From the moment when an intervention group exports until the moment of arrival at the venue, Chief of intervention can only partly generate a picture of what awaits him at the scene on the basis of information that he received when he was called, and the information provided to him by the ReCO during the drive. This information are very basic and tell him only what sort of an incident it was, how many were injured and where they are located. Often they are also misleading as this information is only an objective assessment of the observer or even of the victims of the event.

2.1.1 Regional notification centre (ReCO)

In Slovenia, there are 13 regional notification centres (ReCo), which are relatively evenly distributed across the country: in Celje, Maribor, Nova Gorica, Novo mesto, Trbovlje, Murska Sobota, Koper, Brežice, Ptuj, Postojna, Slovenj Gradec, Kranj and Ljubljana. Geographical position of 13 ReCo centres in Slovenia is presented in figure 1 below.

Figure 1: Geographical position of RECO in Slovenia

Source: http://www.sos112.si/slo/page.php?src=ks12.htm

The functions of the ReCO are determined by the laws and regulations and are stated at official sites of Administration for Civil Protection and Disaster Relief (www.sos112.si) briefly as follows:

- the provision of dispatch services for fire departments, emergency medical care, mountain, cave, underwater and other emergency service (police forces do not belong into this group);
- collecting and processing data on interventions, accidents and emergencies;
- submitting the required information to emergency services, government authorities, local communities, media, etc.;
- proclaiming the dangers;
- implementation of public;
- forwarding instructions to residents to deal with the dangers and disasters;
- providing logistical support to emergency services on the field.

2.1.2 Slovenian Fire Service

Slovenian fire service is voluntary; only in major cities professional fire departments are set up. Today, more than 120 Fire unions are joined in Firefighters Association of Slovenia, which unites 1,348 volunteer fire brigades, where more than 151,156 members work, of which 23 percent are young members and 30 percent are female members. 45,227 operational firefighters are trained and deployed in operational fire departments that provide high operational readiness for protection and rescue in the event of fire and natural or other disasters.

2.1.3 Fire fee

Fire fee will be levied on insurance premiums by the policyholder, which is prayed by the insurer under an insurance contract, to hedge the risk of fire (fire premium). Taxpayers who pay fire fee are all insurance companies and agents or brokers of foreign insurance companies engaged in insurance business in the territory of the Republic of Slovenia. Fire Fund Assets are divided in such way that at least 70% of monthly collected funds is to carry out the tasks of fire protection in local communities. Assets for fire fee are intended solely for the co-financing of the purchase of fire trucks and fire protection and rescue equipment in fire fighting units.

With the resources of fire fee manages the municipality, which we have 212 in Slovenia. Each municipality has at least one central fire brigade.

2.2 Short UAV overview

“UAVs are semi-autonomous or fully autonomous aircrafts that can carry cameras, sensors, communication equipment or other payloads. UAVs are classified as either rotary-wing or fixed-wing. Fixed-wing vehicles are simple to control, have better endurance, and are well suited for wide-area surveillance and tracking applications. Fixed-wing vehicles have another advantage – they can sense image at long distances. The disadvantage though is that it takes sufficient time to react, as turning a fixed-wing vehicle takes time and space until the vehicle regains its course. The rotary-wing vehicles are also known as Vertical Takeoff and Landing (VTOL) vehicles. They have the advantage of minimum launching time, as well as they don’t need a lot of space for landing. They have high manoeuvrability and hovering. The drawback of such type of vehicles is that the rotary motion leads to vibration.” (Puri, 2005, p. 3)

UAVs have different payload weight carrying capability, their accommodation (volume, environment), their mission profile (altitude, range, duration), and their command, control and data acquisition capabilities vary significantly. A summary of the UAV capabilities and characteristics are presented in Table 1 below.

Table 1: UAV classification

UAV description	Weight (kilogram)	Overall size (feet)	Mission altitude (Feet above the Surface)	Speed (Miles per Hour)	Mission Radius (Miles)	Mission endurance (Hours)
NANO	<0,5	<1	<400	<25	<1	<1
MICRO	0,5-2	<3	<3.000	10-25	1 to 5	1
SMALL	2-25	<10	<10.000	50-75	5 to 25	1 to 4
ULTRALIGHT AIRCRAFT*	25-120	<30	<15.000	75-150	25 to 75	4 to 6
LIGHT SPORT AIRCRAFT*	120-600	<45	<18.000	75-150	50 to 100	6 to 12
SMALL AIRCRAFT*	600-5700	<60	<25.000	100-200	100 to 200	24 to 36
MEDIUM AIRCRAFT*	5700-18600	TBD	<100.000	TBD	TBD	TBD
***Federal Aviation Administration: Defined Manned Aircraft Weight Categories**						

