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KAZALO

OIL SKIMMERS FOR COASTAL WATERS AND OPEN SEA CLEANING

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ABSTRACT

The transport of crude oil requires the adoption of safety measures in port terminals, especially during the operations of loading and unloading of crude oil. Accidents at sea are further serious cause of oil pouring and cause pollution. For these reasons the port terminals are equipped with oil skimmers and boats that intervene promptly to define and collect the spill at sea. The technology of oil skimmers is subject to continuous innovation, to ensure prompt actions when operating in restricted waters, as may be the area of the Gulf of Trieste, Northern Adriatic Sea or other restricted areas within the refineries and oil terminals.
In the paper the principles by which the oil skimmers recover and transfer oil and some of the more salient changes introduced recently in this technology will be explained. Then we will present a new oil skimmer design, called FL.O.C (Flexible Oil Collector), developed under the Jonathan Project, in collaboration with the University of Trieste and the Area Science Park of Trieste. This project is currently under construction and should allow the availability of such a system as a standard equipment in short time. The new skimmer will allow the recovery of a high percentage of hydrocarbon in comparison to the traditional oil skimmers, will be available in very short time and will require small maintenance.

Keywords: Sea Skimmers, Oil Pollution, Crude Oil Transport

1 INTRODUCTION

It is not easy to determine the amount of oil spilled into sea every year but, according to estimates, it is expected to be around 4 million tonnes in the whole planet and 600.000 tonnes for the only Mediterranean. No spill situation is similar to another, both because of the variety of existing hydrocarbons, both for the different locations and environmental conditions in which they occur. However, there are general and common characteristics that must be taken in planning activities. Generally, standard methods of decontamination are used, which consist mostly to contain the spill paid through special floating booms and then collect the spilled oil at sea. The amount that cannot be recovered is left in the sea, so that it degrades naturally. If, however, these substances are near the coast, it is possible to intervene with dispersants but, in long run, may prove harmful to the environment. The intervention depends greatly on the type of spill happened and the means used to recover the oil differ, depending on the operating steps of the intervention.

2 SPILLS

Spills at sea are injections of hydrocarbons, either intentional (e.g. washing tanks) or unintentional (e.g. explosion of an offshore platform), in the water mass. They are classified according to classes of crude oil paid. In industrial areas proximate to the sea or in port areas, small spills “inevitably” occur for the mere performing of routine activities in those areas. Oil spills and its derivatives draw together in thin extended surfaces and float, as a result of their lower specific weight than water. The extension of these surfaces increases over time, while their thickness decreases. Wind, atmosphere and water waves distort and shift the spills: they alter spills by oxidizing and beating them together, thus leading to their emulsification and/or sinking; they move spills by cracking them into thinner and wider extensions and pushing them onto the coasts, where the environmental damage is even worse.

Disasters result from exceptional circumstances, in scope and severity, and are caused by human activities, e.g. the explosion of the Deepwater Horizon in the Gulf of Mexico, or by natural events, such as an earthquake. Containment and remediation interventions last for a long time, they are imposing in extent and require supranational involvement. All possible means are put in place and in the course of the emergency new devices intended to help in the rescue will be designed, constructed and employed.

Spills are classified as accidents resulting from mishandling, collision of ships or broken structures. The places most at risk of accidents are ports, refineries and industrial areas along the sea and pipeline terminals. The determination of the risk involves the on-site emergency response of specific organizations and materials to be used in case of need. The specific agencies are public (Coast Guard, Harbor Master, Fire Brigade) or private (industrial properties or companies formed for this purpose).

Spills can be classified as “routine” when they consist in small, but continuous discharges, resulting from leakage, loading / unloading, refueling, etc. Reclamation works are not consequent to states of alarm, but are maintenance works; they are daily operations carried out continuously by municipalities and private organizations, by means of limited-size instruments that scan and suck the water surface.

3 HUMAN INTERVENTION

Human intervention [1] is divided into the following phases :

3.1 Identification of pollution sources

In the event of an accident, the very ships involved call for help; in other cases (e.g. in illegal dumping of oil into sea), a very active surveillance of the coasts and sea with ships and aircraft by the competent authorities is required. In cases of a ship damage, the main task of the commander is to safeguard the lives of the people on board and then the integrity of the ship, trying to save the load; only later he should deal with the damage caused by the load poured at sea.

3.2 Limitation of the spill

In the event of an accident and whenever sea water reaches deposits, tanks, double bottoms or boxes containing pollutant liquids, their content must be transferred to other intact containers, when possible. To be effective and to limit the extent of damage, the intervention must be immediate, timely and performed by appropriate means.

3.3 Containment of oil

It is an operation that is carried out by using protective barriers with buoys and booms, both at an early stage and in the operational phase. In pipeline terminals, barriers are often present to prevent that the floating oil escaped into the sea could spread into the surrounding environment. In this case, the protections are anchored on the bottom and arranged in such a way as to be active at most, without being sucked or damaged by the currents. Currents with speed above 1.5 knots, typically found in rivers and estuaries, can cause the oil content to spill over the barrier. More recently air bubble chains, flowing from submerged pipes, generate an immersed barrier to the oil propagation near the oil pipeline terminals.

On the high seas, it is very difficult, if not impossible, to lay and secure the protective barriers. So they are free to float and must be able to contain, in limited size, the maximum amount of crude oil. There are several types of effective barriers in presence of wind, currents and waves. They have a sufficient free edge to prevent the oil from spilling over if driven by the waves and an adequate depth to avoid current carrying the oil from the bottom. In such fences, the oil reaches a thickness of a few centimeters (up to ten).

4 CLEANING THE SEA

Once defined the area affected by pollution, the sea must be swept by collecting or destroying the pollutant.

4.1 Use of fire

One of the first methods used, though only partially effective, is to ignite the oil. This operation must be done soon, before the lighter components volatize, and only under conditions of total safety. To activate the combustion, highly flammable substances can be shed on crude oil by planes or helicopters. There are also fire resistant barriers which restrict the wildfire burning through and cause the explosion of incendiary charges installed on the barriers. The results obtained with these operations are limited. The temperature of the water cools the pollutant and prevents the various components of crude oil from reaching the combustion temperature, especially if the state of the sea is rough.

4.2 Oil skimmers

The collection of spilled oil is performed by means of special vessels called oil skimmers. The ultimate aim of any recovery operation is to collect as much oil as is reasonably and economically possible. These vessels can be specially-built for the purpose or fitted with equipment to be used for intervention. The intervention can be very different depending on the theater of action; the open sea or ocean, rivers, harbors or confined areas; in the presence or absence of winds or currents, etc. Another factor which characterizes the operation is the quantity of oil that should be recovered. It can range from a few hundred kilograms (for example in port areas contaminated by routine operations) to the millions of tones (for example in the episode of the Gulf of Mexico). A successful recovery system must overcome the interrelated problems of encountering significant quantities of oil and its subsequent containment, concentration, recovery, pumping and storage. The recovery and pumping elements of the overall operation are frequently combined in a skimmer. All skimmers are designed to recovery oil in preference to water, but designs vary considerably according to the intended use, for example in sea, in sheltered waters or onshore and for this reason the units used in these types of interventions are therefore deep sea, ocean, coastal, or port.

Furthermore, the unit responsible for the collection can be autonomous in operations, i.e. it can circumscribe, collect and transport the residue to the ground by itself; or it may require other units and vessels in order to perform, in which case it operates in groups of units.

A number of factors should be considered when selecting a skimmer, the most important of which are viscosity and adhesive properties of the split oil (including any change in these properties due to "weathering" over time), together with the sea state and levels of debris. In relative predictable situations, such as at fixed facilities, for example, marine terminals and refineries, the type of oil handled may be known and a specific skimmer can be selected. This can be the case of the upper Adriatic harbors, characterized by a pipeline terminal (Trieste) and fuel deposits for the ships (Koper, Rijeka, Trieste, Venice, etc.).

Conversely, a versatile skimmer, that may be required to address a variety of situations and oils, may be preferable as part of a national stockpile. However, no single skimmer can cope with every situation that may be encountered as a result of an oil spill and a selection of skimmers may be required, particularly as the oil weathers (Table 1). This classification, of the International Tanker Owners Pollution Federation Limited (ITOPF) [2], can be used to identify the best skimmer solution to be used in the different situations. In this table a primary identification is made between the oleophilic skimmers and the others.

The oleophilic skimmers employ materials that have an affinity for oil in preference to water. The oil adheres to the surface of the material, commonly taking the shape of a disk, drum, belt, brush or rope-mop which, as they rotate, lift the oil from the water surface. Alternately to oleophilic skimmers there are the non-oleophilic skimmers, which can be classified as suction skimmers, weir skimmers or other skimmer type.

Non oleophilic skimmers can be the vacuum or suction skimmers in which the oil is recovered by pumps or air suction systems directly from the water surface. In particular these sy stems can operate in combination with vacuum trucks or trailers, that combine the elements of recovery, storage, transport and oil/water separation, which are often ready locally.

Table 1: Generic characteristics of commonly encountered skimmers [2]

Skimmer		Recovery Rate	Oils	Sea State	Debris	Ancillaries
Oleophilic	Disc	Dependent on number and size of discs. Tests show grooved disc can be	Most effective in medium viscosity oils.	In low waves and current can be highly selective with little entrained water.	Can be clogged by debris	Separate power pack, hydraulic and discharge hoses, pump and suitable storage

		highly effective		However, can be swamped in choppy waters.		requirements.
	Rope mop	Dependent on number and velocity of ropes. Generally low throughput.	Most effective in medium oils although can be effective in heavy oil.	Very little or no entrained water. Can operate in choppy waters.	Able to tolerate significant debris, ice and other obstructions.	Small units have built in power supply and storage. Larger units require separate ancillaries.
	Drum	Dependent on number and size of drums. Tests show grooved drums are more effective.	Most effective in medium viscosity oils.	In low waves and current can be highly selective with little entrained water. However, can be swamped in choppy waters.	Can be clogged by debris.	Separate power pack, hydraulic and discharge hoses, pump and suitable storage required.
	Brush	Throughput dependent on number and velocity of brushes. Generally mid-range.	Different brush sizes for light, medium and heavy oils.	Relatively little free of entrained water collected. Some designs can operate in choppy waters, others would be swamped in waves.	Effective in small debris but can be clogged by large debris.	Separate power pack, hydraulic and discharge hoses, pump and suitable storage required.
	Belt	Low to mid-range	Most effective in medium to heavy oils.	Can be highly selective with little entrained water. Can operate in choppy waters.	Effective in small debris but can be clogged by large debris.	Can deliver oil directly to storage at the top of the belt. Ancillaries require to discharge from a vessel to shore.
Non - Oleophilic	Vacuum/ suction	Dependent upon vacuum pump. Generally low to mid range	Most effective in light to medium oils.	Used in calm waters. Small waves will result in collection of excessive water. Addition of a weir more selective.	Can be clogged by debris.	Vacuum trucks and trailers are generally self-contained with necessary power supply, pump and storage.
	Weir	Dependent upon pump capacity, oil type, etc.. Can be significant.	Effective in light to heavy oils. Very heavy oils may not flow to the weir.	Can be highly selective in calm water with little entrained oil. Can be easily swamped with increase in entrained water.	Can be dogged by debris although some pumps can cope with small debris.	Separate power pack, hydraulic and discharge hoses, pump and storage. Some skimmers have built-in pumps.
	Belt	Low to medium	Most effective in heavy oils.	Can be highly selective with little entrained water. Can operate in choppy waters.	Effective in small debris. Clogged by large debris.	As for oleophilic belt.
	Drum	Mid range	Effective with heavy oils.	Can be highly selective in calm water with little entrained oil. However, can be swamped in waves.	As for weir skimmer.	As for weir skimmer.

The weir skimmers use gravity to selectively drain oil from the surface of the water. By positioning the lip of the weir at, or just slightly below, the interface between the floating oil and water, the oil flows over the weir to be selectively recovered with minimal amount of water. Advanced types of weir skimmers have adjustable weirs and accurate vertical positioning of the weir is usually achieved by a self-leveling arrangement.

Other skimmer designs have been adopted to cope better with waves and rough seas. Upward rotating belts, for instance, can be partially lowered beneath the oil/water interface, to reduce the influence of surface waves; the oil is then scrapped off the belt as it rises above the surface and drops into a storage tank or other container. Other skimmers use buckets or paddles on the belt, to aid lifting of the oil from water surface.

5 THE JONATHAN PROJECT (JP)

It is the result of a research carried out jointly at the Area Science Park (Padriciano, Trieste), with the support of Innovation Factory (Area Science Park branch) and the Department of Engineering and Architecture of the University of Trieste. This idea is related to a device for the interception and collection of oily substances pollutants, which float on the surface of the sea, rivers or lakes, to be used mainly in harbors and in coastal waters. The idea has been patented with patent Nr. 10884PTWO.

The idea of Jonathan Project [3] consists of a skimmer equipped with a funnel-shaped conveyor, supported by floats, drawn inside of the spill to be cleaned or self-propelled in it with its own drive and/or remote-controlled guide. This device has been named FL.O.C. (Flexible Oil Collector) and has the primary function to intercept and collect the share of surface water, on which float pollutants and debris to be removed. It can be classified as a weir skimmer (Table 1), which is very flexible and used with light and heavy oils. It can be equipped with different ancillaries, such as a separator and a collection tank, and used autonomously or have tugs or support ships to transfer the collected oil, to be treated on board. It is scalable in different sizes so as to be used for land reclamation in areas with limited space up to catastrophic theaters. In reduced dimensions, it is equipped with inflatable floats, so that they can be stored in a tank of reduced overall dimensions, both for the boarding of vessel and for the transport (Figure 1).

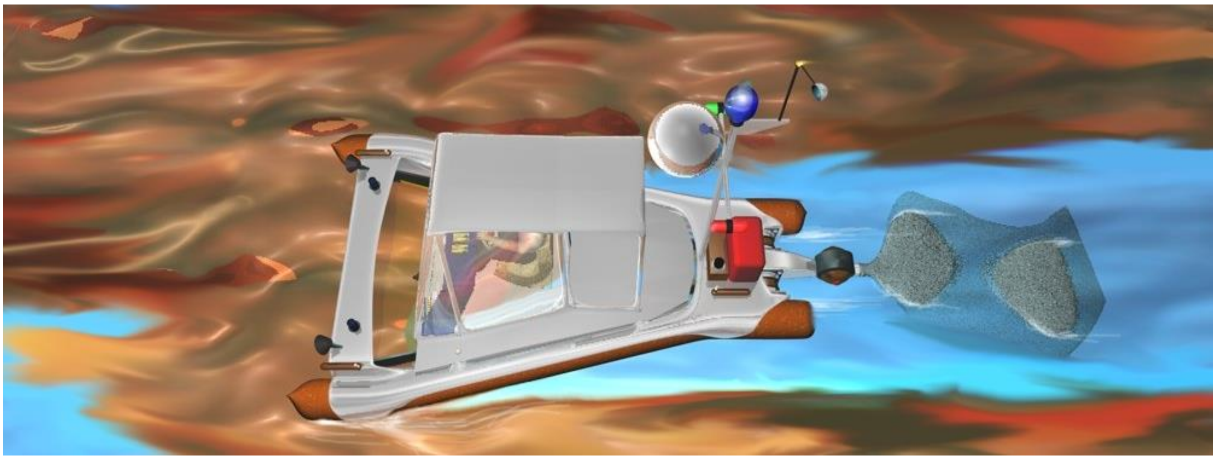

Figure 1: Jonathn Project Oil Skimmer cleans the oil slick and collects the polluted oil.

5.1 System operation

The device, supported by suitable floats, is placed on the surface of the water to be reclaimed

and moves in the direction of the pollutant to intercept and collect. The movement is obtained by towing or by using its own drive. The device is constituted by a funnel-shaped collector plate tapered from the larger cross-section, in the direction of motion, to the lower section, in the queue according to the motion. It is equipped with a front opening and with one or more rear openings.

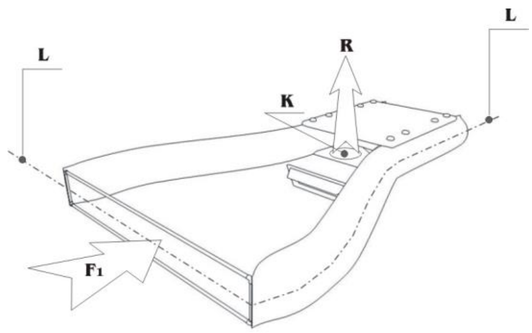

Figure 2: View 3/4 front of the device

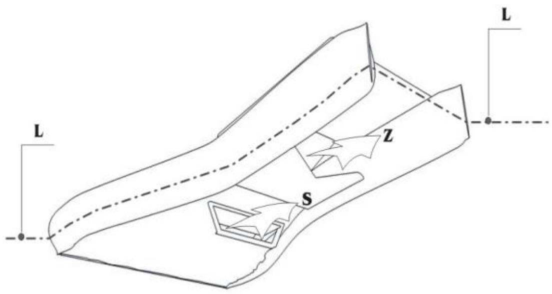

Figure 3: View 3/4 rear the device

The opening front generates an inlet flow (F1 in figure 2) function of the speed of advancement of the device and of the ratio of the immersed area of the opening itself. This inlet flow must be balanced by the sum of the flows at the output (R (recovered oil) in figure 2; S (water in excess) and Z (not collected oil) in figure 3).

$$F1 = R + S + Z \tag{1}$$

Outgoing flows are generated by the flow of a suction pump (R in figure 2), which sucks to water's surface as much as possible, and by one or more openings controlled by heads and placed in the lower face of the funnel (S and Z in figure 3). The balancing of the flows generates the benefit of facilitating the entry of the inlet flow, without opposing pressure waves. The inlet flow is necessarily constituted more by water than by floating hydrocarbons, because the film of the hydrocarbons can be very thin and for the effect of water motion. The openings controlled on the face of the funnel immersed allow the escape of the excess water, in order to convey the maximum possible rate of hydrocarbons into the suction area of the pump (K in figure 2).