Source: http://uavss.org/UAVSS/UAS_Vehicles.htmv

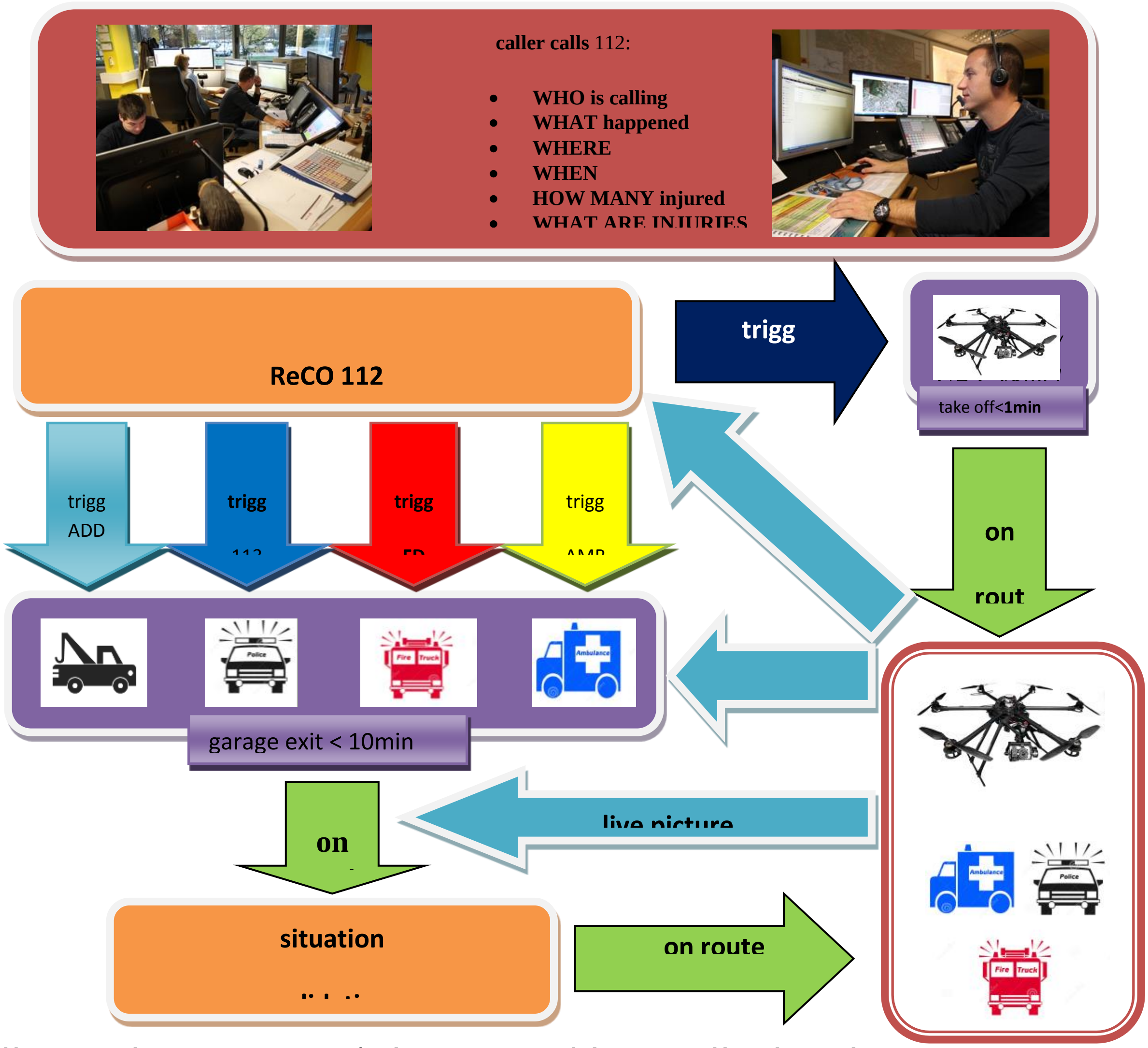
To mark unit of measurement I used knots, nautical miles and feet. These units are used in marine and aviation throughout the world as the use of these units of measurement is crucial for the safety and unity in the maritime and air traffic.

2.3 Future

Simultaneous activation of UAV and emergency services would mean that intervention teams on the ground would have an accessible live picture from the actual venue already during the ride. In addition, a picture would be sent, not only to intervention group, but also to ReCO, where the operator, based on live picture, acquired information and experience, could trigger additional units or even recall those already sent.

2.3.1 Triggering system

Take off or triggering system could be carried out from the ReCO, which have initial information about events, accidents. When an operator at ReCO according to the prescribed procedures estimates that more information is needed about the event and triggers UAV, he should enter the coordinates of the event so the system knows where to fly. Micro-location at the scene would be corrected by the operator at ReCO or it could be taken over by the operator firefighter, who would come to that venue. From figure 2 below is apparently that in case of triggering UAV at the same time as emergency services UAV would come to the scene few minutes before emergency vehicles and provide live picture to all for better awareness.



Abbreviation explanation: trigg-trigger; FD-fire department; AMB-ambulance; ADD-additional; 113-Police

Figure 2: Information flow

Source: pictures from www.sos112.si and www.rcgroups.com/forums

2.3.2 E-call

From this year on in Europe in case of a crash, an eCall-equipped car will automatically call the nearest emergency centre. "Even if no passenger is able to speak, e.g. due to injuries, a 'Minimum Set of Data' is sent, which includes the exact location of the crash site. Shortly after the accident, emergency services therefore know that there has been an accident, and where exactly it took place." (Digital Agenda, 2015). In the future UAV could acquire the position directly from eCall application, and the ReCO operator would not have to insert it manually. The same principle would also be appropriate with development of android applications for all other types of emergencies.

2.3.3 Users

The first users would definitely be firefighters, as they are almost always the first on the spot of intervention and most in need for the first information they could get from the system.

Depending on the priority list, which would have been made already in the software structure of the system, users would be able to change it already on site as needed.

2.3.4 System home base

For easy system introduction the fire stations are ideal. If we have 1348 fire brigades in Slovenia, a little more than 6 per municipality, surely in each municipality they would find at least one fire station where they could keep an UAV. It should be an ensured shelter with electricity supply. The most ideal would be towers of stations, which have already lost their former function of drying tubes, and many are thus unexploited. This way, a relatively high security storage system would be ensured in times of readiness and also the safety of persons during takeoff.

2.3.5 System Purchase

The first purchases of UAV could be carried out from the funds that accumulate in the municipalities for the fire fee. If the majority of municipalities would purchase 1 UAV, some minor would be without them and some of the larger municipalities with more than one device, we would come closer to the optimal number of UAV spatial coverage of the whole territory of the country. The country should ensure the establishment of network for connections between ground control station (GCS) and UAV.

2.3.6 Legal issues

Because of the most straightforward legal regime the UAV would be classified as a special fire means. The application could have been in the fire system that is already in place, which would be simply upgraded and it would not be necessary to set up a parallel system or even several smaller systems by individual departments.

The ideal would be to find a way by which all municipalities would choose the same type of UAV, which would be particularly important for reducing the cost of acquisition, long-term maintenance and ease of user training.

3 TECHNOLOGICAL STRUCTURE OF THE SYSTEM

Model of application of UAV in Slovenia aims to integrate already functioning systems of protection and rescue in Slovenia with the new technology, which makes big steps of progress in recent years. Some quite innovative and some already outdated systems are on the market, even though they were actually developed recently. I think that a system of using UAV should be set so that it could follow the development and new opportunities which could be developed over time. I realize that we cannot predict today how quickly or in what direction the use of UAV will be evolved and what the trends will be which is why I made the model of the modular use of UAV in Slovenia. Modular in the sense that each UAV consists of a platform and the payload. The platform is a flying carrier part of the system to which the payload is attached.

Skrzypietz (2012) established that UAV system basically consists of three parts:

- ground control station (GCS) for controlling UAV and payloads,
- UAV,
- connection between GCS and UAV.

3.1 GCS

GCSs should be able to control multiple types of UAVs and not be blocked by walls made by manufacturer. It should be accepted as a common, open GCS architecture supporting every UAV engaged in the system. A user friendly system should be accepted, which is enabling the support of Slovenian system demands.