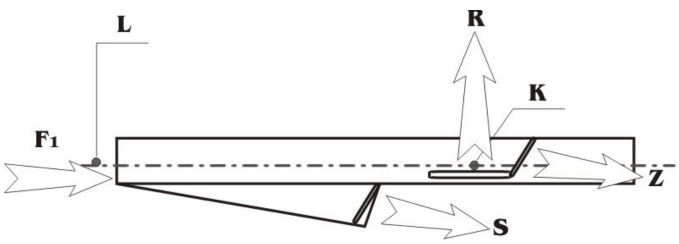

Figure 4: Side view

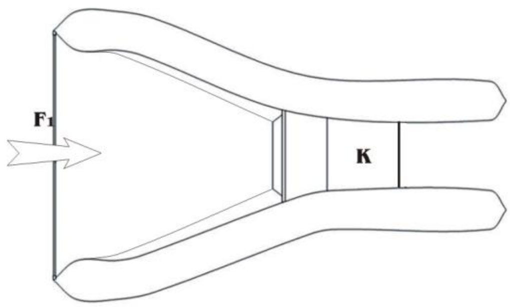

Figure 5: Plan view

The concentration of hydrocarbons in a thicker mass floating on water is generated by the dual-dimensional gradient of the funnel. The face is immersed inclined downwards from the front opening and narrows in the plan view towards the rear opening; in this way the section of the inlet flow varies from a flat rectangular shape, very wide and very low, to a narrower and higher rectangular shape. The area of the free surface of the funnel is reduced and then generates a greater thickness for hydrocarbon. The excess water is discharged downwards, directly before the suction area.

A more general representation of the functioning of the collector is shown in figure 6.

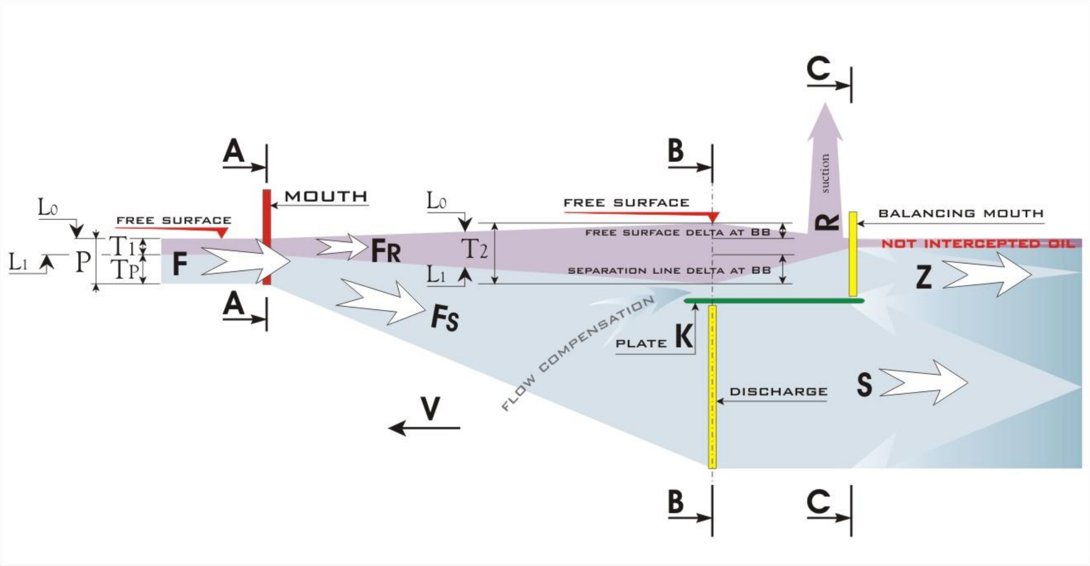

Figure 6: General representation of the collector

The symbols of figure 6 correspond to those of figures 2 - 4 as follows : F is F1, R is FR,, S is FS; other symbols have not been changed.

The collector functioning and its response to the different speeds of the skimmer have been simulated with specific programs and in creating physical models, which have been tested in the towing tank of the University of Trieste. The presence of oil has been simulated with different density foams, product easily removable from the basin. With the experiences carried out it has been verified, at different speeds of the collector, the ability to collect and convey the floating material into the collection bags; in fact it is not uncommon that the collector, with little ability to suck, rejects the crude oil that must collect.

5.2 **Application of FL.O.C. to JP skimmers**

The collector FL.O:C. is part of all the JP skimmers that, in the first series, are sized according to the maximum measures transportable by trucks and are devoted to the maintenance of pools of water and emergency measures for occasional spills up to 7 tons.

It is shown in figure 7 a general outline of FL.O.C..

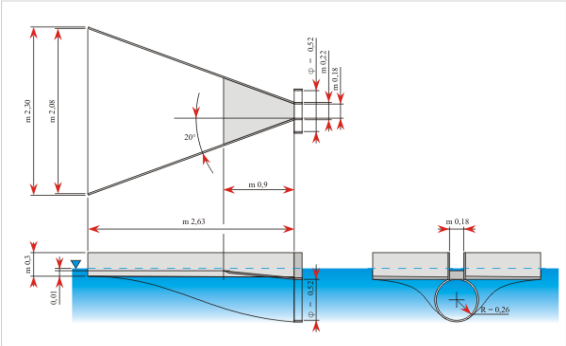

Figure 7: FL.O.C. general outline

A further accessory plant is called Drac - Oil, which is a container - filter (Figure 8) in which the collected oil is conveyed. This is also a filter, as it keeps the oil polluting, pulling it away from water/oil, while releasing the water clean. Drac - Oil is a "core - product" that JP uses in setting its skimmers and can it supply as third part to manufacturers who wish to use this device downstream of their skimmer systems.

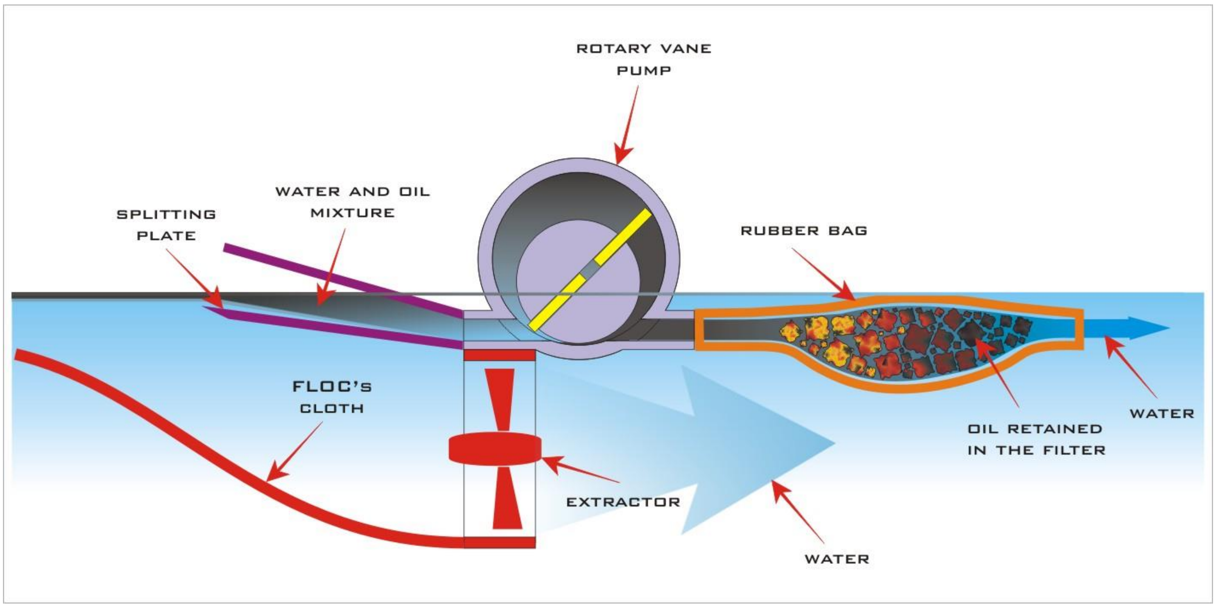

Figure 8: Drac-Oil container - filter

The mixture water-oil is selected from the splitting plate; the extractor flows the deep water clean, while the rotary vane pump pushes the water-oil mixture into the rubber bag, without increasing significantly the emulsion. The filtering particles absorb the oil, by holding it, while the clean water comes out from the bottom. Drac-Oil can be used to filter any mixture of oil and water collected by skimmers; its use makes unnecessary the use of separators for the storage of the pollutant mixture; for this reason is not necessary the use of settling tanks on board the support ship or moving the collected pollutant. The saturated Drac-Oil containers are placed directly into a container box and can be sent to landfills for disposal. All basic operations, within the cycle, are extremely clean.

The range of oil skimmers JP consists of three subsystems : a) The system FL.O.C., b) the collected system and c) the vessel. We already discussed in detail on the FL.O.C. system.

The sampling system has the function to remove the pollutant from the bulk water by filtration in a filter bag (Drac - Oil system) or adduction of the mixture on board of a support boat. The vessel has the function of assembling and connection between FL.O.C., the collection system and the auxiliary machines (engines, generators, batteries, piloting, etc..) necessary for the correct functioning of the whole skimmer system and ensures the operation and navigation.

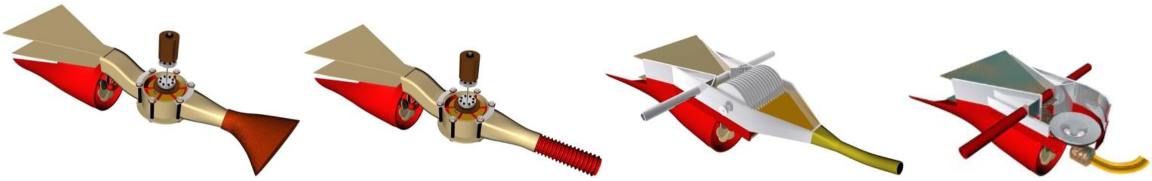

Figure 9: JP systems to collect and transfer the pollutant mixture.

The systems used to collect and transfer the mixture can be (see figure 9, in progression): a) FL.O.C. and Drac-Oil systems; b) FL.O.C. and a connecting pipe; c) FL.O.C. and oleophilic drum; d) FL.O.C. and a weir system.

The boat is the rigid structure which groups together and allows working all the systems placed on board. It is composed of a rigid frame to which are attached the floats, the azimuth pod engines for propulsion, the control systems for the pods, FL.O.C., its frame and its planting, the deep flow extractor and the suction rotary pump. Il figure 10 a view of the different component parts of the skimmer is shown.

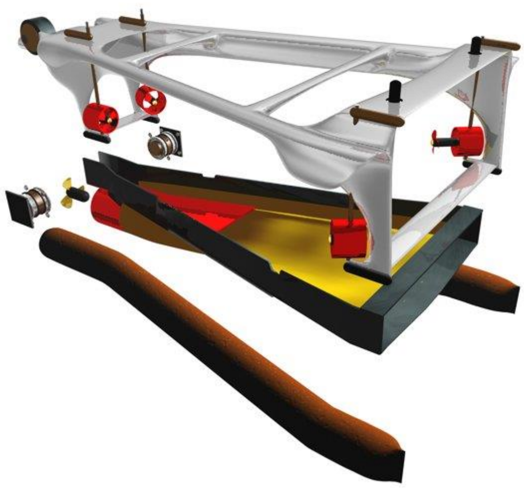

Figure 10: JP skimmer components

Figure 11: Self propelled JP skimmer

A more complete visualization of a possible self-propelled skimmer is shown in figure 11.

We can notice that the solutions provided for JP skimmers are various and include the wire-guided solution, the remote distance controlled and unmanned solution and the piloted one. One of the basic principles that have inspired the choice of these solutions is that they must be readily available, as soon as the operational need arises. It will then be the user to define in detail the type of solution that best suits to the local port requirements.

6 CONCLUSIONS

The solution presented for the oil skimmer to be used in coastal waters and ports is the result of studies, research and experiments on models carried out at the University and Research Area of Trieste. The solutions presented take into consideration the needs required to have a unit that is available quickly, easily manageable and easy to use, adaptable to complementary activities, such as cleaning of beaches and small harbors. The obtained product, still in the experimental phase, should respond to the requirements and be available in short time.

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ANALYSIS OF DRAUGHT SIZE OF VESSELS ON THE LOWER SECTOR OF THE SAVA RIVER

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ABSTRACT

The future transport policy in landlocked countries has to be based on inland waterway transport (IWT). The development of the cargo transport on each inland waterway depends directly on its technical and exploitation characteristics. Analysis of navigational characteristics on inland waterways always comes before a transport planning and scheduling or building of ships which are the most suitable for these conditions on river. The size of the vessel's draught (T) usually is the limiting value in project tasks and it is conditioned by the depth of the waterway or depths in certain ports. The Sava River is the greatest tributary of the Sava River and it connects four countries. Navigation characteristics on the lower sector of the Sava River have to be determined as precise as possible, especially from the aspect of determination of a possible draught of vessels. The analysis of water level changes on the Sava River during the last sixty years was done.

Keywords: The Sava River, navigational characteristics, vessel's draught

1 INTRODUCTION

Inland water transport (IWT), as a crucial transport mode, could be the backbone of the future European intermodal transport chains, due to the fact that it can ship heavy as well as a large amount of commodities in combination with price advantages [2]. Besides, inland waterways have still free shipment capacities. In Europe around 14,000 km of approximately 29,000 km of inland waterways are used for freight carrier. Also, IWT represents the only means of land transport which does not suffer congestion problems like that of rail or road within Europe. In general, inland waterways are underused, but inland navigation is not considered as a truly competitive alternative to other means of land transport. Estimates suggest that inland navigation would carry up to 425 million tons per year, including the accession countries, in the European inland waterway network, if the necessary action towards an integration of IWT into managed intermodal logistics chains were undertaken [8] [5].

The basic problems in the transport planning and risk management in IWT are probabilitiy of a disturbance occurrence and duration of period with restriction in navigation. This paper approaches determination of possible size of draught of vessels in the lower section of the River Sava as one of their most important technical characteristics.

2 BASIC OBSERVATIONS ON THE LOWER SECTIONS OF THE SAVA RIVER

The Sava River is an international river (Slovenia, Croatia, Bosnia and Herzegovina, Serbia) and it is 944 km long. Navigable part of the Sava River is 583 km long, but navigation for larger vessels is possible to Slavonski Brod (km 377). The navigable part of the Sava

River is divided in three parts: the upper Sava, the middle Sava and the lower Sava. The lower section of the Sava River is from km 178 (mouth of the Drina River) to its mouth in the Danube River (Belgrade). According to the slope of the river bed and the regime of the waters the lower Sava River is a typical lowland river and it is divided into lots of river branches with many islands, sandbars and shallow waters which have variable characters. On the part of the lower Sava River downstream from the mouth of the Drina River (km 178), there are a few shallow waters which can limit navigation considering vessel's draught.

Having in mind that the lower Sava River has a typical lowland river character, with a great amount of alluvium which forms sandbars and shallow waters, navigation is regulated according to few water level measuring stations of which the most suitable is the one in Šabac. The basic data of water station Šabac are shown in the Table 1.

Table 1: Basic data of water station Šabac

River	Basin	Foundation year	Point of "0" (height above the Adriatic Sea)	Distance from the river mouth
Sava	Danube	1921	72,61 m	106,28 km

Source:www.hidmet.gov.rs

The norm of vessel's draught for this station is 150 cm when the water level is 0 cm.

3 BASIC OBSERVATIONS ON THE LOWER SECTIONS OF THE SAVA RIVER

The research includes the oscillation of water level at the water level indicator in Šabac (Serbia) which is used to plan the navigation in this section of the Sava River from the aspect of low water levels because low navigation levels limit the size of draught of all vessels. It is known that the size of the vessel's draught (T) is usually the limiting value in project tasks and it is conditioned by the depth of the waterway or depths in certain ports. Based on vessel's draught and by carefully choosing the relation between draught and width (T/B) the constructive width of the vessels hull (B) can be approximately determined which is of great importance [6] [7]. This is the reason why navigation characteristics of the Sava River have to be determined as precise as possible, especially from the view point of determining the real possible draught of vessels [1].

To get even more precise condition of waterway on this section of the Sava River, from the view point of navigation of vessels with large draughts, during research it has been started from the assumption that the possible draught of vessels is T=150 cm when water level measuring station Šabac shows H=0 cm or $T \leq 150$ cm when $H \leq 0$. By using the adopted principle research carried on to determine navigation condition for following draughts of vessels: for $T \leq 175$ cm ($H \leq +25$); $T \leq 200$ cm ($H \leq +50$); $T \leq 225$ cm ($H \leq +75$); $T \leq 250$ cm ($H \leq +100$); $T \leq 275$ cm ($H \leq +125$) and $T \leq 300$ cm ($H \leq +150$).

Research has been done for the period between years 1950 and 2011, which was divided into three parts: the first from 1st January 1950 to 31st December 1970, the second from 1st January 1971 to 31st December 1990 and the third from 1st January 1991 to 31st December 2011. The results of research are shown in following chapters according to adopted periods of research.

3.1 Results of research in the first period (from 1st January 1950 to 31st December 1970)

Basic navigation characteristics of importance for determining vessels' draughts in this period are:

- the lowest navigation level determined in the period 01.I 1950÷31.XII 1970 is -74.

- the highest navigation level determined in the period 01.I 1950÷31.XII 1970 is +575.
- the average navigation level in the period 01.I 1950÷31.XII 1970 is =180 cm with standard deviation from the average value *s*=±148 cm, which gives an interval of possible values of navigation level H_{min}=+32 cm and H_{max}=+338 cm, or draughts of vessels, average 1= 330 cm, minimal T_{min}=182 cm and maximal T_{max}=488 cm.

Hydrographs for all of years in the first observed period are shown in the Figure 1.

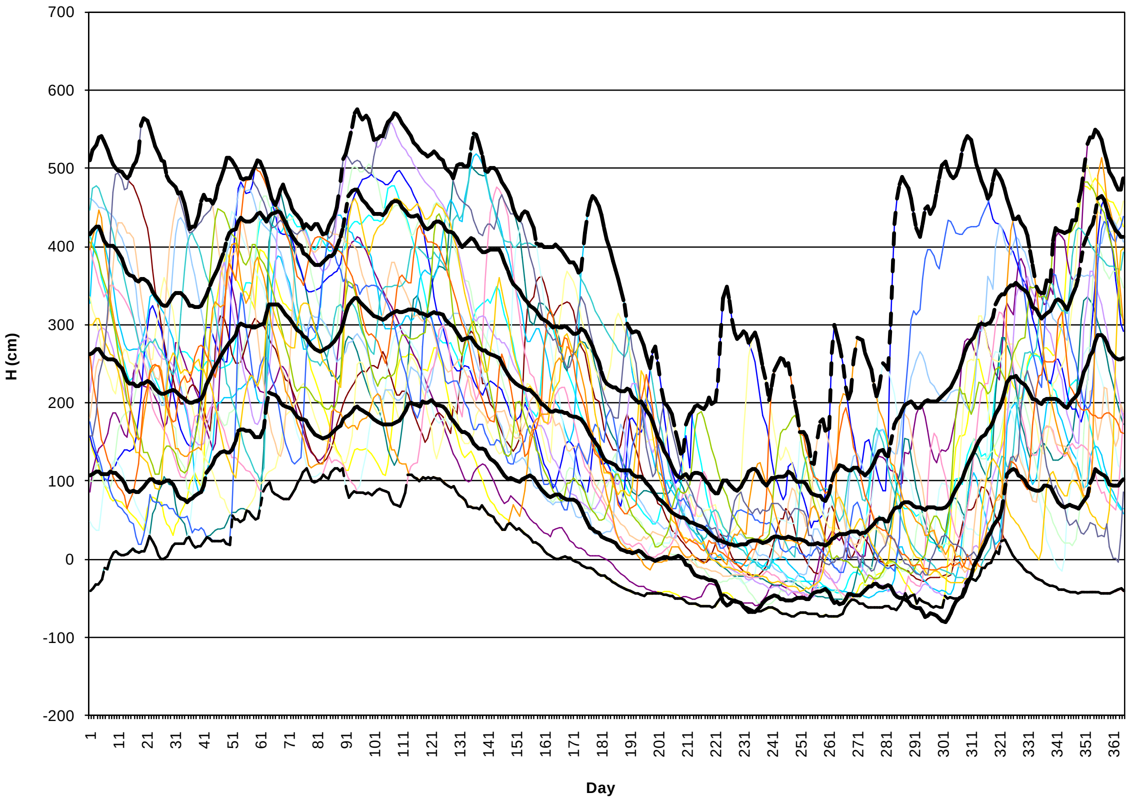

Figure1: Hydrographs of all of years from the period 1st January 1950 to 31st December 1970

Probabilities of occurrence of adopted navigation levels, possible draughts and expected number of days for navigation in a year according to adopted levels for water level measuring station Šabac in this period are shown in the Table 2.

Besides given data it is important to notice the following values (Table 3) which are necessary for evaluation of navigation characteristics of the Sava River on lower section of its flow, from the mouth of the Drina river to its mouth into the Danube River, and they are:

- average number of days in a year with water level which is lower than adopted (*H*<0; 25; 50; 75, 100; 125; 150);
- expected start of the period with water levels lower than adopted (*H*<0; 25; 50; 75, 100; 125; 150);
- expected end of the period with water levels lower than adopted (*H*<0; 25; 50; 75, 100; 125; 150);
- expected length of the interval of the period with water levels lower than adopted (*H*<0; 25; 50; 75, 100; 125; 150);
- average duration of the period with water levels lower than adopted-calculated only for those years when limited water levels occurred.

By analyzing the data from the Table 3, it is obvious that there are in average 49 days a year when water level is lower than 0 (H<0); expected start of the first period with water level lower than 0 (H<0) is on 12th August; expected end of the first period with water level lower than 0 (H<0) is on 14th October. Expected start of the second period with water level lower than 0 (H<0) is on 24th November; expected end of the second period with water level lower than 0 (H<0) is on 6th January. Also, expected length of the interval of the first period with water level lower than 0 (H<0) is 64 days and expected length of the interval of the second period with water level lower than 0 (H<0) is 44 days.

It can also be seen that for all of water levels there are two periods of limitation. For example for water level H<100 it is expected that the first period of limitation starts on 18th July and to end on 31st October and the average duration of lower water period in the first period is 35 days, while the start of the second period is on 25th January and to end on 17th February and the average duration of lower water periods in the second period is 25 days.

Table 2: Probabilities of occurrence of water levels and possible draughts of vessels in the period 01.I 1950÷31.XII 1970

Probabilities of occurrence of water levels and possible draughts of vessels		Expected number of days for navigation
lower then adopted water level (draught)	higher than adopted water level (draught)	
P(H<0)=0,135→ P(T<150)=0,135	P(H≥0)=0,865 → P(T≥150)=0,865	0,865 · 365=316
P(H<+25)=0,193 → P(T<175)=0,193	P(H≥+25)=0,807 → P(T≥175)=0,807	0,807 · 365=295
P(H<+50)=0,254 → P(T<200)=0,254	P(H>+50)=0,746 → P(T≥200)=0,746	0,746 · 365=272
P(H<+75)=0,312 → P(T<225)=0,312	P(H≥+75)=0,688 → P(T≥225)=0,688	0,688 · 365=251
P(H<+100)=0,366 → P(T<250)=0,366	P(H>+100)=0,634 → P(T≥250)=0,634	0,634 · 365=231
P(H<+125)=0,417 → P(T<275)=0,417	P(H≥+125)=0,583 → P(T≥275)=0,583	0,583 · 365=213
P(H<+150)=0,478 → P(T<300)=0,478	P(H≥+150)=0,522 → P(T≥300)=0,522	0,522 · 365=191

Table 3: Average number of days in a year with water level which is lower than adopted water level, expected start of the period, expected end of the period, expected length of the interval of the period and average duration of the period with limited water levels

Water level	Characteristic				
	average number of days in a year with water level which is lower than adopted	expected start of the period with water levels lower than adopted	expected end of the period with water levels lower than adopted	expected length of the interval of the period with water levels lower than adopted (days)	average duration of the period with water levels lower than adopted (days)
H<0	49	12.VIII 24.XI	14.X 06.I	64 44	35 25
H<25	70	08.VIII 02.XII	12.X 18.I	66 49	39 22
H<50	93	02.VIII 16.XII	14.X 22.I	74 36	40 18
H<75	114	25.VII 24.XII	23.X 28.I	91 36	51 24
H<100	134	18.VII 25.I	31.X 17.II	106 24	62 18
H<125	152	14.VII 23.I	31.X 25.II	109 34	62 19
H<150	174	06.VII 23.I	05.XI 23.II	123 32	70 19

3.2 Results of research in the first period (from 1st January 1991 to 31st December 2011)

Basic navigation characteristics of importance for determining vessels' draughts in this period are:

- the lowest navigation level determined in the period 01.I 1991÷31.XII 2011 is -116;
- the highest navigation level determined in the period 01.I 1991÷31.XII 2011 is +572;
- the average navigation level in the period 01.I 1991÷31.XII 2011 is $\overline{H}$ =137 cm with standard deviation from the average value s=±137 cm, which gives an interval of possible values of navigation level H_{min}=0 cm and H_{max}=+274 cm, or draughts of vessels, average $\overline{T}$ = 287 cm, minimal T_{min}=150 cm and maximal T_{max}=424 cm.

Hydrographs for all of years in the third observed period are shown in the Figure 2.

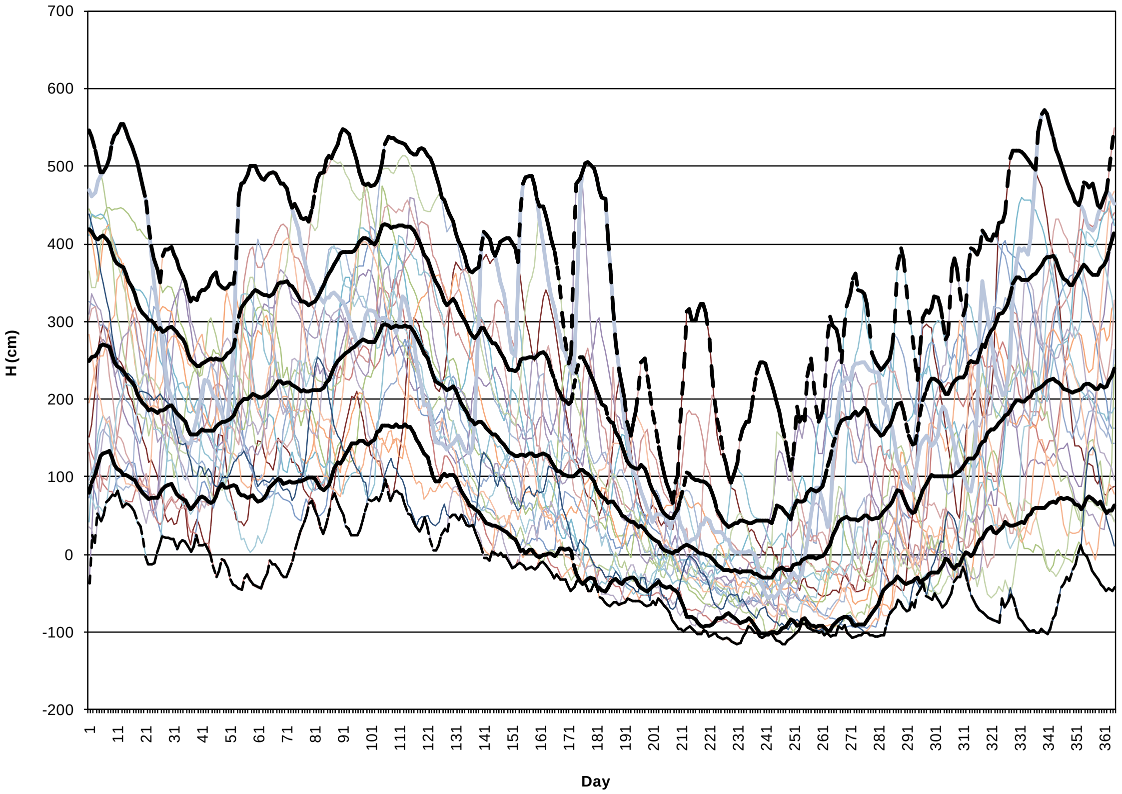

Figure 2: Hydrographs of all of years from the period 1st January 1991 to 31st December 2011

Probabilities of occurrence of adopted navigation levels, possible draughts and expected number of days for navigation in a year according to adopted levels for water level measuring station Šabac in this period are shown in tables 4 and 5.

General characteristic of the third period from 1st January 1991 to 31st December 2011 is that limitation of water level occurs two times a year. For the level H<25 the first period of limitation is expected to start on 14th July and to end on 14th October, while the start of the second expected period of limitation is on 9th January and the end on 3rd February; for the water level H<50 the first period of limitation is expected to start on 4th July and to end on 17th October while expected start of the second period of limitation is on 9th January and the end on 1st February. Identical claims can be made for all of other water levels.

Table 4: Probabilities of occurrence of water levels and possible draughts of vessels in the period 01.I 1991÷31.XII 2011

Probabilities of occurrence of water levels and possible draughts of vessels		Expected number of days for navigation
lower then adopted water level (draught)	higher than adopted water level (draught)	
P(H<0)=0,214→ P(T≤150)=0,214	P(H≥0)=0,786 → P(T≥150)=0,786	0,786 · 365=287
P(H<+25)=0,276 → P(T≤175)=0,276	P(H>+25)=0,724 → P(T≥175)=0,724	0,724 · 365=264
P(H<+50)=0,336 → P(T≤200)=0,336	P(H≥+50)=0,664 → P(T≥200)=0,664	0,664 · 365=243
P(H<+75)=0,385 → P(T≤225)=0,385	P(H≥+75)=0,615 → P(T≥225)=0,615	0,615 · 365=224
P(H<+100)=0,454 → P(T≤250)=0,454	P(H≥+100)=0,546 → P(T≥250)=0,546	0,546 · 365=199
P(H<+125)=0,520 → P(T≤275)=0,520	P(H≥+125)=0,480 → P(T≥275)=0,480	0,480 · 365=175
P(H<+150)=0,573 → P(T≤300)=0,573	P(H≥+150)=0,427 → P(T≥300)=0,427	0,427 · 365=156

Table 5: Average number of days in a year with water level which is lower than adopted water level, expected start of the period, expected end of the period, expected length of the interval of the period and average duration of the period with limited water levels

Water level	Characteristic				
	average number of days in a year with water level which is lower than adopted	expected start of the period with water levels lower than adopted	expected end of the period with water levels lower than adopted	expected length of the interval of the period with water levels lower than adopted (days)	average duration of the period with water levels lower than adopted (days)
H<0	78	22.VII 15.XII	03.X 17.I	74 33	44 32
H<25	101	14.VII 09.I	14.X 03.II	93 26	57 17
H<50	122	04.VII 09.I	17.X 01.II	106 24	65 16
H<75	141	30.VI 12.I	16.X 07.II	109 27	63 19
H<100	166	16.VI 19.I	26.X 20.II	134 33	77 19
H<125	190	08.VI 18.I	01.XI 23.II	147 37	80 24
H<150	209	01.VI 17.I	05.XI 11.II	158 42	84 25

4 COMPARISON OF NAVIGATION CHARACTERISTICS ON THE LOWER SECTION OF THE SAVA RIVER FOR OBSERVED PERIODS

With the goal of easier analysis of navigational characteristics on the lower section of the Sava River, according to water levels at water level measuring station Šabac, in the Table 6 most important characteristics have been presented at the same time based on which the most important constructive characteristic of vessels can be determined which is draught T.

Table 6: Basic navigation characteristics on the lower section of the Sava River

Characteristic		Period of observing the water levels	
		01.I.1950÷31.XII.1970	01.I.1991÷31.XII.2011
Lowest water level (cm)		- 74	- 116
Highest water level (cm)		+ 575	+ 572
Average water level and standard deviation (cm)		H=+180 (s=±148)	H=+137 (s=±137)
Average draught of vessels (cm)		T=330 (T_{min}=182; T_{max}=448)	T=287 (T_{min}=150; T_{max}=424)
Expected number of	H≥0→ T>150	316	287

days for navigation according to the water level (cm) and the draught of vessels (cm)	$H \geq +25 \rightarrow T > 175$	295	264
	$H \geq +50 \rightarrow T > 200$	272	243
	$H \geq +75 \rightarrow T > 225$	251	224
	$H \geq +100 \rightarrow T > 250$	231	199
	$H \geq +125 \rightarrow T > 275$	213	175
	$H \geq +150 \rightarrow T > 300$	191	156
Expected duration of limitation of navigation (days)	$H < 0 \rightarrow T < 150$	49	78
	$H < +25 \rightarrow T < 175$	70	101
	$H < +50 \rightarrow T > 200$	93	122
	$H < +75 \rightarrow T < 225$	114	141
	$H < +100 \rightarrow T < 250$	134	166
	$H < +125 \rightarrow T < 275$	152	190
	$H < +10 \rightarrow T < 300$	174	209
Expected periods with water levels lower than adopted (days)	$H < 0 \rightarrow T < 150$	12.VIII÷14.X 24.XI ÷ 06.I	22.VII÷03.X 15.XII ÷ 17.I
	$H < +25 \rightarrow T < 175$	08.VIII÷ 12.X 02.XII ÷ 18.I	14.VII÷ 14.X 09.I ÷ 03.II
	$H < +50 \rightarrow T > 200$	02.VIII ÷ 14.X 16.XII ÷ 22.I	04.VII ÷ 17.X 09.I ÷ 01.II
	$H < +75 \rightarrow T < 225$	25.VII ÷ 23.X 24.XII ÷ 28.I	30.VI ÷ 16.X 12.I ÷ 07.II
	$H < +100 \rightarrow T < 250$	18.VII ÷ 31.X 25.I ÷ 17.II	16.VI ÷ 26.X 19.I ÷ 20.II
	$H < +125 \rightarrow T < 275$	14.VII ÷ 31.X 23.I ÷ 25.II	08.VI ÷ 01.XI 18.I ÷ 23.II
	$H < +10 \rightarrow T < 300$	06.VII ÷ 05.XI 23.I ÷ 23.II	01.VI ÷ 05.XI 17.I ÷ 11.II

5 CONCLUSION

By analyzing the values from the Table 6 it is obvious that in the third period (01.I.1991÷31.XII.2011) there has been significant worsening of navigation conditions on the lower section of The Sava River in comparison to the first period (01.I.1950÷31.XII.1970). The thing that deserves special attention is that expected duration of limitation of navigation in the third period is about 30 days longer in comparison to the first period observed. Also, average daily water level in the third period is lower for about 0,40 m in comparison to the first period observed, which caused noticeable reduction of average draught of vessels.