3.2 UAV

In the basic configuration each UAV in readiness would be fitted with camera and communication equipment to broadcast live images from the venue. Basic equipment would vary depending on the practical experience of users at the interventions.

3.3 Platform

Due to good match with terms and conditions to build up a system in Slovenia, I suggest to use a small UAV for a platform. Boer and Buuren (2011) described a good practice from the Dutch police forces, where they use several small UAVs within the Program against Organized Crime and Cannabis Cultivation, which shows some UAV they were experimenting with for the fight against narcotics. The UAV used and the main specifications are presented in table below.

Table 2: UAV used by the Dutch Police Forces

UAV used by the Dutch Police Forces	**Delft Dynamics RH2a**	**AscTec Falcon 8**	**AirRobot AR-100**	**CannaChopper Suave 7**	**AeroVironment Raven B**
Dimensions:					
Rotor	Ø 180 cm	8 rotors	4 rotors	Ø 182 cm	
Overall span		77 cm	100cm		137 cm
All-up Mass	17.0 kg	1.8 kg	1.0 kg	15 kg	1.9 kg
Payload	2.5 kg	0.5 kg	0.2 kg	6 kg	0.2 kg
Engine	combustion	electrical	electrical	combustion	electrical
Endurance	60 minutes	15 minutes	15 minutes	120 minutes	90 minutes
Max. windspeed	10 m/s	8 m/s	4 m/s	10 m/s	10 m/s (5 bft)
Payload sensor	EO/IR	EO/IR	EO	EO/IR/sniffer	EO/IR

Source: Small UAS for Law Enforcement; The use of UAS within the Dutch Police forces; Jan-Floris Boer; National Aerospace Laboratory NLR; Gerard ten Buuren; Netherlands Police Agency KLPD

The selection of the entire UAV system, that could be used, should be done with thoughtful international Competition in order to get as favourable as possible provider that would meet the set requirements. Competition conditions should follow closely the usefulness and longevity.

3.4 Payloads

Various payloads could get to the scene with the intervention vehicles and would be mounted on the platform at the scene, according to the requirements of the situation and the decision of the Chief of interventions. Payloads could support a whole range of different tasks, fire, rescue, police and others.

“The range of surveillance technologies with which the UAV can be equipped is extensive. The capacity for UAVs to be outfitted with a range of additional visualization and sensor technologies make them flexible in terms of large scale of tasks they can perform and also specific in terms of the purpose of their deployment. The possibilities for data collection by UAVs are very extensive because also the range of advanced technologies that can be mounted on UAVs is very diverse:

- high power zoom lenses: collect real-time video and image capture from a distance that is imperceptible to the object or target under surveillance;
- night vision, infrared, ultraviolet, FLIR (Forward Looking Infrared Radar), LIDAR (Light Detection and Ranging): enable UAVs to detect and enhance detail, in particular, information such as heat emanations that is being created from inside a building, but can be detected on an external surface of a building;
- Radar technologies: penetrate surfaces such as buildings, walls, obstructions caused by poor weather conditions, and foliage, as a means to detect and track individuals or other processes;
- Video analytics technology: accompany UAV data collection to aggregate and define normal patterns in urban or other environments as a way to algorithmically flag any deviation from normal processes in these spaces;
- Distributed networked surveillance: UAV technologies are integrated with other video surveillance networks, or digital technologies such as smart-phones, or databases as a means to facilitate intelligence analysis through expanded surveillance operations;
- Facial recognition or other »soft biometric recognition«: based on algorithmic calculations, allows the UAV to detect and identify biographical attributes such as height, age, gender and skin colour;
- WiFi information communication technologies: UAVs relay information communication signals;
- Automated – license plate recognition (ALPR) where UAVs utilize optical character recognition on images to read vehicle license plates;
- Modular cyber attack hardware and software which allows the UAV to operate as an airborne laptop to intercept and/or corrupt wireless network communications.“ (Bracken – Roche and oth., 2014, pp. 18,19).

In the set of payloads we could have even such equipment that supports purely commercial tasks. These are for example various energy audits of buildings or power lines, photography or survey terrain etc. for contractors as they would not have to buy their own platforms and have expenses associated with ownership, but would hire a platform. This way the funding of fire services could also be solved partially.

3.5 Connection between GCS and UAV

To create appropriate connections between the GCS and UAV, it would be necessary to establish a stand-alone system, which would not be dependent of established commercial systems, because it is important that the system is designed for operation in extreme operating conditions. For technical establishment of the system a geographic spread of fire departments is very suitable, which can be used for the installation of navigation and communication system. Connections should provide:

- Reliability and durability;

- Hierarchy management should include ReCo. Due to flight safety ReCo should have the opportunity to survey and limit the zone of flight of the UAV;
- Connectivity in the ATC system. The system must be developed in parallel with the development and changes in the flight control systems.

4 CONCLUSION

This paper is a proposal of a model of application of the UAV in Slovenia. The model tries to comprehend the existing working system of protection and rescue in Slovenia with the technology which is coming to our lives with great speed and low altitude. It means that in developing system we will have to be fast and careful at the same time.

An UAV has a rapid launch as compared to a manned aircraft, while it has better manoeuvrability as compared to ground vehicles. UAVs can be triggered and controlled remotely from great distance even without human assistance and provide live picture from place of the event even before the first intervention group arrives to the location. There are only few reasons why UAVs are so popular lately.

I see mayor advantages of my model, since the organization is already in place and active with enough human resources which only need to be trained and equipped with the appropriate UAV system.

In the area of application of UAVs there are some great ideas and also sophisticated systems worldwide that are still waiting for the approval of different regulatory agencies for flying the UAVs in open airspace.

Slovenia is a small country, which also means that the system to utilize UAV could be simpler. I believe I have found a way to make use of our resources, and our way of life for an even better user experience and service. If we follow my model, we could build an innovative, cheap, and useful way to use the UAV for the surveillance of various communications from the air.

REFERENCES

[1] Boer J.B., Buuren G.. (2011). Small UAS for Law Enforcement; The use of UAS within the Dutch Police forces.

[2] Bracken-Roche C., Lyon D., Mansour M.J., Molnar A., Saulnier A., Thompson S.. (2014). Surveillance Drones: Privacy Implications of the spread of Unmanned Aerial Vehicles in Canada.

[3] European Commission. Digital Agenda for Europe. (23.2.2015). (http://ec.europa.eu/digital-agenda/en/ecall-time-saved-lives-saved).