The trend of reduction in average annual water level, or flow, is evident in almost all the rivers in Europe [3] [4]. The results of the analysis lead to general conclusion on the conditions on the lower section of the Sava River – determining the exact conditions demands more detailed analysis on every shallow that is stated which can be realized by careful measuring in the field. Only then based on such analysis the possible draught of vessels can be considered, which is, in great extent, limited.

Further work will be directed toward forming of model for estimation of occurrence and duration of the possible vessels draught, which will be based on presented analysis.

ACKNOWLEDGMENTS

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HYDROCARBONS IN PORTS AND MARINAS IN THE GULF OF TRIESTE-THE IMPACT OF MARITIME TRAFFIC

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ABSTRACT

The impact of maritime traffic on the pollution of marine environment in the Gulf of Trieste was studied by the determination of the distribution and sources of aliphatic (AH) and polycyclic aromatic hydrocarbons (PAH) in sediments at eight sites in the gulf. The results of the analyses show higher concentrations of hydrocarbons in the port of Koper, in the marina of Portoroz and in the Koper and Izola harbors. The influence of pollution was also evident in rather higher concentrations of hydrocarbons in the surrounding area in the Bays of Koper and Piran. Concentrations of the total resolved aliphatic hydrocarbons were in a range from 1095 to 4888 ng g-1. Concentrations of the total PAHs were between 209 and 4416 ng g-1. Polycyclic aromatic hydrocarbons are primarily of pyrolytic origin with some contribution of the petrogenic, while the aliphatic are mostly of petrogenic origin with significant amounts of biogenic derived compounds of terrestrial and marine origin. According to the data from the literature for other parts of the world the investigated area can be still considered as moderately polluted.

Keywords: Pollution, maritime traffic, hydrocarbons, Gulf of Trieste, sediments

1 INTRODUCTION

Traffic is nowadays becoming the most important source of environmental pollution. It has an important impact on all compartments of the environment. It is an important pollution source of the atmosphere by the emissions of different gasses and particles (NOx, CO, hydrocarbons, PM10, PM 2.5). Many pollutants are accumulated in soil and in natural waters (metals, hydrocarbons, antifouling compounds, MTBE…). Traffic is also a very important source of pollution in the marine environment. More than 40 % of the pollution of the sea is caused by the maritime traffic (tanker operations, residues of fuels and lubricants, tanker accidents, marine terminals) [1]. It is an important source of metals and hydrocarbons, especially in the coastal sea.

Hydrocarbons are widely distributed in the natural environment throughout the world. The most important sources of these compounds in the marine environment are oil seepage, oil spillage, traffic, urban runoff, waste waters and sewage effluents, as well as atmospheric deposition [1]. Hydrocarbons are hydrophobic compounds. Because of their low solubility in water, hydrocarbons tend to adsorb on organic or inorganic particles in the water column. The enriched suspended matter settles down to the sediment surface. In the sediment phase hydrocarbons are less subjected to physico-chemical or biological processes and may accumulate to higher levels. Because of this, marine sediments often contain hydrocarbons of higher concentrations than those in the overlaying water.

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. These are important reasons to devote a special attention to this class of organic compounds.

The aim of the present work was to assess the impact of maritime traffic on hydrocarbon content in sediments of the Gulf of Trieste. For this purpose our own results of the analyses of sediment samples, as well as results from the literature were used. Sediment samples at 8 sampling sites were collected and the content of aliphatic (AH) and polycyclic aromatic hydrocarbons (PAH) was determined.

2 STUDY AREA

The investigated area (Gulf of Trieste) is a part of the northern Adriatic (Fig. 1). The marine environment along the coast is affected by the pollution from different sources since this area is one of the most urbanized in the northern Adriatic.

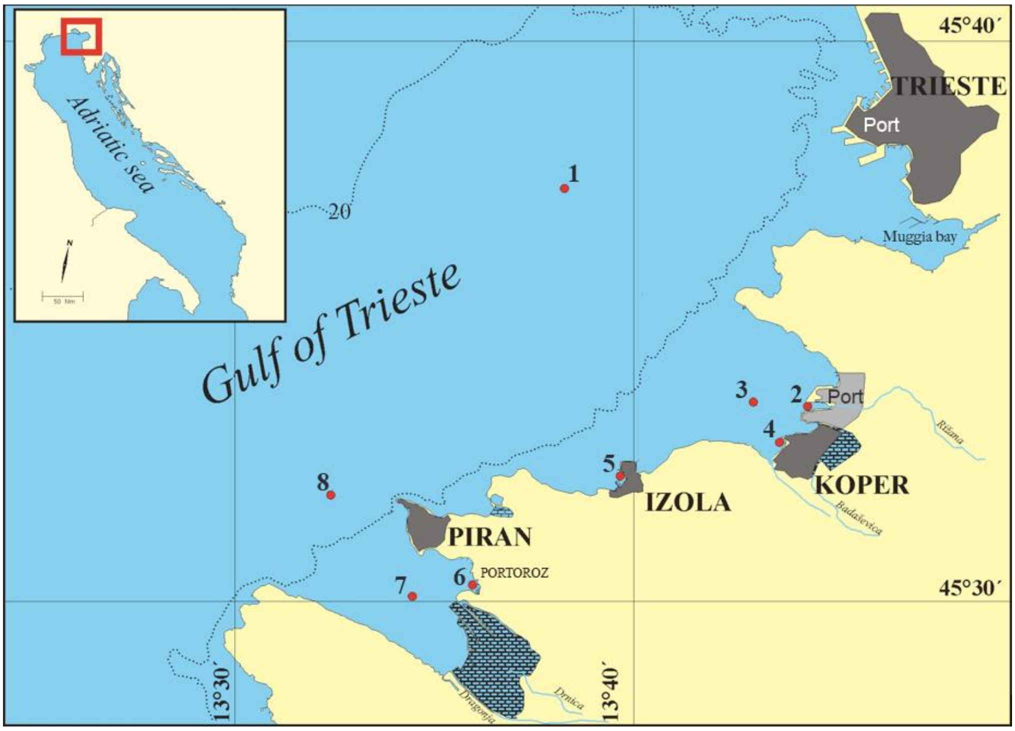

Figure 1: Location of sampling sites within the investigated area

The maritime traffic to the three ports (Koper, Trieste, Monfalcone) is very intensive, about 70 million tons of different 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 (more than 10 marinas and small harbors).

The investigated area is also affected by intensive road traffic, especially in the summer period due to developed tourism. Moreover, the marine environment within the studied area receives wastewaters from several sewage treatment plants and fresh water from rivers, which carry also wastewater of the local industry, as well as waters, which drain rather large agricultural areas. Coastal waters of the Gulf of Trieste are also used for other economically important activities, like tourism, fisheries and mariculture.

Table 1: Description of the investigated sampling sites

Sampling site	Description
1	Central part of the Gulf of Trieste
2	Port of Koper
3	Central part of the Bay of Koper
4	Municipal harbor of Koper
5	Municipal harbor of Izola
6	Marina of Portoroz
7	Central part of the Bay of Piran
8	Reference site

3 EXPERIMENTAL

Sampling and analyses of sediments were performed according to the procedure of UNEP [2]. Briefly, sediment samples were collected using a gravity core sampler. After freeze-drying, the samples were extracted with organic solvents and concentrated. Partition of hydrocarbons into aliphatic and aromatic fraction was performed with column chromatography (Silica, Alumina). Concentrated extracts were analyzed first by fluorescence spectroscopy and additionally by gas chromatography.

4 RESULTS

Concentrations of total hydrocarbons in sediment samples are presented in Table 2. The highest concentrations were detected in the marina of Izola and Koper harbor (sites 4 and 5).

Table 2: Concentrations of total hydrocarbons in sediment samples

Sampling site	Concentration (μg/g, dry weight)
1	17.2
2	18.0
3	14.0
4	49.6
5	68.6
6	13.5
7	6.2
8	4.2

The Bay of Piran (site 7) and the reference site off Piran (site 8) were the less contaminated areas. The content of hydrocarbons at other sampling sites was somehow in the middle and comparable between them. This could be a first indication of the impact of maritime traffic. The relatively lower concentrations in the Port of Koper (site 2) and Marina of Portoroz (site 6) are probably due to the better environmental protection management. The area in the Port of Koper is also not so closed and the exchange of water masses is more intensive, resulting in lower accumulation of different pollutants. Similar elevated concentrations were also obtained in the central part of the Gulf of Trieste (site 1). This is an indication of the influence of the Port of Trieste and the City of Trieste as well.

Concentrations of aliphatic hydrocarbons, presented in Table 3, showed a little bit different distribution pattern. The highest concentrations were detected in the Koper harbor, but rather high concentrations were also obtained in the port of Koper and marina of Portoroz. The influence from these two areas is also evident in the central parts of the Bays of Koper and Piran. As expected, the less contaminated was the reference site 8. Concentrations of aliphatic hydrocarbons were also relatively low in the marina of Izola, what is different compared to the presented results of the total hydrocarbons. This could be an indication of another source of pollution.

Concentrations of heptadecane (C17) are rather high compared to the concentrations of octadecane (C18), especially at sites 4, 5, 6 and 7. It is well known that this hydrocarbon can originate also from intensive production of algae and microalgae [3]. This is not surprising since all the investigated area could be considered as coastal area, with significant inputs of nutrients by the rivers and from the sewage treatment plants. The ratio Pristane/Phytane is used to distinguish between the petrogenic (petroleum) and biogenic (organisms) origin of aliphatic hydrocarbons. This ratio is low in the case of pollution by petroleum and high in the case of important contribution of the biogenic origin [4]. The prevailing petrogenic origin is evident especially in both marinas and Koper harbor.

Table 3: Concentrations of aliphatic hydrocarbons in sediment samples (ng/g, dry weight)

	Sampling site							
	1	2	3	4	5	6	7	8
C 17	54	73	91	306	187	826	453	61
Pristane	51	101	46	77	27	14	49	1
C 18	19	27	20	110	57	19	20	2
Phytane	2	23	4	131	49	47	5	1
C 14 - C 34	2040	3404	2752	4888	1793	3603	2854	1095
Pristane/Phytane	25.50	4.39	11.50	0.59	0.55	0.30	9.80	1.00

Concentrations of PAHs are presented in Table 4. The highest concentrations are in the marina of Izola and Koper harbor. At all other sites concentrations are much lower. Even in the marina of Portoroz the concentrations are only slightly elevated. In the case of PAHs it is possible to point out two major origins of these compounds, petrogenic (from petroleum) and pyrolytic (combustion of organic matter, e.g. fossil fuels). To assess the proportion between these two origins different evaluation indices are used [5,6,7]. Two of the most important are presented at the end of Table 4. In our case the pyrolytic origin is the prevailing one, but different contribution of the petrogenic is also evident, especially at sites 1, 3, 6, 7 and 8.

Table 4: Concentrations of polycyclic aromatic hydrocarons (PAH) in sediment samples (ng/g, dry weight)

	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	2
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	2
Dibenzo[a,h]anthracene	8	17	4	128	34	24	2	1
Benzo[g,h,i]perylene	9	29	10	156	15	26	3	2
Total PAH	442	335	381	3528	4416	666	389	209
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
	Petrogenic				Pyrolytic			
LMW/HMW	>1				<1			
PHE/AN	>15				<10			

5 CONCLUSIONS

The results of the present study show an evident impact of maritime traffic on the pollution of the sea in the Gulf of Trieste. Concentrations of hydrocarbons were much higher at the expected sources of pollution (port, harbors, marinas) and in the surrounding area under their influence. The major origin of hydrocarbons is pyrolytic with some contribution of the petrogenic. In general, the investigated area can be still considered as moderately polluted.

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SPECIAL PROGRAMME OF SEAFARER EDUCATION AND MANAGEMENT OF MODERN TECHNOLOGIES

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ABSTRACT

According to the International Maritime Organization, 80% of all accidents at sea are caused by human error. Fast technological changes formed the structure of technical - technological systems of marine vessels, especially in the sphere of information technologies. Investigations shows existing disproportion in the application of new, especially information technologies of the ship exploitation, in regards to the human factor. Because of these reasons, special attention must be paid to the education and training of seafarers. The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, London, 78, (STCW Convention) prescribes minimum requirements that education systems of seafarers, in states that are parties to the Convention, must satisfy, and this paper will give an brief overview of the existing systems for the education of seafarers in Republic of Croatia.

Keywords: Higher Maritime Education, Special education program for seafarers, ECTS, Lifelong learning, Human error

1 INTRODUCTION

Rapid technological development has influenced the structure of tehnical and technological systems of ships. 80% of all accidents at sea are caused by human error. The sophosticated information systems of ship management should be viewed with regard to the models of seafarer education and training. A continuous technological improvement of marine vessels has lead to the phenomenon of an increasingly fast training of seafarers. In the Republic of Croatia, higher education of seafarers is conducted through university studies. From March 2011. at Maritime universities currently it is undergoing “Special education program for seafarers”. It is a model of lifelong learning for the acquisition of highest positions on board the ships. The basis of accelerated seafarer training or Special education programme for seafarers is based on the requirements of maritime industry for "more rational" acquisition of the required maritime knowledge and sa matching ship explaitation technology, in relatively short time. The existing programmes of seafarer education in the Republic of Croatia are based on the IMO model programmes providing minimum requirements according to 95/98 STCW Convention.

2 HIGHER MARITIME EDUCATION IN REPUBLIC OF CROATIA

Higher Education in the Republic of Croatia is carried out through university studies and professional studies. University study prepares students for work in science and higher education, business, public sector and society at large, and educates them in the development and application of scientific and professional achievements. Professional study provides students with the application of knowledge and skills to perform professional activities and qualify them for immediate employment.

In the Republic of Croatia, higher education of seafarers is conducted through university studies:

1. University of Maritime Studies in Rijeka,
2. University of Maritime Studies in Split
3. Maritime department of the University in Zadar
4. Maritime department of the University in Dubrovnik.

According to the Law on Science and Higher Education, University studies are divided into three levels:

1. Undergraduate study,
2. Graduate study
3. Postgraduate study

Undergraduate study in a period of three years may enroll persons who have completed four years of high school. Those who had not completed secondary education of nautical, marine engineering or other relevant field, are required to take and pass Additional training program and Additional education program under the Ordinance on changes and amendments to the Ordinance on Vocations and Certificates of Competencies of Seafarers (Official Gazette no: 142/10). Those subjects that are prescribed by the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, London, 78, with the 95th amendment (the STCW Convention) and are required for the acquisition of the highest positions in the maritime industry are covered by the program of the first two years of undergraduate study. Upon completion of two years of undergraduate study, students are issued a certificate on which they can apply for the exam necessary for obtaining the highest positions in the maritime industry organized by the Port Authority.

After completing the undergraduate study, student receives the academic title Bachelor, with reference to the field and can continue his/her education at the graduate level.

Graduate program lasts two years and at the end student is awarded with the academic title of Master with reference to the field of profession. Upon completion of the graduate program, students may enroll doctoral studies for a period of three years after which the student receives a Ph.D. degree.

3 SPECIAL EDUCATION PROGRAM FOR SEAFARERS

Together with the current education system of seafarers in Republic of Croatia, from March 2011. at Maritime universities currently it is undergoing “Special education program for seafarers”. It is a model of lifelong learning for the acquisition of highest positions on board the ships. Program content is defined by the Ordinance on changes and amendments to the Ordinance on Vocations and Certificates of Competencies of Seafarers (Official Gazette no: 142/10).

The basic requirement for admission to “Special education program for seafarers” is high school education for marine engineering, nautical or other relevant field in period of at least four years, and in which are included mandatory subjects of section A-II / 2 of STCW Convention. Another requirement is a minimum of 36 months of aggregated sea service as an engineer officer in charge of a watch in the engine room with the machine propulsion power of 750kW or more, or a same number of time (36 months of aggregated sea service) as officer in charge of a navigational watch on board ships of 500 GT or more. Evidence for this requirement is issued by the Port Authorities according to a valid record in the seaman's book.

By the Ordinance on changes and amendments to the Ordinance of the professions and certification of the seafarers ("Official Gazette", No. 142/10) it is required that the "Special education program for seafarers" lasts for six months. Due to the specific work of seafarers and their contracts with the shipping companies, in practice, the date for completion of the Special Program is usually extended.

Table 1: The statistic at the Maritime Department of the University in Zadar

Programme	No. of participants who completed the Program	Average time
Marine Engineering	51	15 months
Nautical	30	13 months

Source: Maritime Department of the University in Zadar

Of the total of 51 participants who completed Marine engineering course, and 30 participants completed the Nautical course only six of them (two Engineers and four Navigators) decided to complete the entire program within 6 months with no interruption. Other participants mainly decided to combine active sailing and participation in the Program between contracts on board the ships. After completion of "Special education program for seafarers" participants are receiving Certificate of successful completion of Program, enabling them to apply for exam organized by the Port Authorities, necessary to acquire highest positions sailing on board the ships. It is important to emphasize students do not acquire the academic title, but allows them to continue their education at the undergraduate level if they choose so.

3.1 Special Education Program for Seafarers as a Form of Lifelong Education

Learning outcomes for the subjects of the Special Education Program for Seafarers have been defined and were given ECTS Credits[1] which will be recognized for the possible future undergraduate education. Learning outcomes are statements that describe the knowledge, skills, autonomy, responsibility and attitudes that learners should have after successfully completing a learning experience or programme.[2] ECTS credits are based on the student workload required to achieve the objectives of a programme. Student workload in ECTS consists of the time required to complete all planned learning activities (such as attending lectures, seminars, independent and private study, preparation of projects, examinations, and so forth) needed to achieve the expected objectives of learning.[3] The student workload in the formal context of learning is 30 ECTS credits per semester. In most cases the student workload during one academic year amounts to around 1 500 to 1 800 hours per year so one credit stands for around 25 to 30 working hours.[4]

[1]ECTS credit – European Credit Transfer and Accumulation System is a systematic way of describing an educational programme by attaching credits to its components. The definition of credits in higher education systems may be based on different parameters, such as student workload, learning outcomes and contact hours.
[2]Dželalija, M. and others: Croatian Qualifications Framework, Introduction to Classifications, Croatian Government, Ministry of Science, Education and Sports, 2009.
[3] http://public.mzos.hr/Default.aspx?art=9852&sec=3304
[4]B. Divjak and others: Ishodi učenja u visokom školstvu, TIVA Varaždin, Faculty of Organization and Informatics, Varaždin, 2008, page 13.

Table 2: ECTS credits at Faculties of Maritime Studies

Faculty of Maritime Studies – Rijeka		Faculty of Maritime Studies - Dubrovnik		Faculty of Maritime studies - Zadar	
Programme	ECTS credits	Programme	ECTS credits	Programme	ECTS credits
Marine Engineering	76	Marine Engineering	79	Marine Engineering	90
Nautical Studies	79	Nautical Studies	76	Nautical Studies	88

Source: Official web sites of the Faculties of Maritime Studies[5]

Table 2 shows that the workload of the attendants of the Special Education Program for Seafarers (6 months duration) is greater than the undergraduate student workload so the question whether this type of collecting credits is appropriate arises. The possible answer could be the working experience of the attendants of the Special Education Program for Seafarers which should be taken into the consideration when giving a credit to a certain course.

3.2 Special programme of seafarer education and management of modern technologies

In the past decade fast technological changes formed the structure of technical - technological systems of marine vessels, especially in the sphere of information technologies. Investigations show that there is a disproportion in the application of new, especially information technologies of ship exploitation, with regard to the human factor. Frequent maritime accidents are indicative of the presence of human error as the cause of the accident in 75-96%[6] of the accidents recorded. In this sense, we can put into relation the application of modern technologies to the education and training of seafarers who are possibly not at the level of prevention of the occurrence of human error. Therefore, arising of human error in relation to sophisticated information systems of ship management should be viewed also with regard to the models of seafarer education and training.

A continuous technological improvement of marine vessels has lead to the phenomenon of an increasingly fast training of seafarers to counterbalance the traditional acquisition of maritime knowledge and skills at different European maritime universities. The basis of accelerated seafarer training or special education programme is based on the requirements of maritime industry for "more rational" acquisition of the required maritime knowledge and skills matching ship exploitation technology, in a relatively short time. In that sense, there appears the necessity of involving into the programme of technological changes a coherent programme of seafarer education whose duration and content will contribute to achieving effectiveness from the aspect of safety and optimization of modern technology applications.

The existing special programme of seafarer education in the Republic of Croatia has been created for pragmatic reasons and under urge coming from the maritime industry to establish a more effective education system that would produce seafarers trained at management level. The quality of such education is based on IMO model programmes providing minimum requirements according to 95/98 STCW Convention and complying with the university programmes according to the life-long education model. Such a programme of seafarer education is not based on previous projects and research that in cooperation with maritime industry would emphasize the optimum segments of the required knowledge and skills as

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[5] http://www.pfri.uniri.hr/, http://www.unidu.hr, http://www.unizd.hr/promet-pomorstvo

[6] Rothblum, A.: Human Error and Marine Safety, Maritime Human Factor Conference, Linthicum, MD, March 13-14, 2005.

regards the exploitation of the modern technical ship systems. This is due to the traditional view on seafarer education that is still present and results in insufficient research that could optimally be applied to maritime industry.

Therefore, the former attendants of the Special Programme should be followed in order to make corrections and improvements of the existing programme on the basis of their practical experience. With this in mind socio-technical evaluation of the staff mentioned should be carried out as they must fit into the modern technological changes that simultaneously require organizational changes. Consequently, the method of comparison of the established – traditional education and innovative – special education should be applied to the domains of[7]:

1. Technology in the field of: detection, acceptance and use of new technologies; critical selection of new technologies; formation of clear and fast response to the requirement of functionality of new technologies.
2. Communication systems in the field of: communication within and outside teams; communication from the top of the hierarchy towards its bottom and vice versa; creating communication characterized by expectation and wish in every individual to respond to, and not only accept the information – interactivity.
3. Leadership and management styles in the field of: innovation – creativity and openness to new ideas; autonomy and leadership – ability to cooperate; flexibility – acceptance of cultural differences; creating communication climate; participating leadership; delegating; motivating.
4. Results and safe acting in the field of: solving problems in interaction among technologies – communication – leadership; overcoming emergencies.

Using parallel statistical analysis of the established and innovative education according to the above mentioned approach indicators of certain educational models' effect on managing present-day technologies can be obtained both from the technological and organizational aspects. In this respect it should be borne in mind that the implementation of technological changes on board marine vessels is conditioned by the commercial requirements of the shipping companies and, generally, by profit tendencies of marine equipment industry in which usability standards are neglected. In short, this means that the equipment with the same purpose and goal there are different usability standards depending on the manufacturer and model, and varying from vessel to vessel.

In evaluating a model of education, therefore, it should be taken into account to clearly indicate in the domain of technology implementation the possibilities of critical selection of marine equipment elements according to its usability and functionality. It can be expected that in this sense the statistically acceptable responses will be based on the total seafaring experience and not on the previous education, as such a comparison has not been incorporated into the existing educational programmes. This would be an opportunity to practically compare congenial types of equipment models produced by different manufacturers following the criteria of usability and functional characteristics. Such an example contributes to opening further possibilities of upgrading the existing educational programmes in compliance with the actual requirements of managing present-day maritime system technologies.

4 CONCLUSION

The minimum STCW requirements are basic elements of all the above mentioned educational systems in the Republic of Croatia. The common requirement for admission to

[7] Mraović, B: Organizacijske implikacije tehnološkog razvoja, Nakladni zavod Globus, Zagreb 1995.

certain forms of education is four-year secondary school. To enrol on a special programme of education, as a part life-long learning, completed secondary education in a nautical college is required as well as previous sailing experience of 36-month-duration. Since both cases mentioned correspond to similar programmes, in the future the degree of success of the staff having finished the special programme based on the above mentioned methodology should be followed in order to be able to correct the study programmes, not only the special ones but also in ordinary studies. The tendency towards new forms of seafarer education will be increasingly pronounced due to the transition of maritime affairs to new organisational – technical components in conducting and managing the vessel. In this sense changes will probably also become necessary in the structure of the programmes currently prescribed by STCW.

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[10] http://www.azvo.hr

[11] http://e.europa.eu/lifelong-learning-policy/ects_en.htm

[12] http://www.marifuture.org

[13] http://www.unidu.hr,

[14] http://www.unizd.hr/promet-pomorstvo

[15] http://www.pfri.uniri.hr

[16] http://public.mzos.hr

TECHNOLOGICAL SYSTEM OF DYNAMIC POSITIONING

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ABSTRACT

Dynamic positioning is defined as the technological system featuring predefined programs and processes for maintaining and controlling the vessel's position. This paper deals with the position reference systems in combination with the controlling systems in dynamic positioning processes. The technological system of dynamic positioning is a relatively new technology which has been continuously developing since the 1960's. A comparative analysis of these systems has shown all their advantages and disadvantages. IMO has defined classes for DP equipment in line with specific DP operations. The paper presents a flowchart diagram of IMO classes in accordance with the risk assessment for particular DP technological operations.

Keywords: dynamic positioning, maintaining of position, controlling of position, position reference systems, controlling systems.

1 INTRODUCTION

Dynamic positioning (DP) may be defined as a technological system whose processes control the vessels fitted with DP systems. The system maintains the vessel's position and heading, i.e. enables changes in its position by implementing various systems and processes. The most important systems for maintaining or altering the vessel's position include:

1. Control DP system for controlling and directing a DP vessel, and
2. Position reference system for DP

The technological system of dynamic positioning (DP) is a relatively new technology, having emerged as a result of the increasing demands of the oil and gas exploration industry. In the early stage of the development of shore-based technologies, the exploited sources were in shallow waters and the technical and technological requirements for shore-based structures grew accordingly. The requirements for shore facilities have been progressively followed by the requirements for developing technologically advanced shore technologies and, simoultaneously, by the requirements for reliability and redundancy of DP systems. Risk analyses have been systematically made and suggestions for risk elements calculations have been given by means of the tabulation model which determines the risk level of individual DP processes.

On the basis of a comparative analysis of the existing systems and the pre-determined criteria for analysing the systems of positioning, advantages and disadvantages of the technological DP systems have been defined, as well as the suggestions for their improvement. The analysis is presented with the aid of the flowchart diagram, separately for each system.

2 TECHNOLOGICAL SYSTEM OF DYNAMIC POSITIONING

The technological system of dynamic positioning consists of the central processor connected to a number of systems. In DP processes, these systems are grouped into:

1. Position reference systems
2. Position control systems
3. Thruster systems
4. Reference systems in relation to the environment.

The position reference and control systems present two major systems of vital importance in the DP process. The entire DP process and the involved systems can be presented as the model in Figure 1.

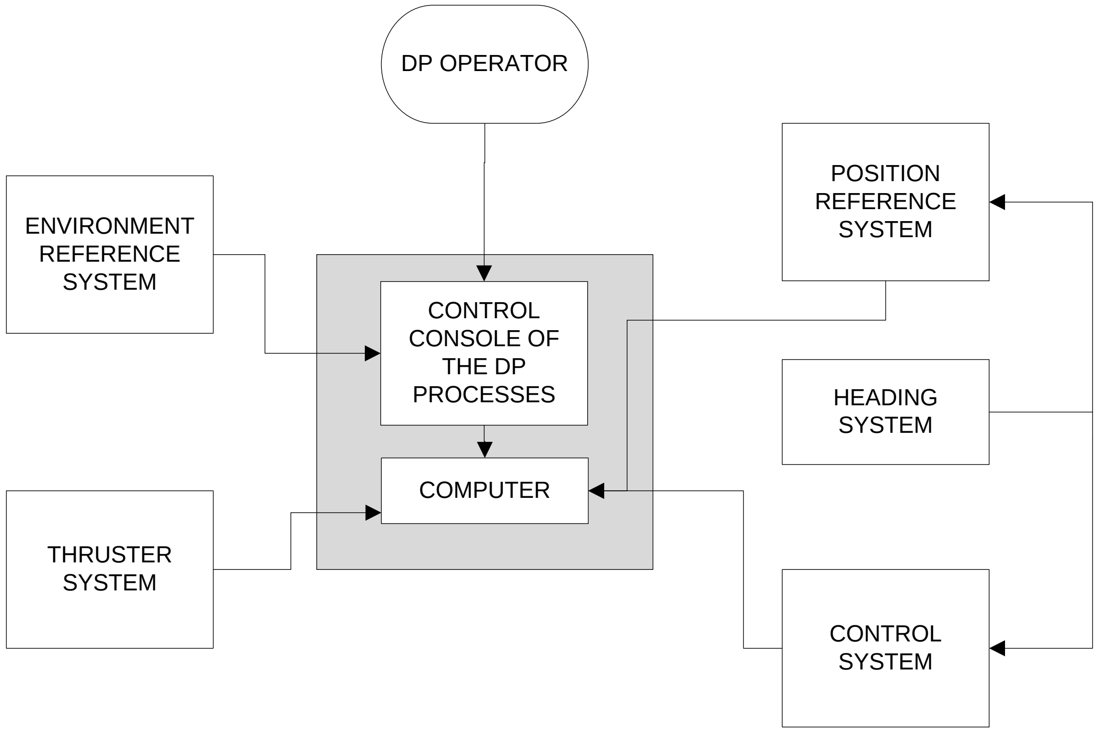

Figure 1: General model of the DP system and processes

Source: authors

2.1 Position reference systems

Maintaining the reliable and accurate reference position is the basis and the essential prerequisite for the successful technological DP process. When using Position Reference Systems (PRS), it is required to obtain the position data from a number of associated systems at a rate of once per second. During the process, it is necessary that the DP vessel maintains its position with the accuracy of one to two metres from the set point or the set position. DP vessels and DP processes use PRS systems that have been specifically designed for such services. The main PRS system types are:

- Hydro-acoustic Position Reference (HPR) technological system
- Artemis technological system
- Taut Wire System (TWS)

- Differential Global Positioning System (DGPS)[1]
- Radar technological system
- Laser positioning system.

Each of these systems operates separately and independently of the technological DP system. The DP system can receive multiple PRS input of data for determining the optimum position. This process is a function of the mathematical model of the system, presenting the connection of the system with the environment consisting of PRS systems (Figure 4).

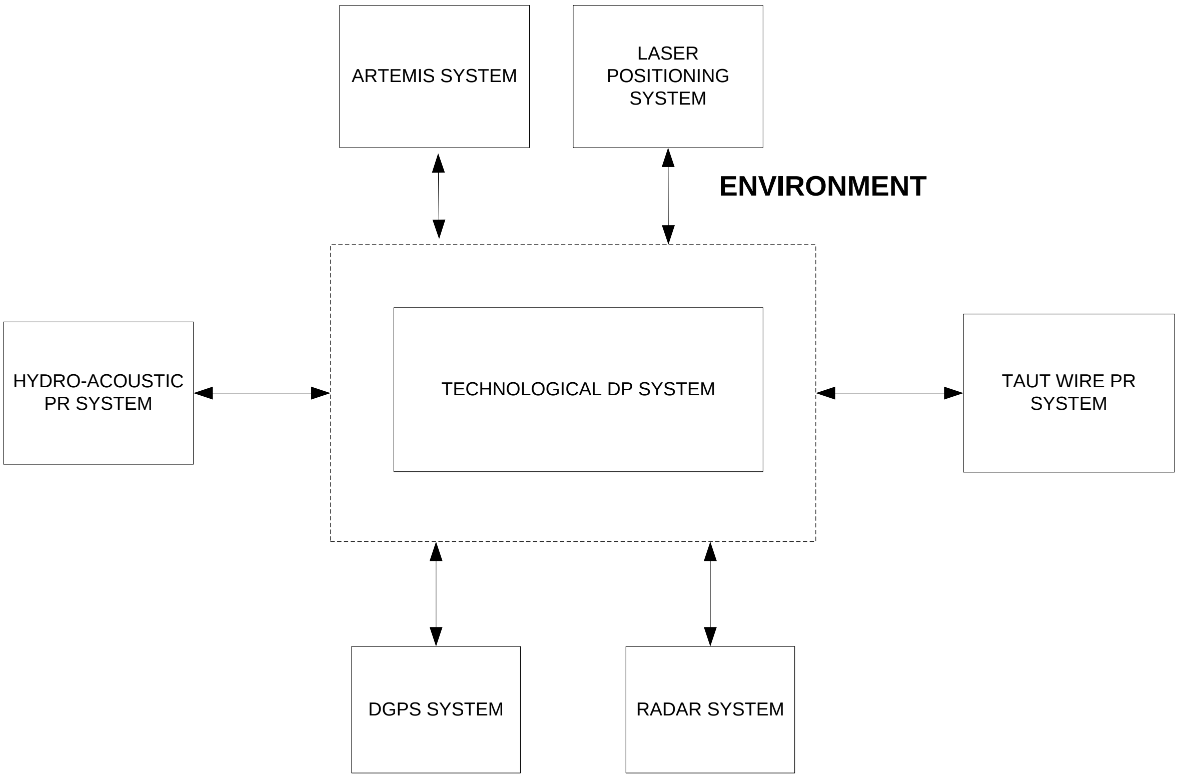

Figure 2: Connection of the DP system with the environment (PRS systems)

Source: authors

Each position of the reference system provides the relative position measured in relation to the known reference point. The reference point of the reference system's first position that has been selected becomes the original reference point. For the purpose of redundant operations, the vessel integrated in DP technological processes usually uses three or more position reference systems, allowing the DP system to apply the principle of voting logic for selecting the position.

The number of the applied position reference systems depends on:

- Level of risk involved in the operation
- Class of equipment as required by International Maritime Organization (IMO)
- Availability of reference systems that are reliable with regard to the risk of the DP processes
- Consequences of losing one or more references for obtaining the position.

[1] DGPS is one of the commonly used reference systems for DP vessels. In order to improve GPS accuracy to levels useful for DP, differential corrections are applied to GPS data by using reference shore-based stations.

In DP processes using Class 2 or Class 3 equipment, at least three position reference systems should be installed and simoultaneously available to the DP control system during DP processes.

2.2 Dynamic position control systems

Manoeuvrability of DP vessels is essential in DP processes. The main system in charge of maintaining the manoeuvrability is the DP control system. Efficient and reliable control systems are essential to successful DP processes. The main element of the control system is the thruster system. IMO requirements for thruster systems are the following:

- Thruster system has to provide adequate propulsion in the longitudinal and transverse directions
- Ensure the yaw moment for the control of heading
- In DP systems using Class 2 or Class 3 equipment, thruster systems have to be connected to the power supply systems in such a way that in the event of a power supply failure the thruster system keeps running
- Values of the momentum that the thruster systems use should be corrected by taking into account the interference between the thrusters and other factors affecting the momentum.