[4] Puri A., A Survey of Unmanned Aerial Vehicles (UAV) for Traffic Surveillance. (2005). Department of Computer Science and Engineering, University of South Florida. CiteSeerX – Scientific Literature Digital Library and Search Engine.

[5] Skrzypietz T.. (2012). Unmanned Aircraft Systems for Civilian Missions. BIGS Policy Paper.

[6] http://www.defenseindustrydaily.com/uav-ground-control-solutions-06175

[7] http://www.sos112.si

[8] http://uavss.org/UAVSS/UAS_Vehicles.htmv

SYSTEM FOR GUIDING TO VACANT PARKING PLACES FOR MOTION-DISABLED PERSONS IN LJUBLJANA

Luka Žunec*
luka.zunec@gmail.com

Marko I. Valič
University of Ljubljana
Faculty of Maritime Studies and Transport
Pot pomorščakov 4, SI-6320 Portorož, Slovenija
marko.valic@fpp.uni-lj.si

Andrej Stijepić
JP LPT d.o.o., Kopitarjeva ulica 2, SI-1000 Ljubljana, Slovenija
andrej.stijepic@lpt.si

ABSTRACT

All cities have similar needs about traffic and parking. Accessible parking policies affect all transportation in the city: when parking is crowded, drivers circle the block and double-park, congesting the streets, slowing transit, and decreasing pedestrian safety. When parking is difficult to find, access is reduced, especially for those with disabilities. In the contribution, the present state of stationary traffic management in the municipality of Ljubljana (MOL) is described. Discussed are solutions already in use or in their planning phase. Presented are selected ITS systems and services for guiding to vacant parking places already implemented in some cities abroad. The possibilities of implementing a complete parking solution for entire parking system for all space types and a specific system designed for the group of motion-disabled (MD) persons in Ljubljana, are considered. Proposed is an intelligent parking guidance and information (PGI) system for providing information to find a free place to park within city parking facilities. The lack of parking guidance results in increased circling and delays while motorists search for a parking spot. The anticipated prime benefits will be prospered by all stakeholders, above all MD users, which will have at their disposal a direct view on the data for parking space availability in real time. Consequently, cut downs of the travel costs of this PGI application users and a decrease in road traffic loads are expected.

Key words: Stationary traffic, traffic management, PGI system, ITS, motion-disabled persons, parking guidance, parking availability, vacant parking spot.

1 INTRODUCTION

The traffic flows and the motorization on our roads are steadily increasing. Above all, in bigger cities and on the city's main inn-roads, the traffic infrastructure is frequently overcrowded. Heavier traffic flows on the road network are the cause for longer travel times, decreased traffic safety and comfort, increased environments pollution and for ever-increasing difficulties in connection with parking. The key to the stated problems lies in the management and implementation of proper traffic and transportation policy based on an increased use of

* Graduate student of the Faculty of maritime studies and transport

sustainable means of transport. The positive trends of such approach are showing up in all areas of traffic, including that of stationary traffic. Traffic policy of sustainable mobility namely encourages the use of transport means, e.g., public transport, cycling and walking, which are friendlier to the environment. In the past few years, within the boundaries of Ljubljana municipality MOL, just such a traffic policy (⅓ personal car traffic, ⅓ public transport, ⅓ pedestrians and cyclist) for year 2020 is urged [1]. In the field of stationary traffic, apart from an adequate traffic policy covering all areas of a traffic system, it is also necessary to implement ITS systems and services, which provide users with the latest information and directions to free parking places.

The management of stationary traffic in larger cities is becoming increasingly important. The lack of closer link-up between cities urbanism and traffic policy in last decades resulted in to an almost complete predomination of cars. The decisions with the management of stationary traffic (construction of parking places or their abolition, construction of parking garages, etc.) lead to long term consequences which, and how, influence the city development and the quality of life in them. Regulation of stationary traffic is thus linked with city's living place planning and interventions made in it, environment safety and management of public travel transport. In this context, adding to city planning deployment of an intelligent parking and guidance (PGI) system delivering proper information about the occupancy of parking places, above all for MD persons, can much improve the lives to its users.

The aim of this article is to describe the actual state of stationary traffic with the emphases on parking and parking guidance in the municipality of Ljubljana and to advocate some proposals for deployment of PGI systems. For this purpose, it was necessary to stir up for PGI systems to free parking spaces, successfully set up in some cities abroad. The general findings are that deployment of such information systems stimulates a more efficient use of parking lots. Consequently, they reduce the waiting queues at the parking lot entrances and the search time for free parking spaces. In mega-cities, the savings in this time reach up to 40% of the total travel time. Worth noting is also the finding, that the search for a parking lot is not always entailed to insufficient number of parking places, but frequently to the lack of information on whereabouts they are. From this review, possibilities of setting up an integral system and a specific sub-system intended for the group of motion-disabled (MD) persons in Ljubljana, are presented. The needs in terms of the number and space distribution of such parking places are analyzed. The proposals for deployment of both types of systems, delivering information about the occupancy of parking places, are defined in a conceptual form. With deployment of one or the other system type, the users will have a direct view on the occupancy data in real time, thus easing up their search for parking places. This is particularly important for MD persons.

2 GOOD PRACTICE EXAMPLES OF SOLVING PARKING PROBLEMS IN CITIES

The aim to present some existing applications of parking management is to give a brief, transparent survey of available options for the users and planners. The objectives of these options are the same, i.e., shorten travel times, reduce wondering around rides and consequently, unburden the traffic and the environment. These options achieve their goals in different ways by concept and design. There are some similarities and many differences to choose what is best for a particular environment. Important for the planners are the costs and to avoid mistakes and for the user the type of useful information (distance to be walked, type of parking place, state and number of free parking places, price, weather) they can deliver.

If no changes in the area of stationary traffic management are made, then lowering of the quality of life in cities are expected. The solution is the implementation of ITS systems, which employ intelligent, interconnected transport means and use real time up-to-date information. Many transport and traffic experts believe that for traffic congestions, the availability of parking places is not problematic, but the availability of non-payable or too low prices for parking places. Namely, if a driver knows, that there is a possibility of finding non-payable parking, then he will circle around until he finds it. Therefore, it is necessary to enforce an adequate price policy, which will allow to covering the cost and maintenance of the PGI system, to reduce the city traffic and to assure a sufficient number of free parking places.