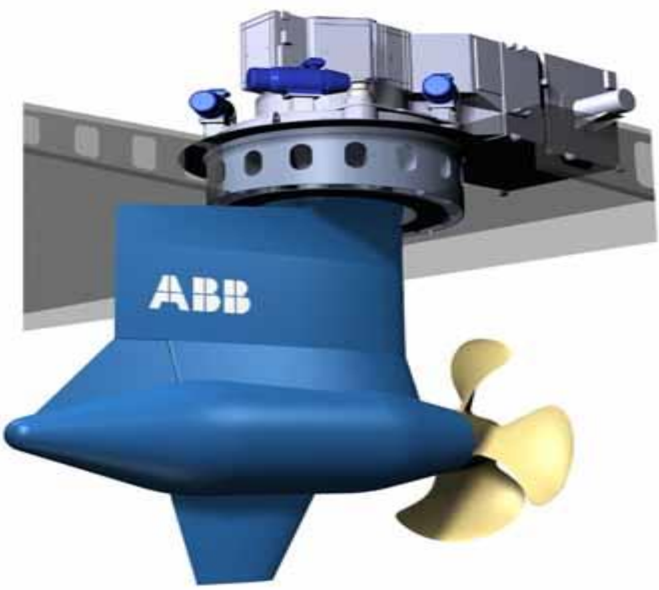

Figure 3: Thruster system of a DP vessel

Source: http://articles.maritimepropulsion.com/category/Research-Development.aspx

Thruster system failures affect the elements of the DP process:

- Control of pitching
- Control of heading
- Control of speed

Failures should not result in the thrust system idling or running in the uncontrolled heading during the DP process. During the process the thrust depends on two factors:

- Time that the DP vessel spends in the DP process
- Time that the DP vessel spends on long-haul voyages in conventional mode.

The very choice of the thruster system applied in the DP process depends on:
- Design of the DP vessel (size, hull configuration, draught and type of power supply system)
- Function of the DP vessel
- Level of required redundancy
- Type of the DP process that the DP vessel is engaged in.

Thruster systems may take the following designs:
- Main propellers
- Tunnel thrusters
- Azimuth thrusters.

2.2.1 Main propellers

Main propellers make part of the main propulsion system. The system may feature either single or twin screw propellers as well as a multiple rudder system as the propulsion's sub-system. In addition to the main propulsion, any DP installation may include various thrusters for better manoeuvrability.

2.2.2 Tunnel thrusters

Tunnel thrusters are fitted in the bow or in the stern of the DP vessel, allowing her to turn or to move sideways during the DP process. Three bow tunnel thrusters and two stern tunnel thrusters are required in complex DP processes.

Figure 4: Tunnel thruster system

Source: http://www.nauticexpo.com/cat/marine-propulsion/ship-lateral-thrusters-DA-1406.html

The efficiency of tunnel thrusters may be presented as a set of variables K[2] which depends on the coefficients: d_{ip}, c, d, p_s, s_v, $l_{t.}$

f (d_{ip}, c, d, p_s, s_v, l_t) = K

d_{ip} = depth immersion of propeller
c = cavitation
d = draught
p_s = pitching
s_v = speed of vessel
l_t = length of tunnel

The greatest impact on a DP process is exerted by the coefficient of pitching ($p_{s).}$ Tunnel thrusters are limited to manoeuvring operations. Unlike azimuth thrusters, they can not be used as back-up propulsion.

2.2.3 AZIMUTH THRUSTERS

Azimuth thrusters can be rotated to provide thrust in any directions. They may be grouped into:

1. Fixed thrusters
2. Podded thrusters.

Figure 5: Azimuth thruster system (fixed)

Source: http://www.ngc.com.cn/en/proinfo.asp?id=145

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[2] Source: authors

Figure 6: Azimuth thruster system (podded)

Source:
http://www.zf.com/corporate/en/products/product_range/further_product_ranges/boats/azimuth_thrusters

Unlike tunnel thrusters, azimuth thrusters can be controlled at higher speeds. They have the advantage that they can provide additional manoeuvrability and are often used as main propulsion in lieu of conventional propellers. When under way, the azimuth thruster system should allow the function of controlling the vessel and is connected to the autopilot[3]. This type of thruster may be retractable, rectracting into the hull and extracting from the hull horizontally and vertically.

The technological process of azimuth thrusters has two main functions:

1. Function of moving ahead (Ah) – the efficiency is maximum
2. Function of moving astern (As) – at 60% of the maximum efficiency.

The size of the azimuth thrusters depends on the size of the vessel above and below the waterline and on weather conditions under which they operate.

The weather conditions affecting the azimuth thrust operation include:

- Wind speed (b_v) and wind direction (s_v)
- Sea state (v_v) and wave direction (s_w)
- Current force (b_s) and current direction (s_s).

In technological DP processes using azimuth thrusters, a DP process may be considered successful if the thruster system responds accurately and timely.

3 ADVANTAGES AND DISADVANTAGES OF DP TECHNIQUES

Mobile platforms, the so-called Jack-up barges, was the first technology used for dynamic positioning in offshore drilling operations. It started in the 1960s and was accompanied by anchoring technique. With drilling moving into ever deeper waters, Jack-up barges could not be used any more and anchoring became less economical so that, during the 1960s, the dynamic positioning system was invented and has been continuously upgraded and enhanced ever since. Figure 7 provides a comparative analysis of position-keeping options, presenting their advantages and disadvantages.

[3] An autopilot is a navigational device whose task is to keep the vessel on the set course during navigation.

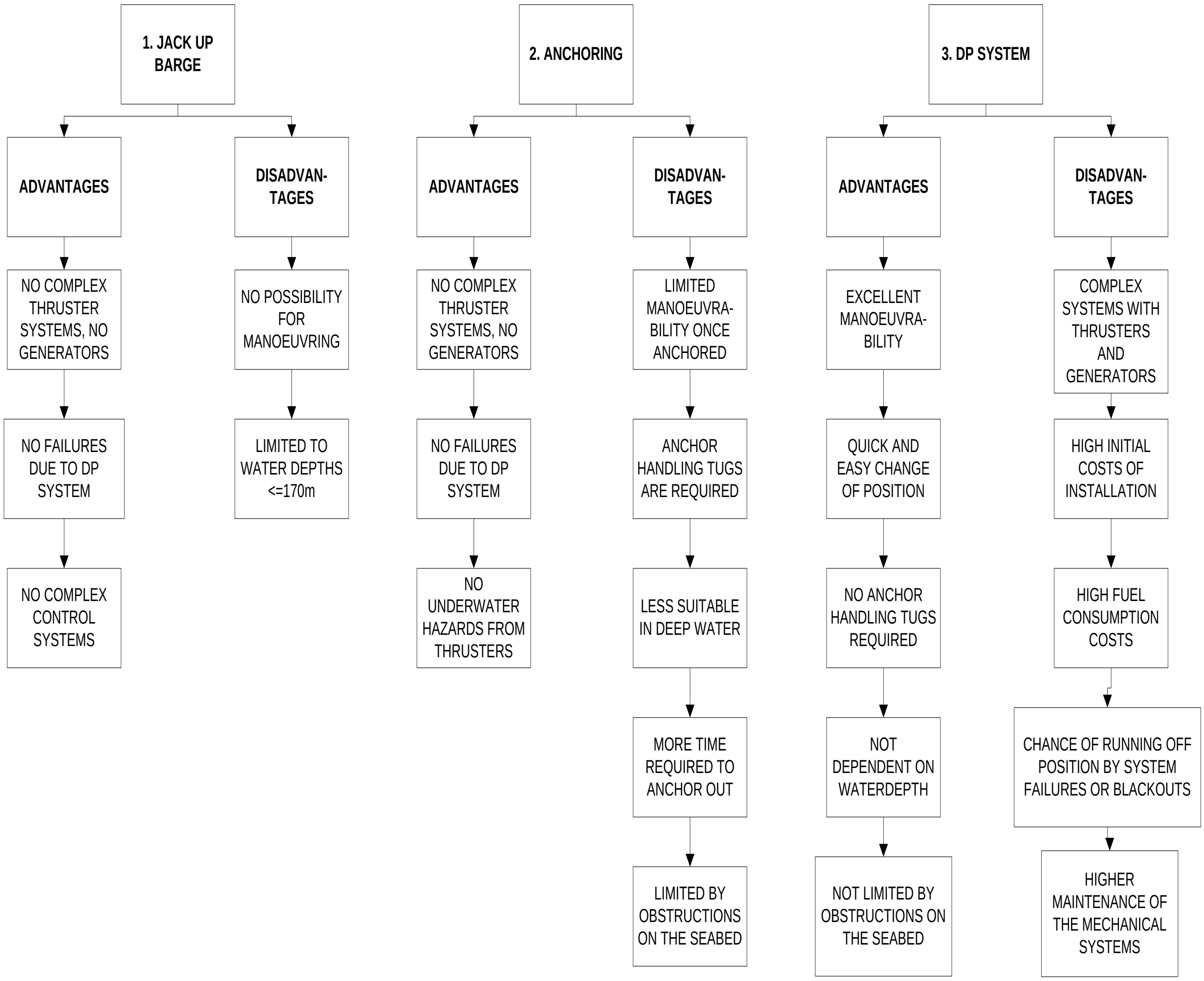

Figure 7: Advantages and disadvantages of position-keeping systems

Source: authors

4 CONCLUSION

It can be noted that the DP process is just one of the position-keeping operation options. In spite of the advanced DP technology, it is not an ideal solution, given the fact that the system has its drawbacks. Further research should be encouraged and new measures introduced in order to bring the DP technology onto a higher level of safety and operability. It is suggested that the vessels experiencing difficulties and accidents are continuously monitored and that, with regard to these events, detailed risk analyses are made. On the risk assessment basis, measures can be defined and introduced for reducing the risk. Pursuing a higher profit, most of the DP equipment manufacturers wish to install higher Class DP equipment, which is not really necessary in some cases. A tabular list of equipment according to the level and class is suggested, in line with the existing risk level and the specific area where a DP process is carried out, which is not the practice on today's DP vessels. Taking into consideration the technical complexity of the DP systems that are engaged in performing DP processes, it can be concluded that these systems have not yet reached the level of full automation as the control of the entire process still remains dependant on human factor. The paper has also provided a comparative analysis of the reference positioning systems and has described the ways they differ by indicating the advantages and disadvantages of these systems. It is exactly their variety and operating limitations that require further study and analysis, in order to be able to select the appropriate technology to be engaged in specific operation and onboard a specific vessel.

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ANALYSIS OF A MODEL OF ENERGY OPTIMIZATION FOR A TRAIN DRIVER ASSISTANCE SYSTEM

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ABSTRACT

The minimization of energy consumption represents a key challenge for train operating companies to reduce the operational costs of fuel or electricity and to provide cost-effective services to users.
Commercial timetables are usually designed so that drivers can use part of the running time reserve between the minimal estimated time and the commercial time in order to recover short delays. As known, there is a relationship between the energy consumption and the running time. Therefore, the more the train circulates close to the minimal running time, the greater is the energy that is consumed.
This research proposes a model which calculates the energy-optimal speed profile for electric trains in undisturbed operations under a given timetable. The core element of the obtained driving strategy is the so-called ‘coasting’ phase, the driving regime during which no tractive or braking effort is applied.
The algorithm intuitively indicates the driver the switching points of the optimized sequence of driving regimes through simple advisory instructions displayed in real time. The difference between the minimal estimated energy consumed at pantograph level and the actual energy consumption for some local passenger trains, which has been previously measured through GPS data logging, is then reported.
This simple approach is ready to be integrated in an on-board ITS device of a ‘driver assistance system’, which requires real-time train location by the use of GPS or odometers.
This paper contains preliminary results of the research and also some recommendations for further analysis.

Keywords: railway, energy, optimization, driving, assistance

1 INTRODUCTION

The use of innovative technologies is a key factor of success when train operating companies and infrastructure owners aim at improving overall performance, quality of service and profits. Intelligent Transport Systems (ITSs) may lead to safer, more cost-effective public transport services, which are therefore likely to attract a greater number of users and achieve a higher level of flexibility to meet the demand. Furthermore, another important outcome is the reduction of operational costs as well as the rising resource management.

Technologies aimed at minimizing the energy consumption of trains prove to offer great opportunities and can support train operating companies to effectively reduce the energy costs. Various approaches can be found in the literature concerning on-board devices for energy-efficient driving.

1.1 Approaches in the literature

Various approaches for the computation of the energy-optimal driving strategy can be found in the existing literature and grouped as follows:

1. Modeling the train run between two consecutive stations as a linear or non-linear optimum control problem with explicit solution by means of the *Pontryagin's Maximum Principle* ([1] - [3], [6] - [8], [11]);
2. Representing the train run between two consecutive stations or along a route with multiple stops as a multi-stage decision problem solved by means of *Bellman's Dynamic Programming* ([1] - [3], [6]);
3. Modeling the driving style of a train as a linear or non-linear optimum problem solved by means of search algorithms (e.g., Genetic Algorithms [4]);
4. Modeling the driving style of a train as a non-linear simulation with implicit solution of the optimum problem by means of different initial values of the switching points ([12]);
5. Taking into account also disturbances in the whole railway network and determining the optimal speed profile for each single train involved in the conflict-affected area by means of search methods ([3]).

The existing models show some limits which has led to the formulation of a new approach. In fact, an explicit solution of the optimal control problem requires some linearization of the laws of motion, which proves to be barely adequate to long distance traffic. Moreover, when dealing with real-time conflicts, a continuous communication with the signaling system and the traffic control centre is necessary but expensive, so the fifth type of models are out of the scope.

The presented approach keeps the theoretical basics of the first family of models and extends them through the method of the second group in the list. A specific method is used to solve the problem and proves to be more suited than the others according to the level of complexity.

1.2 State of the art

A *Driver Assistance System* (DAS) helps train drivers by making recommendations concerning speed and acceleration or deceleration for energy-minimal operations. The driver receives real-time data on a personal digital assistant (PDA), on a laptop or on the in-cab displays. The software tool calculates optimized target speed and traction force and constantly updates them to the actual time and position. The system thereby minimizes the energy needed to run a train according to its allotted timetable and allows smoother operation of the trains so as to reduce wear and costs.

The fundamental requirements of a DAS are as follows:

- Determination of the target arrival time for the train at stations and junctions that must be achieved to satisfy the published timetable and avoid conflicts with other trains;
- Calculation of an energy-optimal speed-distance profile starting from the current train location and time, to achieve the target arrival times along the route;
- Monitoring the movement of the train and providing information to the driver so that the speed-distance profile is followed and target arrival times are achieved.

Today there are several systems that are offered by suppliers or developed by railway undertakings for their own use. The majority of these are stand-alone train-borne systems, but in most cases there is possibility of future links to a control centre of a traffic management system. A complete list of these systems can be found in the literature [5] [10].

2 METHOD

The method of development consists of the following steps:

1. Definition of the model for the motion of trains in the energy-optimal train control problem based on previous works;
2. Development of the algorithm for solving the problem;
3. Adjustments to the procedure in order to take into account the actual driving of a train.

2.1 Principles

The most important part of the energy consumed by railways is the mechanical energy used to overcome the driving resistances to which the vehicle is subject while moving from one point of its route to another. The driving style adopted by the train driver greatly influences the mechanical energy consumption and the energy costs of the railway undertaking as a consequence. The mechanical power at the wheel-rail interface P_{mech} can be expressed as the product of tractive effort F at wheel rim and speed v. Then, the mechanical energy E_{mech} consumed during train movements is given by the integral of mechanical power P_{mech} over time t.

$$E_{mech} = \int F(t)\, v(t)\, dt \quad (1)$$

If we consider electric powered trains, the net electric energy consumption E_{el} is given by the ratio of mechanical power P_{mech} to the efficiency of the traction system η.

$$E_{el} = \int \frac{P_{mech}}{\eta}\, dt \quad (2)$$

Positive tractive effort (during acceleration or while holding speed) determines energy consumption and should be reduced as much as possible within the given timetable. The higher the speed to hold is, the more energy is consumed during the driving process. Every acceleration process requires a certain amount of energy, so unnecessary acceleration should be avoided, whether it follows a regular stop (planned process) or a stop at a signal (unplanned stop).

This strategy is greatly influenced by the punctuality of the train according to the scheduled timetable, since neither late arrivals nor early arrivals at stations are permitted (at least for a given time tolerance). In fact, planned running times, on which timetables are based, consist of the sum of the minimum running time and a running time reserve, which takes into account possible short deviations. The shorter the running time reserve until a target point is available, the more the train has to accelerate, and the more energy is consumed. If the train departs with a delay greater than the available running time reserve, it has to follow the time-optimal trajectory (i.e., as fast as possible) so as to reduce that deviation from timetable as much as possible (i.e., with the maximum energy consumption). Conversely, if that delay is less than the available running time reserve, an energy-optimal driving strategy – i.e., determining which tractive or braking effort to apply at which instant of time – may be followed in order to minimize mechanical energy.

If the track is presently unoccupied and the route to the next station is set, the train will move from one station to the next according to the scheduled timetable – i.e., with no disturbance. In undisturbed operations, the energy-optimal train control problem is modeled to find the points in space and time at which the driving style shall change in order to arrive at the next target point on time and with the lowest energy consumption. In other words, it is a constrained optimization problem with continuous control. The goal is the minimization of a cost function which expresses the energy consumption of the train and the constraints are given by timetable, infrastructure and train data.

The simplest application of energy optimization in undisturbed operations deals with a train movement between a pair of stations (i.e., with no intermediate stops) on a line section which has one permitted speed restriction and one slope. The key input variable of this approach is the availability of the running time slack of that line section under the given timetable.

According to the optimal control theory [1], a train journey between a pair of stops can consist of an energy-optimal sequence of at most four driving regimes, which are as follows:

1. Acceleration with maximal tractive effort;
2. Speed holding (also known as 'cruising')at the maximum permitted value with partial tractive or braking effort;
3. 'Coasting' – i.e., the driving regime during which no tractive or braking effort is applied;
4. Braking with maximal braking effort.

Coasting may precede speed holding in case of steep descents – i.e., when the sum of all resistances is negative.

Depending on the available running time reserve on the line section, the energy-optimal driving strategy can omit the coasting driving regime or the speed holding one. In fact, a relationship exists between mechanical energy consumption and available running time reserve. In other words, the more the train circulates close to the minimum running time, the more energy is consumed during operations.

2.2 Model

The model is based on some assumptions which are commonly used in simulation programs:

1. The train is modeled as a mass point;
2. Return travel is excluded;
3. Speed limit exceeding is not allowed;
4. Only line sections between two consecutive stops are considered;
5. Each line sub-section, into which the section is divided, has only one speed limit and gradient;
6. Only continuous train control is considered;
7. The adhesion limit at the wheel-rail interface depends on the weather conditions that may influence the status of the rail rolling surface;

The definition of the dynamics of the movement of a single train along a certain route is fundamental to the resolution of any problem involving railway vehicles. The key physical laws concerning the mechanical behavior of a train, which moves on a line section between two consecutive stops, are presented with reference to the four driving regimes listed in

Chapter 2.1 and are taken from sources of international proven validity found in the literature [13].

As known [1], the speed profile of a train running with the shortest possible time between two consecutive stops consists of a non-linear acceleration with maximal rate, speed holding when the maximum allowed speed has been reached and a constant deceleration so as to come to a standstill (see Figure 1).

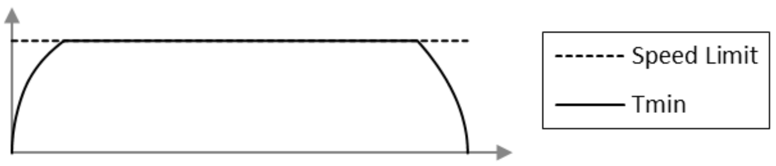

Figure 1: Speed-distance diagram of a train running between two consecutive stops (minimum running time)

However, some adjustments have been introduced into the proposed model in order to take into account the actual behavior of train drivers. In fact, the power output while the train is speeding up is limited for passengers' comfort and to reduce the wear of the rolling stock. The target speed to be hold is lower than the maximum permitted one (e.g., -5 km/h) in order to avoid the risk of emergency braking due to the intervention of the onboard automatic train protection system (ATP). The deceleration rate while the train is slowing down with the application of brakes is equal to half the UIC default value.

According to the commercial timetable, the scheduled running time between each pair of consecutive stops is fixed and a running time reserve is available so that trains can recover short delays if necessary. If the train is already running late, the running time reserve is used to arrive on time at the next stop along the route. Conversely, if the train is likely to come earlier to the next station according to the time-minimal speed profile, a 'coasting' driving regime can be included during real operations based on the current train location. This driving strategy allows trains to run on time as well as to minimize the energy consumption since coasting needs no mechanical energy. As a consequence, if the available running time reserve is sufficient to allow the energy-saving strategy, the initial and final points of coasting in the speed profile shall be determined to guarantee the expected punctuality (see Figure 2). The more the train circulates close to the minimum running time, the more energy is consumed.

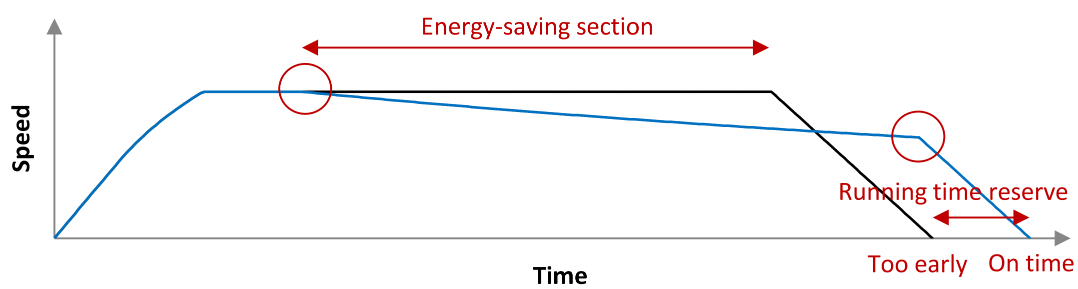

Figure 2: The role of the running time reserve for the energy minimization

3 APPROACH TO THE PROBLEM

The proposed model is based on the four driving regimes of the energy-optimal train control problem presented in Chapter 2.1. Firstly, the simple case of a line section with single positive gradient and constant speed limit is considered. Secondly, negative gradients and changes of slope and maximum allowed speed are considered as an extension of the previous case.

3.1 Level tracks and ascending slopes

If a horizontal line section is considered, the net mechanical energy consumption increases non-linearly during acceleration, takes a lower constant value during speed holding and is equal to zero during coasting and braking. This implies that the shorter the speed holding time interval (or distance interval) is, the more mechanical energy is saved during the whole journey. This time interval depends on the duration of the coasting driving regime, whose final speed shall be calculated (see Figure 3).

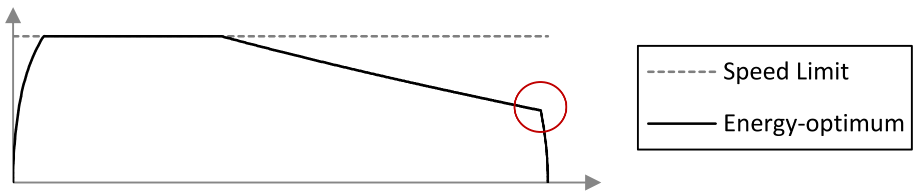

Figure 3: Speed-distance diagram of a train running on a horizontal line section and coasting after having reached the maximum allowed speed

If the line section is short (or the remaining running time is long) so that the maximum permitted speed is not reached (Figure 4), speed holding is omitted, coasting starts at a lower speed to be determined, and even less energy is consumed.

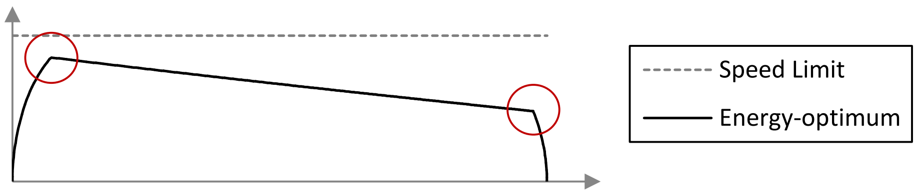

Figure 4: Speed-distance diagram of a train running on a horizontal line section and coasting before reaching the maximum allowed speed

The key solutions of the problem defined in the proposed model are the switching points between the driving regimes of the energy-optimal speed profile (see red circles in Figure 3 and in Figure 4). The minimization of the mechanical energy consumption is then implicitly achieved.

If we do not assume the energy-efficient driving of a train on a level line section as subject to a given timetable, two different speed profiles act as boundary strategies:

1. *Time-minimal driving strategy*: It is the trajectory of a train moving from one stop to another with the minimum running time of the line section, thus causing the maximum energy consumption during the journey; coasting is omitted.
2. *Energy-minimal driving strategy with infinite time horizon*: It is the trajectory of a train moving from one stop to another with the maximum running time of the line section, thus not taking into account a certain time horizon and causing the minimum energy consumption during the journey; full braking is omitted.

When considering a given timetable, the net energy consumption of a train depends on the available running time reserve and, since the solution of the energy-optimal train control problem with finite time horizon is unique, the 'goal running time' of a specific journey corresponds to only one energy-optimal driving strategy. The goal running time is given by the sum of the minimum running time and the available running time reserve, and it might take any value between the minimum running time and the maximum one.

As can be seen in Figure 5, the coasting driving regime for a specific set of train and track data describes a family of curves depending on a parameter that is the goal running time mentioned above. Each curve referring to a certain value of the running time intersects the 'speed holding' horizontal line (or the 'acceleration' curve if maximum permitted speed is not reached) and the 'braking' curve so as to indentify the unknown switching points.

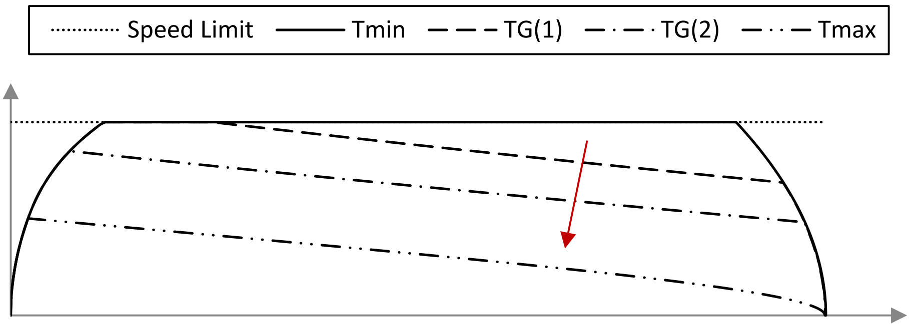

Figure 5: Speed-distance diagram of a train running on a horizontal line section with different running times

3.2 Descending slopes

According to Equation (4), the acceleration becomes zero on moderately or steeply descending grades for a certain value of speed, which is called 'critical speed'.

$$v_{crit} = v_{00} \cdot \left(\sqrt{\left(\frac{a_1}{2 \cdot a_2}\right)^2 - \frac{a_0}{a_2}} - \frac{a_1}{2 \cdot a_2} \right) \tag{3}$$

Therefore, the critical speed causes the total running resistance to change sign on descents, and it generates a uniform linear motion with constant velocity if no tractive effort is applied, since the vehicle resistance equals the line resistance. If the instantaneous speed is higher than the critical speed, the instantaneous acceleration is always negative, so the train slows down while coasting as in the case of horizontal lines and ascents. Conversely, if the instantaneous speed is lower than the critical speed, the instantaneous acceleration is always positive, so the train speeds up while coasting. In case the maximum allowed speed is lower than the critical speed (i.e., in case of steep descents), the target speed during the 'cruising' driving regime is hold through the application of brakes.

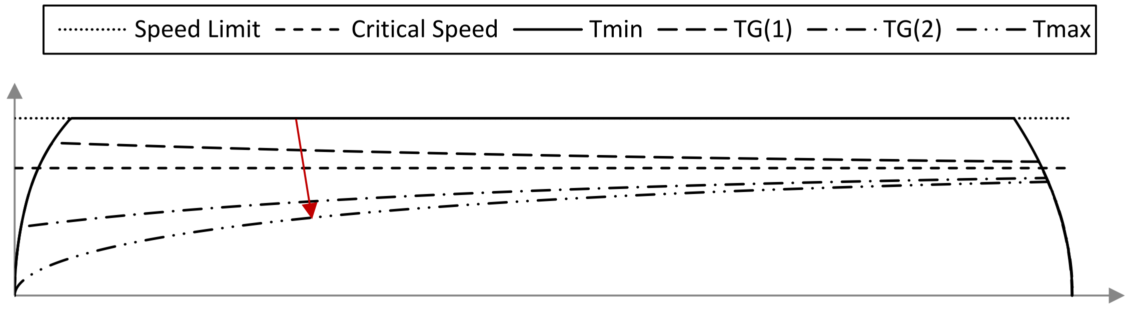

Figure 6: Speed-distance diagram of a train running on a descending line section with different running times

4 ALGORITHM

The considered problem is a continuous constrained optimization problem which minimizes the mechanical energy of a single train moving between two consecutive stops under a given timetable.

4.1 Single gradient and speed limit

If we consider a line section with constant gradient and speed limit, a search method can find an optimal solution in one or two variables (i.e., the switching points of the coasting driving regime, see Chapter 3.1) over a real-valued constrained search-space. A metaheuristic based on the Generalized Reduced Gradient (GRG) method is used to solve this non-linear constrained multivariable problem. In case of non-smooth problems, the GRG method might move from a candidate solution to another similarly to a 'steepest ascent hill-climbing' method, where all successors are compared and the closest to the solution is chosen and which fails if there are local maxima in the search space which are not solutions. However, the GRG method is still able to find an optimal global solution of the non-smooth energy optimization problem if the initial conditions are properly chosen at every restart of the algorithm.

Before the procedure is launched, all train and track data must be given. Then, switching points are unknown in terms of speed, distance and time. Some of the switching speeds are immediately known and the time and distance intervals are derived according to proven formulas [13].

The analyzed energy-optimal train control model seeks the global maximum and minimum of energy consumption with infinite time horizon, which correspond to the time-unconstrained 'energy-maximal' (or 'time-minimal') and 'energy-minimal' (or 'time-maximal') trajectories respectively. Afterwards, the time-constrained energy-minimal trajectory is computed for a given goal running time within the real-valued bounded interval between the previously determined minimal and maximal running time.

Every goal trajectory can be influenced by at least one of the following possible events:

- The line section has a significant negative value of the gradient or not;
- The train circulates on a line section with a steep descent, in which the maximum permitted speed is higher or lower than the critical speed;

- The length of the line section is sufficient for reaching the maximum permitted speed or not – i.e., the 'speed holding' driving regime is omitted or not.

As a consequence, different sets of driving regimes are derived and the algorithm is adapted for every single sub-problem of the multi-level structure of routines.

In every sub-problem, the boundary conditions on the switching points and on the 'speed holding' driving regime are set and the initial feasible values of the unknown switching points are found. Then, the GRG method gives the final solution to be verified through some tolerance tests.

Finally, the net electrical energy consumption can be determined according to Equations (1)-(2) and a simulation algorithm computes the energy-optimal speed profile.

4.2 Multiple gradients and speed limits

Shall a line section with a stepwise speed limit and/or at least two different slopes be modeled properly, an extension of the approach described so far is recommended. The energy-optimal train control problem for line sections with multiple speed limits and gradients is solved by means of *dynamic programming* [6], which solves complex problems by breaking them down into simpler sub-problems in a recursive manner. In this case, the simpler sub-problems are the energy optimization problems for line sections with constant speed limit and gradient, while the general problem uses a recursive algorithm similar to the gradient descent method. The procedure consists of the following steps:

1. Division of the considered line section into a set of sub-sections with constant gradient and speed limit;
2. Determination of the maximum entrance and exit speeds for every sub-section;
3. Computation of the time-minimal trajectory and of the time-maximal one;
4. Determination of the difference between minimum and maximum running time for each sub-section and of the available running time reserve for the whole section;
5. Iterative loop: computation of the energy-optimal trajectory by increasing the overall running time;
6. Iterative loop: computation of the energy-optimal trajectory by decreasing the exit speeds of the sub-sections.

At each iteration, the net electrical energy consumption of every single sub-section is estimated after changes of running time or exit speed. The simulated changes are approved for the sub-section which has the greatest value of energy savings according to the difference quotient. The procedure stops when all the available running time reserve has been distributed uniformly among all the sub-sections into which the line section had been divided.

5 CASE STUDY

A comparison between simulated and real driving is necessary to prove the effective benefits of a DAS based on the proposed model.

The case study is the conventional mixed-traffic railway line Trieste C.Le – Udine, which is standard-gauge, double-track and electrified with a DC 3kV overhead catenary power supply system on all its length of 82 km. Since the daily rail traffic is not dense and the probability of conflicts is low, the hypothesis of undisturbed operations is correct in this case.

The considered trains are those of the current modern passenger fleet for public local transport:

- Italian FS Class ALe 501-502 “Minuetto” EMUs (“Regionale” service);
- Italian FS Class E.464 electric locomotive hauling MDVC/MDVE passenger cars (“Regionale Veloce” service).

A sufficient set of measurements has been recorded for data collection through the installation of GPS devices onboard during real operations.

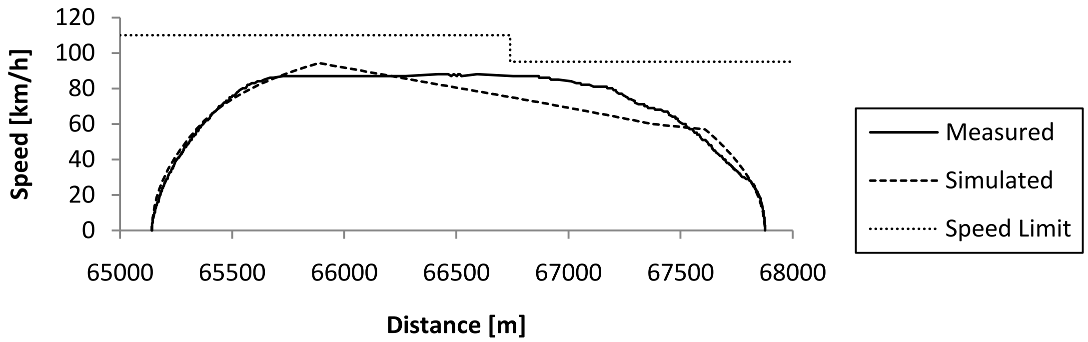

Figure 7: Speed-distance diagram of an Italian FS Class ALe 501-502 EMU: measured and simulated speed profiles in the case study on the line section from Sistiana Visogliano to Bivio d’Aurisina

As can be seen in Figure 7, train drivers are likely to hold a target speed much lower than the maximum allowed speed and to set a multi-stage service braking so as not to overcome the next planned stop. The presented approach is focused on the coasting driving regime since the latter does not consume mechanical energy and finds the switching point at which the train driver has to apply an uniform braking. Therefore, a DAS may also support drivers for those actions which are hard to predict without a specific tool.

The preliminary results show the significant benefits which may be obtained through the implementation of the proposed algorithm in a DAS and they are summarized in Table 1 in terms of average differences between simulated and measured energy savings for every considered train service.

Table 1: Average Differences between Simulated and Measured Energy Savings in the Case Study

Route	Service	Average Difference of Energy Savings
Trieste C.Le – Udine	Regionale	12,30%
Monfalcone – Trieste C.Le	Regionale	16,15%
Trieste C.Le – Gorizia C.Le	RegionaleVeloce	15,20%

6 REAL-TIME OPERATIONS

Various disturbances such as longer dwell times at stations, adverse weather and temporary speed restrictions might affect the train journey during real-time operations. A driver support tool must take into account the way external elements influence the adherence to the timetable and the resulting behavior of drivers, thus causing an energy consumption which becomes different from the one forecasted at the departure from the last stop. The algorithm for energy optimization shall compute a new speed profile instant by instant in order to minimize the mechanical energy effectively according to the current state of the system (see Figure 8).