2.1 Parking guidance and information system

Traffic experts aiming to mitigate the ever-increasing traffic in cities are developing different strategies. The development of systems to guide drivers to free parking spaces and the change of their parking habits are among them. Possible measures are an increase of prices for parking services, higher surveillance effectiveness for illegal parking and increased fines for offence. Gradual restrictions of the personal car use create incentives for more sustainable means of travel, decrease environment pollution and thus leading to an improved quality of living in cities. With the aim to decrease the number of unnecessary cruising for vacant parking spaces, information about their number and locations is mediated to the users. In contrast to conventional traffic boards and signs, such PGI systems feature an important advantage of being dynamic, i.e., they adapt the information according to the instantaneous traffic situation. An intelligent PGI system is of a modular design as shown in Fig. 1, composed functionally of the following components:

- detectors for monitoring vacant parking spaces;
- local control stations for data collecting and communication;
- central traffic management center (TMC) for data processing;
- means of information dissemination to users;
- automatic ramps and parking ticket machines;
- operating software.

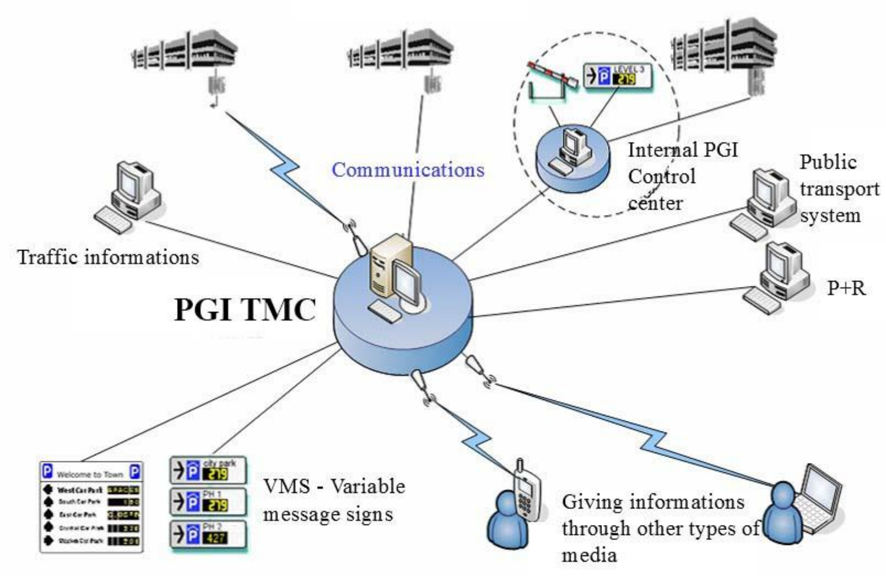


Figure 1: Concept of a PGI system [2]

2.2 Examples of intelligent PGI systems

2.2.1 e-parking

An e-parking system represents an improvement of classic PGI systems. It enables to have a look at information about free parking spaces before the start of a travel already. Additionally, it allows making parking space reservation and adapt parking prices depending on the time of the day or demand. A user can access the database via smart phones or internet. With so-called Bluetooth technology, the system identifies the car at the parking entrance, actuates the automatic parking procedure and executes the payment transaction. Such a demand-responsive system 'SFpark' is used by San Francisco municipal transportation agency [3]. In exploration, among other things, it was established, that, by controlling/adapting the parking prices on demand, the traffic congestions are alleviated. These measures secure sufficient number of free parking capacities on different locations. Of course, the free parking spaces option for MD persons is available through filtering.

2.2.2 'Streetline Smart Parking' system

Parking is one of the great unsolved city problem and it is not getting better any time soon. Many city planners and transport experts agree upon that smart, connected communities (Smart cities) are one way to obtain efficiency gains and to improve the standard of living. In many communities, the energy, transportation and safety systems operate within silos with no connectivity. However, when systems become interconnected in real time, efficiency gains are possible. Many cities are creating a mesh of services related to traffic, employment and police services.

At Streetline company, a leader in smart parking, share that vision beginning with parking [4]. The company is helping to build a 'Smart Parking Ecosystem', that integrates all the key players in the system (city, ministry of transportation, parking revenue management, merchants, police, public and private parking providers, motorists, components providers, system integrators, technology experts), to help managing the true supply and demand of parking. Building and sustaining Smart Cities from the view point of parking, depends on two vital components: 1) the ability to sense vehicle occupancy and driver activities and 2) software that collects this data and reports back to mobile devices and websites so that motorists can more easily find parking and city managers can make quicker, better informed decisions. Streetline's 'Parker' application directs the user to the closest available parking spot. Apart from real-time parking guidance the main features are: voice guidance, filters by preference (EV charging, ADA spaces, payment types accepted), directions back to the car, available for iPhone and selected Android devices.

2.2.3 System 'Smart Parking'

The concept and the model of 'Smart parking' was realized in a pilot project from Boston University with the aim to lay down new guidelines in the field of intelligent solutions of parking in urban environments [5].

Instead of providing the information about free parking places to a user and of leaving the decision up to the driver, the model of smart parking assigns and reserves an optimal parking place, taking into account the requirements defined by the driver in advance. User requirement entered relate to the maximum price, which the user is prepared to pay, and to the maximum distance from final destination. The problem solves a mixed integer linear program

(MILP). The information is given out in intervals in a defined time sequence. The result of each MILP calculation is an optimally located parking space, taking into account the instantaneous information and coincidental events like new demands and new free parking spaces.

The system design is based on the PGI platform with an upgraded TMC center composed of Driver Request Processing Center (DRPC), Smart Parking Allocation Center (SPAC) and Parking Resource Management Center (PRMC) shown schematically in Fig. 2. PRMC center collects and updates all parking information in real time and disseminates them via VMS signs and internet. DRPC center collects all demands for parking places, information in real time (e.g., instantaneous vehicle position) and sends back the allocated parking spaces to the drivers. In consideration of driver's requirements and state of parking resources, the SPAC center makes the allocation decisions, locates and reserves the parking spaces.

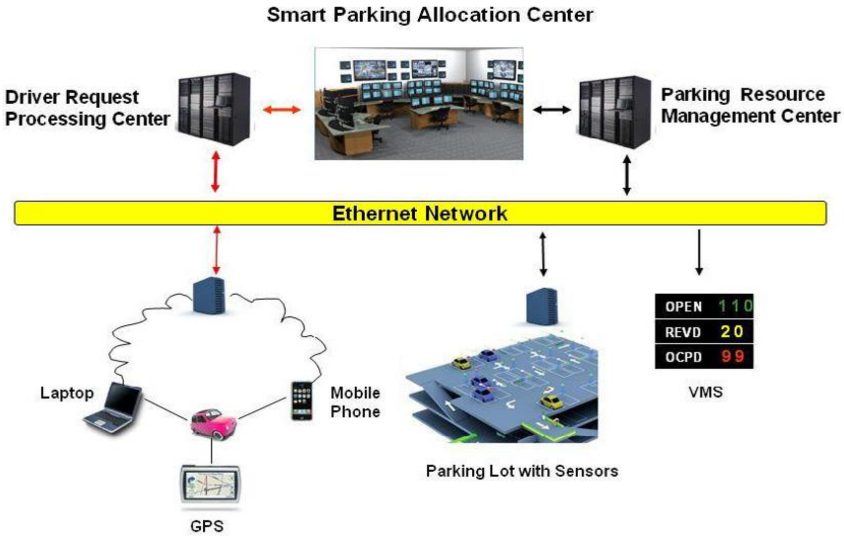


Figure 2: Infrastructure of 'Smart parking' system

Function of the system is shown in Fig. 3. A driver sends a demand via application or internet to DRPC center. With the demand, two requirements are included; upper parking price limit and acceptable most distance location, which the driver must walk from the parked vehicle to his final destination. With a demand, some other general data are included like driving license number, momentary location of driver and car size. SPAC collects all demands in a specified period from DRPC and assigns a location to all users. Information on the assigned parking space is then sent to the drivers via DRPC. If a driver is satisfied with the assigned parking space, he can reserve it. However, he can change the reservation later in the case, that a better parking possibility has been offered. PMRC then refreshes the status of a specified parking space from free to reserve and takes care for a warranty that no one else gets a permission for this parking space. A driver, which for any reason has not reserved to him assigned parking place, must wait until the next decision interval (point). Between these intervals, the drivers without a reserved parking space have the possibility to change their requirements. With this action, the drivers increase their probability to obtain a free parking space in the case, when a parking lot is close to be fully occupied. Of course, a possibility also exists that no parking place is assigned to the driver. Realization of such 'smart parking' model is based on the following key features:

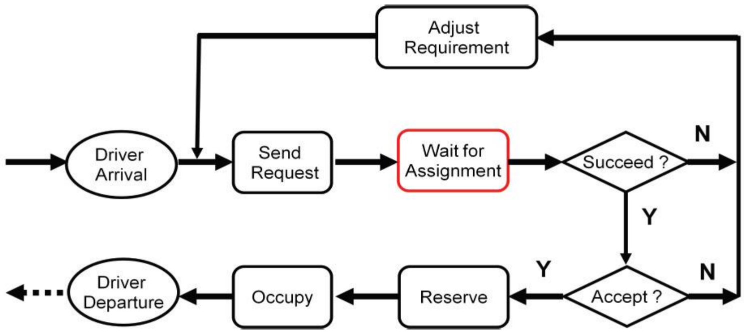


Figure 3: Functional diagram of 'Smart parking' model

- in any instant, the system must know the status of each parking space and position of each vehicles in search for a parking spot;
- an effective wireless communication between vehicles (drivers) and infrastructure must be established;
- the system must have means for reservation guarantee of the parking spots for the users at disposal;
- a very efficient algorithm for allocation of optimal parking spaces is required;
- vehicles equipped with a position modules.

Thus, a successful implementation of the model requires parking detectors for each parking place, means for reservation warranties, equipment for V2I and I2V communication and vehicles equipped with GPS units.

3 OVERVIEW OF PARKING SITUATION IN THE AREA OF MOL LJUBLJANA

Municipality MOL stretches over an area of 274,99 km^2 with population of about 280.000 inhabitants. With its geo-strategic position, Ljubljana represents a cultural, politic and economic center and thus the capital of R Slovenia. Through or by the city run all main traffic roads. At the same time, it is an intersection of road and rail, Trans-European Network (TEN) corridors V and X.

Ljubljana depicts a high degree of centralization and plays a main role in wider urban region. A close functional link-up with neighboring regions is present. The city traffic system is thus more complex and the traffic flows more intensive. For an effective functioning of the city, it is necessary to ensure an efficient use of space and to develop an adequate sustainable traffic policy. Management of the stationary traffic, due to greatly increased motorization, is playing a key role in the determination of effectiveness of traffic policy.

Due to improper orientations in the management of stationary traffic until the end of past decennium in Ljubljana, an almost complete predominance of personal car traffic has occurred in the city. The stationary traffic is most problematic in the city center. However due to ever increasing limitations, the problem is spreading out to neighboring areas, close to the highway- or ring- road intersections and to the areas in which bigger commercial centers erupted. The roads are overburdened, especially during morning and afternoons peak hours, when migrant workers communicate to/from the work. The consequences are felt by traffic congestions, longer travel times, higher environment pollution and a worsened image of the city.

Causally with this, a shortage of parking spaces, originated in the city center and consequently spreading towards the city's outskirts, turned up. Most frequent the drivers are searching for parking places in the areas of Stara Šiška, Bežigrad, Rožna dolina, Mirje, Trnovo, Poljane, Tabor, Vodmat and Zupančičeva jama. Due to shortage of parking places, illegal parking in residence settlements (Savsko naselje, Štepanjsko naselje, Fužine, Jarše) is increasing.

Under the management of LPT there are 23 parking lots with 4825 parking spaces and 37 street type parking locations with 48 parking spaces [6]. Of these 93 are reserved for MD persons. The ratio between payable and non-payable parking lots, with regard to the situation 10 years ago, has changed a lot, especially after the introduction of payable 3 parking zones with zone-1 in the inner part city center. Considering the sustainable traffic policy adopted in Ljubljana [1], in the center and its close neighborhoods, most of the parking places are now payable. This measure positively influenced to a decrease in the use of personal cars. It is an incentive for use of cleaner, environment friendlier means of transport.

In the metropolitan area in which time-limited parking was introduced, 355 parking meters were installed (data from 21/8/2013) and installation of 70 new announced [6]. Payments are possible with cash, or pay cards Urbana or Moneta. In total, there are 2.646 parking places intended for time-limited parking.

In parallel with introduction of time-limited parking zones, a system of one-way street roads was put into effect, with additional on/off the street parking places on some of them. A plan for a gradual change to establish a regime of time-limited parking in the whole area encircled by Ljubljana ring road is planned. It is observed that, by decreasing the number of unpayable parking places, the personal car traffic use towards the center has decreased as expected [6].

Most of the public parking places are equipped with automatic entrance/exit system composed of automatic ramps, cash machines, video cameras for surveillance and communication links with the TMC center. For parking management two software packages, LPT web application ‘Podatkovni model’ [7] and mobile Makro Plus application ‘Parkirišča’ [8] are used. The former is a database for occupancy of parking lots displaying the number of free spaces and an interactive map of parking lots or via mobile phones in the form of wap messages (refreshing time 5 min). Application ‘Parkirišča’ uses ‘Podatkovni model’ as a database. Its main aim is its use with smart phones to show the free parking lots, covering all public parking spaces or those managed by LPT. Apart from its basic function, the information on the occupancy statistic free/occupied of individual parking lots, an overview of seized vehicles, tariffs, working hours and data for contact needs, is available. Two data views forms, table or map, are possible (Fig. 4). As a rule in such applications, user’s interface is offering a simple and fast access to desired information.

Figure 4: Mobile application 'Parkirišča'

Under LPT management are also all street parking spaces. Public parking places under LPT patronage of closed type are equipped with video surveillance, remotely supervised by the MOL's TMC center. Apart from classic parking lots there are, in the area of MOL municipality, 4 parking places of the (P+R) type; Dolgi Most, Ježica, center Stožice and Studenec. There are plans for construction of a network of P+R parking lots in the wider area of Ljubljana consisting of additional 23 parking lots of this type [9].

The situation of stationary traffic management in the MOL area is slowly improving. With adequate managing, considering the principles of adopted sustainable traffic policy [1], the set goals, ⅓ equal distribution among the three traffic categories (personal car, public transport, pedestrians and cyclist) for year 2020 can be reached. With constant inclusions of advanced ITS solutions within the city, Ljubljana can became a modern and people friendlier.

4 INTELLIGENT PGI SYSTEM TO FREE PARKING SPACES IN LJUBLJANA

As revealed, local systems to follow the occupancy state 'full' of individual parking lots in Ljubljana are in use for some time. The information is mediated to the users by simple information panel at the entrance, website or mobile phone. A PGI system in its full operational sense has not been implemented, although it is needed and highly desirable by city planners and users. A conceptual model proposal for an integral intelligent PGI has been made [10]. Summarizing it in rough lines, deployment of such a system is possible by upgrading the presently used parking management. With regard to the existing road infrastructure and communication connections in Ljubljana, the information infrastructure in this model should be of the following three types:

Information on the outside road ring (Ljubljana ring road); Management of ring road does not fall within the competence of city's TMC. Therefore an agreement should be made, e.g., sending the data to the National center for traffic management. The contents and locations of information tables are yet to be defined.

Information on strategically important points; With a detailed analyses of Ljubljana road infrastructure and of traffic flow movements, a defined installation plan for stationary traffic information guiding tables at the intersections of city's arterial roads with two inner rings is to be made. With this, the number of unnecessary rides will decrease and the cars will turn towards the free parking spaces using the shortest road. Due to drivers mistrust in the stationary traffic management systems, the intelligent PGI system installed should be able to show the most exact data. In presenting the information about free parking spaces, considerations of travel times from the information table to the parking place should be accounted for. Based on historic data prognosis for expected free parking places can be made as well. Criteria for defining where to direct the drivers depends primarily 1) on the distance between particular information table and parking lot and 2) on the number of available vacant parking spaces. The aim is to reduce the road loads by directing users to closest parking places.

Information in the immediate neighborhoods of parking places; In the immediate vicinity of parking spaces information tables are in place already, however they show only the status (free/occupied) of parking lots with no information about the number of free parking spots. The local controllers are not connected with TMC center. Communication between the two is presently not possible, but easily realizable because of existing, TMC's own optical network through the city. Handing over exact information about the number of free parking spaces decreases the waiting queues at the parking bay entrance, consequently, leading to higher traffic throughputs. Thus, upgrading the existing information tables with VMS signs and communication links with TMC is essential.

5 CONCEPTUAL MODEL OF AN INTELLIGENT PGI FOR MD PERSONS IN LJUBLJANA

An idea for deployment of an intelligent PGI for the group MD persons has been brought up recently [11]. This presentation is a continuation of the initial work and an attempt to make it public. The aim of such a system is to inform its users about the nearest vacant parking spaces reserved for physically disabled persons. A conceptual scheme for a street parking lot is depicted in Fig. 5.

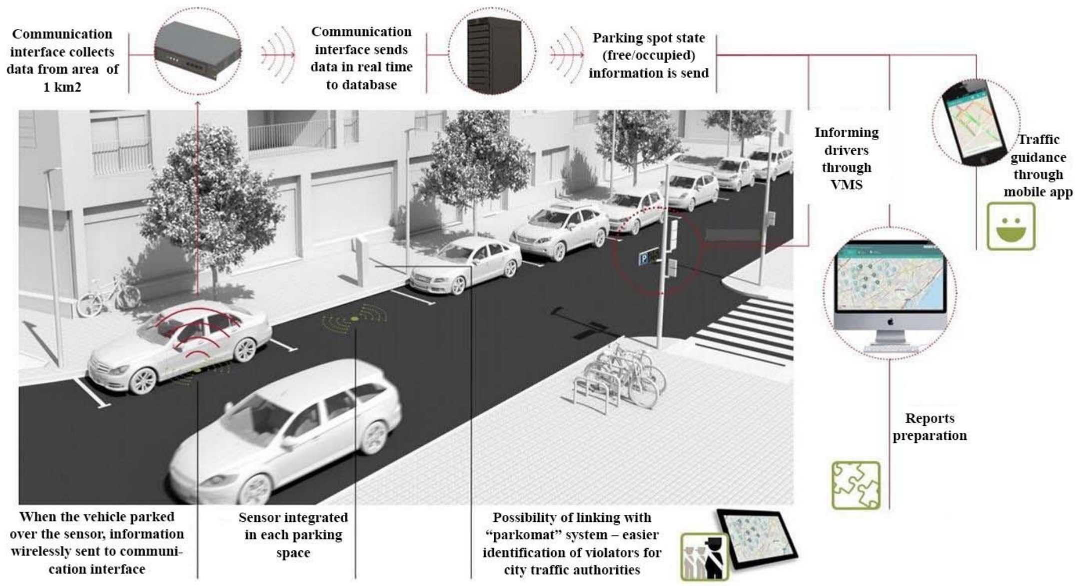


Figure 5: Intelligent PGI system schematically [12]

Frequently encountered difficulties of MD persons are connected with the access (mainly due to inadequate infrastructure), occupancy of spaces reserved for them, and non-optimal allocation of the number of MD parking spaces. Deployment of the system will: alleviate the search for parking spaces, reduce the number of circling rides, improve the exploitation of parking places and make the life of motion-disabled easier. An example of a working system is city of Graz using Worldsensing's smart parking system 'Fastprk' [12]. Fig. 6 presents an electronic street PGI panel and communication interface installed on a public lighting pole. The variable content sign displays the name of the nearest parking lot, the number of available parking places (4) and the number of vacant parking places (0) for MD persons. Drivers benefit from being guided to general and disabled parking spaces, while congestion, and with it, pollution, are reduced.

From the discussions above, an intelligent PGI system aimed to the group of MD persons in Ljubljana, can be set up as:

- an upgrade of the existing parking management system; or
- a sub-system in the framework of a future integral intelligent PGI system.

The number of parking lots under the management of LPT, with parking places reserved for motion-disabled, is 50, each having from 1 to 5 parking spaces reserved for MD persons, totaling to 93 [6]. Since the number of these spaces is only some percent of all, the financial requirements for PGI MD deployment are much lower.

Implementation as an upgrade, by using application 'Podatkovni model', is realizable easier. The model platform remains the same except for the change of the type of data to be collected. Instead of the state of occupancy 'free/occupied' of an individual parking lot, the upgraded system collects the state of each parking spot on an individual parking lot. For system's operation this requires to build-in the vehicle presence detectors to all parking places reserved for motion-disabled and to upgrade local controllers to be able to collect the states 'free/occupied' (0,1) from all presence detectors, by wire or wirelessly. Communication, in

Figure 6: Electronic street PGI panel and communication interface on a public lighting pole [6]

part existing, between these controllers and the main controller in the TMC center, enables real time data transmission. The TMC generates dynamical data in a format acceptable for the application 'Podatkovni model', which is then communicated to VMS signs, the website or to a mobile phone using a mobile application, e.g. a modified application 'Parkirišča'. Later some filters should be added to the application, via which a user could enter his desired criterions for display of parking spaces. Possible filters are parking spaces reserved for MD persons, payable/non-payable parking, parking spaces for motorcycles, and parking spaces with electric power charging station.

Implementation as a sub-system of an integral model of intelligent PGI system is realizable with little costs in a simple way, by filtering out the data for only a sub-group of users. However, the prerequisite is a working integral intelligent PGI system, which is only a wish for the time being. Namely, all parking spaces (some thousands) have to be equipped with vehicle presence detectors and communication links to the local control station and local stations links to TMC center. Further, an adequate information infrastructure has to be developed and installed.

Opinion of the authors is that an integral intelligent PGI system in Ljubljana will be implemented in steps. The neighborhoods covered first will be selected by priority 'most problematic'. In fact, twelve minutes before twelve, the authors were acquainted with a conceptual proposal for a pilot project to equip open street parking spaces to an intelligent PGI level on selected streets in the inner center of Ljubljana [6]. The proposal (initiators Traffic Design and in collaboration with LPT) has been submitted to city's authorities for considerations. The streets planned for deployment are Puharjeva, Prežihova and part of Štefanova. The guidance for their selection was a desire to define a region of streets, with the possibility of choice for an alternative route by users/drivers. It is worth noting that the system will include information for MD persons, a merit of one of the authors.

A further wish for the application is the possibility of user's location via GPS receiver and to write out the nearest vacant parking space, arranged by the present distance of the user.

5 CONCLUSIONS

All cities have similar problems about stationary traffic and parking. Regulation of stationary traffic is linked with city's living place planning. Accessible parking policies affect all transportation in a city. Adding to city's planning deployment of an intelligent PGI system delivering real-time information about the occupancy of parking lots and of individual free parking spots, is beneficial to all stakeholders, above all to those with disabilities. The anticipated prime benefits to all users are direct view of the data for free parking lots and free parking spots availability. Consequently, expected are cut downs of the travel costs and a decrease in road traffic loads.

In the contribution presented is the state of stationary traffic management in MOL municipality. Discussed are solutions already in use or in their planning phase. Selected ITS systems and services for intelligent PGI systems, already implemented in some cities abroad, are described. The deployment possibilities of an integral parking solution for entire parking system for all space types is considered. Conceptual proposal for an intelligent parking guidance and information (PGI) system for providing information to find a place to park within city's parking facilities is described. The lack of parking guidance results in increased re-circulation and delays while motorists search for a parking space. In view of some thousands of parking spots to be equipped with presence sensors and communication links and, considering present financial conditions, the deployment of such a system in Ljubljana will likely be realized gradually. A conceptual model proposal for a specific PGI MD system in Ljubljana is suggested. Since the number of parking spots to be equipped are an order of magnitude smaller than in the case of an integral system, the financial requirement are much reduced. The PGI MD can be set up in an easy way by upgrading the existing parking management system or as a sub-system in the framework of a future integral intelligent PGI system.

REFERENCES

[1] Prometna politika MOL (2011);

[2] Adapted from Žura M. et. all: SITSA-C: Aktualen razvoj inteligentnih transportnih sistemov in storitev (ITS), UL PTI, 2005, p. 104;

[3] Pierce G., Shoup D.: Getting the prices right, Journal American Planning Association (JAPA), vol. 79:1 (2013), p. 67-81;

[4] Streetline: Becoming a smart city, www.streetlinenetwork.com;

[5] Geng Y., Cassandras C.G.: A new ‘Smart Parking’ system infrastructure and implementation, 15-th Meeting of EURO working group on transportation, Procedia-Social and Behavioral Sciences, 54 (2012) 1278-1287;

[6] JP LPT, personal communication;

[7] http://www.lpt.si/parkirisca;

[8] Application ‘Parkirišča’, http://www.makroplus.com;

[9] RRA LUR: Mreža P+R zbirnih središč LUR, vzpostavitveni dokument (2013);

[10] Starčevič B.: Sistem za vodenje mirujočega prometa v mestih, preveritev na primeru Ljubljana, diplomska naloga, UL FGG 2010;

[11] Žunec, L.: Vodenje do prostih parkirnih mest za gibalno ovirane osebe, diplomski projekt, UL FPP 2013;

[12] http://www.worldsensing.com

SPONSORS

LUKA KOPER
Port of Koper

SPLOŠNA PLOVBA d.o.o.

AMBER RAIL

BTC
Logistični center

Rail Cargo Austria
Rail Cargo Group