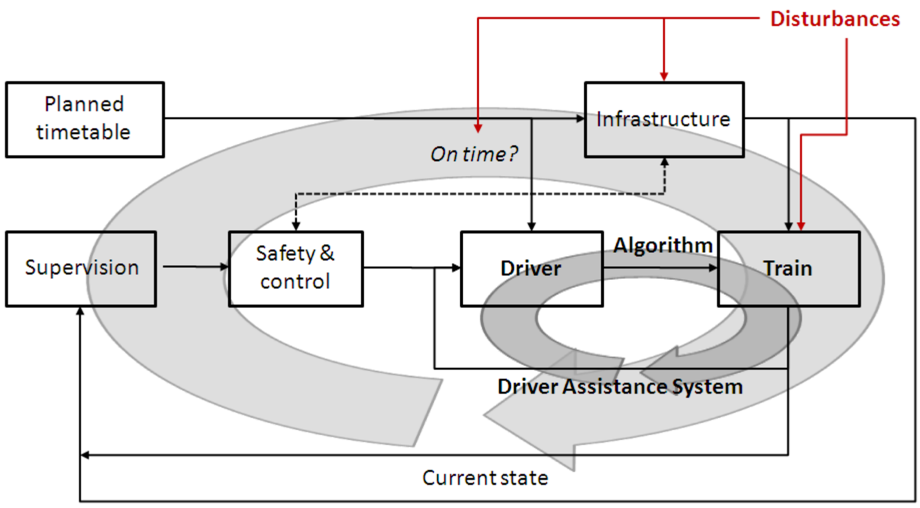

Figure 8: Train control loop

The proposed model for the energy-optimal control of a train can be implemented in a DAS. In fact, as the current position, time and speed of the train are known, the algorithm can compute the energy-minimal speed profile on the line section between the current train location on the route and the next scheduled stop. The goal running time, to which the problem is subject, is given by the interval between the current instant of time and the planned arrival time at the next station. If this time value is less than the estimated minimum running time, there is no more available running time reserve to be used for energy minimization and the train has to run as fast as not to increase the current delay, according to the operating rules. Conversely, if the goal running time is greater than the estimated maximum running time (unlikely in practice), the train will necessarily arrive earlier at the next stop.

The updated switching points between different driving regimes shall be shown to the train driver through a simple driver-machine interface (DMI), so that he/she would be able to intuitively adjust their behavior. The information which is displayed to achieve an energy-efficient driving style shall be conceived in form of advice, since the minimization of energy consumption is not mandatory.

The data to be input in a possible DAS, which can be based on the proposed algorithm, are divided into train data, track data and timetable data. The length and gradient of line sections/sub-sections should be derived from the real horizontal and vertical alignment of the track rather than the 'line file' data (provided to drivers). In fact, the latter is actually a virtual track profile which proves to be an overestimated approximation and is mainly used for safety reasons. All this information may be input and updated directly through the DMI or communicated via radio (GSM-R) from the control centre.

If the driver is already provided with a tablet PC showing real-time information on timetable and route of a specific service, the output data may also include at least the following key advice for the practical energy-minimization:

- Current recommendation on the energy-optimal driving regime;
- Countdown to the next switching point of the energy-optimal trajectory.

All this information must be updated in real-time – i.e., every 5-10 seconds. The switching point at which the driver should start coasting may be also announced with an acoustic signal.

7 CONCLUSIONS

The study proves the potential benefits of the proposed approach for the energy optimization during train operation, and it indicates the possible implementation in a Driver Assistance System (DAS)which provides the driver with real-time advice in order to run on schedule as well as to consume the minimum net electrical energy under the given constraints.

The case study of the Trieste C.Le – Udine railway line has been chosen and several data have been collected on modern regional trains by means of on-board installation of GPS devices. The comparison of the computed energy-minimal driving strategies with the measured speed profiles shows the great difference from the actual behavior, even if trains were running ahead of schedule during operations.

The hypothesis of undisturbed train movements (i.e., not considering unplanned conflicts) proves to be correct for a practical use of the presented approach in the case study only if the track database takes into account speed restrictions due to the lack of the 'infill' functionality of the existing ATP system in some stations.

Although the energy consumption is already brought down in reality without the aid of recommended speeds, the calculation of the theoretical optimal trajectory is still very useful for further improvements since coasting is hard to be precisely predicted in practical driving.

Further research should be done to analyze other case studies and to extend the model to the case of conflict-affected areas, so that the potential of energy-optimal train control might be fully exploited.

The preliminary results confirm the effective potentials for cost savings related to electric power usage during operations in the case study, especially on short line sections with mainly level or descending tracks.

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CITY OF THE FUTURE AND THE SMOOTH AND SAFE FLOW OF TRAFFIC - INNOVATIVE SOLUTIONS

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ABSTRACT

The future city in terms of traffic safety presents the work that shows the capabilities and utilization of surfaces with conceptual designs and safer transportation and movement of passengers, cyclists and pedestrians. In this paper were presented four conceptual solutions as an alternative vision of transportation and movement with bikes and pedestrians and this will increase safety and environmental sustainability. Conceptual design present a bicycle route along the river on both sides, and the bike route between the routes of tram track. Conceptual design of travelator for public transport of passengers. Conceptual design of lowering the tram route in the trough by glass covering roof and outside visual communication. Covering with the dome pedestrian flows in the area of Main Street on the stretch and the fourth segment of the conceptual design of pedestrian flow is covering with movable transparent roofs the main pedestrian street. All solutions are analyzed in terms of the role and importance of safety and environmental feasibility traffic carrier transport functions of city development and communication of citizens. Traffic solutions, transport and mobility offered in this thesis were not present in this region and there are not known to the wider areas of the developing cities and it should serve as idea for increasing problems of developing towns in the area with insufficient space for pedestrians and cyclists as well as an offer for bigger and massive transportation of persons in the city. All of idea and innovations is implementations at simulations of the city Sarajevo which have about half millions citizens.

Keywords: Traffic safety, designs and safer transportation, cyclists and pedestrians, conceptual design

1 INTRODUCTION

In every modern city, there is a specific focus of the pedestrians and cyclists. Alternative forms of transport in the modern world are the trend that every day is more and more widespread [8]. Walkers are the most vulnerable road users that must provide the physical protection of motor vehicles. Sarajevo city of the future needs to follow the trends of European cities and world capitals, to increase alternative modes of transport, modernizing existing infrastructure, increase the level of safety of the road users. Through the master's thesis and its implementation additionally would provided comfortable lifestyle, for walkers would provide areas that are sheltered from the weather and protected from motor vehicles. Urban cycling is not just a form of transportation choice; it is a kind of social phenomenon that incorporates environmental awareness, the desire to own better health, a way to save on transportation costs and vehicle maintenance [7]. We can say that cycling is a new way of thinking of a large number of citizens of Sarajevo who are increasingly opting to become a cyclist. Although the number of cyclists is bigger and bigger every day on the streets of Sarajevo, the city authorities have not yet decided to organized react to this phenomenon [1]. According bike sales trends and current conditions in which cyclists ride, it is expected to further increase the number of bicyclists on city streets lead to serious problems in traffic, especially in high-frequency locations in Sarajevo, where cyclists and pedestrians are moving in the same traffic flow.

2 PROBLEM AND SUBJECT OF RESEARCH

Following the development of the daily traffic in the cities can be seen that the maximum capacity is utilized, and to simply have the need to build new areas primarily for alternative forms of transport and pedestrians. If we look at the situation there is almost no kind of traffic in the city, and that's not broken or cut in level. Start-stop-start system is not in the interests of neither the environment nor to the participants. Pedestrian and bicycle traffic and almost forgotten by the authorities, the only aspect of bike trails for the citizens of the trails in the surrounding hills, which certainly require skill and effort to master. City cycling is present in cycling enthusiasts. Talk on the bicycle and pedestrian traffic there is a problem that is not misled in any of the institutions related to traffic. Nowhere in the documents cannot be found statistics as far as cyclists in the city, and that is their extent of movement as well as what are the official bike paths, and no data exist on pedestrians and their available surfaces. The biggest problem is that the city of Sarajevo remained a small fraction of unused space, and all other requirements in the construction and reconstruction of new investment. One must also take into account the pedestrian area and pedestrians who are targeted by bad weather and with no physical protection from motor vehicles. The frequent occurrence of rainy days reflected desolate streets and pedestrian zones, pedestrians simply have nowhere to shelter from a storm and have no protection from the sun rays.

Subject of this study is to determine the relevant parameters that indicate trends in the development of cities in terms of traffic and that the pace going with the simulation of Sarajevo, Bosnia and Herzegovina. According to the collected information we can see that there is a constant increase of bicycles and their involvement in traffic and an increase in motor vehicle traffic density. These parameters you can see on the streets of the capital every day and is not difficult to come to a conclusion that it is necessary to find a solution or present an idea that would be the basis of further development.

3 THE CURRENT SITUATION OF PUBLIC TRANSPORT IN SARAJEVO

Today, the backbone of the urban traffic in Sarajevo are trams, carrying half of the total number of passengers. Besides tram transport there is trolleybuses, buses and minibuses. GRAS has no competition, and Sarajevo Canton is the majority owner of the company.

Global development directions of the City of Sarajevo in the period up to 2023 The basic elements include the reconstruction and development of transportation, global strategy, development of public passenger transport as well as its relevant segment and have as a final goal of a quality, comfortable, safe and reliable transport, which are adapted to passenger requirements [5]. Satisfying customer needs is imperative, and in the transformation of public transport necessary to provide customers an attractive, comfortable, fast and affordable in terms of public transport, with the smaller investments and lower operating costs. Planned development of the system of public transport passengers will be based on the incorporation of railroads in the system of public transport of passengers, as well as the transformation of the existing tram system in easy rail passenger transportation (LSP). The basic direction that follows the river Miljacka and Sarajevo valley of City Hall to Ilidža and Hadžići still time, and direction of the Bosna river valley Ilijaš to continue, will become in terms of traffic, the key to future development and their throughput capacity, as well as the speed and capacity of the public transportation of passengers on them the most important factor of the overall system of public passenger transport in the city, but also at the regional level.

4 REDESIGN RIVERBED MILJACKA - INNOVATIVE SOLUTIONS FOR PEDESTRIAN / BICYCLE FLOWS

Today the world is more and more emphasis on the use of alternative transportation instead of motor vehicle traffic, build a bicycle and pedestrian paths. This reasoning, which is a European orientated demands detailed and precise planning of available space that will be used at most-used in the future [2]. Conceived stock, to redesign the Miljacka river bed that stretches the entire length of about 10 km. Also, the river Miljacka serves to collect all the surrounding water to streams and rivers from the hills also wastewater pollute the river Miljacka, and in good measure, causing an unpleasant odor, especially in the summer [4]. Since the appearance of the Miljacka river bed is shown in Figure 1 [3], which clearly sees derived form of balconies on both sides of the coast will be a pedestrian and bicycle path.

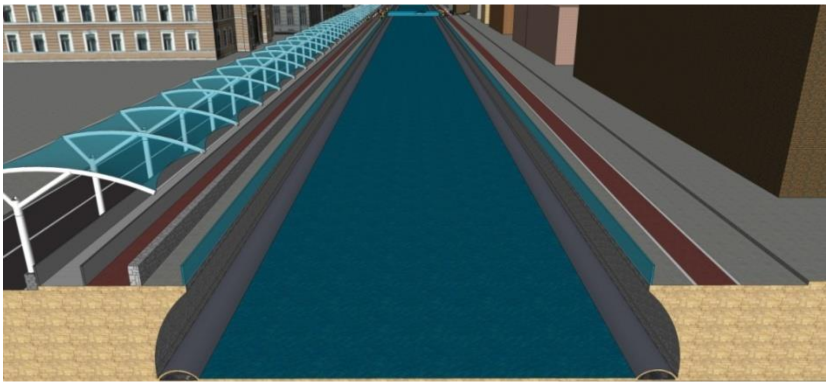

Figure 1: The bed of the river Miljacka transverse layout

For beauty and clearing of the river Miljacka, will make pipes which will collect sewage from nearby villages.

Many analyze and surveys have shown that most of the population moved to an alternative form of transportation when you order to ensure the right conditions. These conditions include the construction of a secure section for pedestrian and bicycle traffic, which would be physically separated from motor vehicle traffic, and the introduction of safe driving education and culture in the traffic [6]. The goal of reconstruction Miljacka river bed and construction of bicycle and pedestrian paths is to develop and massive cycling as a sport, recreation and sustain as an alternative form of transportation, to popularize a healthy lifestyle among the public, particularly children and youth, and the importance of sport and recreation in the preservation of a healthy body and mind, to urbanization and urban environment accompanied modern European and world view trends designed Miljacka river bed can be seen in Figures 3 and 4 where it is clear purpose and total utilization of the redesigned riverbed river.

Figure 3: Showing both bicycle lane

Figure 4: The view from the perspective of a pedestrian in the intersection Obala

Redesigning the Miljacka river bed would increase the level of safety of pedestrians and cyclists on a whole new level. Structure with adequate protection from the weather and security protection of motor vehicles, the majority of citizens in this part of the city of Sarajevo before the motor vehicles used walking or bicycling zone movement.

5 REDESIGN PUBLIC TRANSPORTATION INNOVATIVE SOLUTIONS FOR TRAM TRANSPORT

Trams in Sarajevo provides a central part of the city and takes up the length of the tram network in the amount of 22.9 kilometers performed in the surface route electrical power above the tracks. The biggest problem is its Sarajevo tram noise and obsolescence, and how that power is a tangled web, and mockery of the entire city of Sarajevo. Innovative solutions imply tram transport solutions that will be quiet and pleasant environment. Modern low-floor trams, which derive their power from the rails, are the perfect solution to noise reduction and elimination of power supply networks. Such an approach would enable us burials tram and cycling facilities in the gallery tram routes. Observed tram route length of the city of Sarajevo, we can notice that the belt looks like a lot of tram transport is regulated in areas where cellular systems. Bandwidth tram transport ranges from 13m to 25m and even up to 70m in places where the swing. To show the situation and innovative ideas and its simulation in space is taken locations busiest intersections on the entire route. Interment tram up to the window part contributed to the passengers have visual contact with the environment, which would avoid the "uncomfortable" feeling metro and other systems are to be buried underground, and on the other side by this solution would be comparably cheaper than metro. In the intersection there would be a complete lowering trams underground and re-release immediately after the intersection, which would produce a sustained flow of tram transport at intersections which would largely increase the safety and volume of passenger tram transport. Coverage adequate supporting platforms would get a space that could be used by building bicycle paths on the gallery tram route, and could be used as a time of emergency medical services in cases where the existing roads were overcharged. The tapes are divided grassy strip width 0.4 m, while on the edges of the tape are cypresses 0.3 m wide and 0.5 m height.

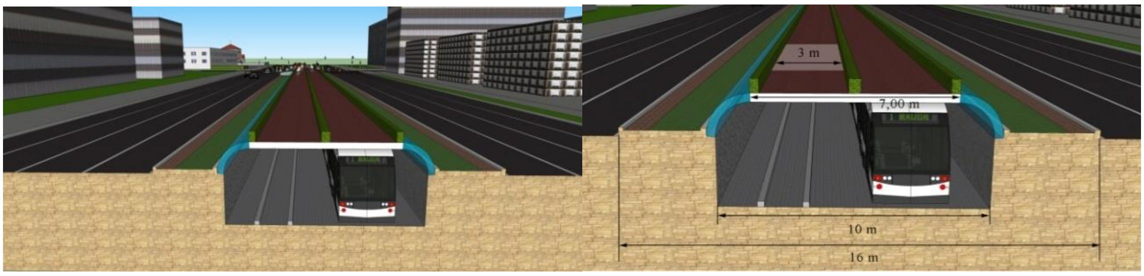

Figure 5: Transversal layout redesign tramlines

Figure 6: Appearance ramps for cycling path

Figure 7: View of the intersection Pofalići from position of cyclists

5.1 The innovative aspect of transportation in the city (old) part of the city - the conveyor belt

This paper presents an innovative display on the inner city (old) part of the tram instead ask conveyor belt. Treadmills would have the function of public transport passengers. Transportation routes by moving tape is shown in Fig 8st Accessing a treadmill designed in four steps: addition of users, users accelerate to 7 (kph), transport users speed 15 (kph), slowing the user to 7 (kph h) [9].

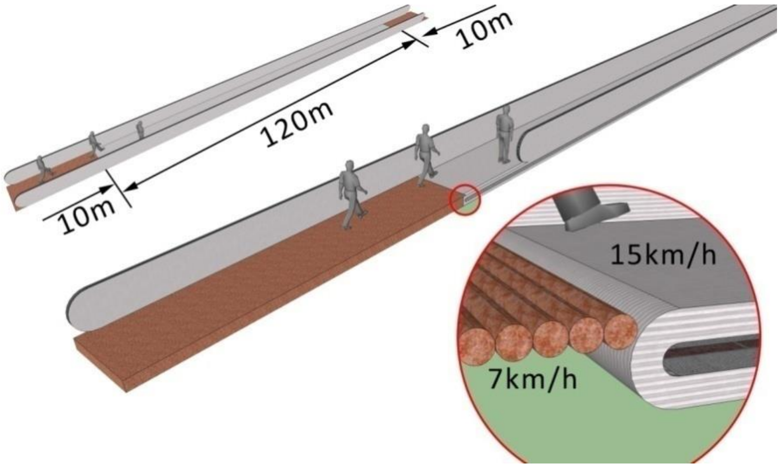

Figure 8: Transversal layout conveyors

Figure 9: Transversal layout conveyors

Figure 10: Interrupting traffic conveyors at the crossroad Obala

Figure 11: View of the strip at the street Obala

Figure 12: Showing conveyor belt in the street Titova

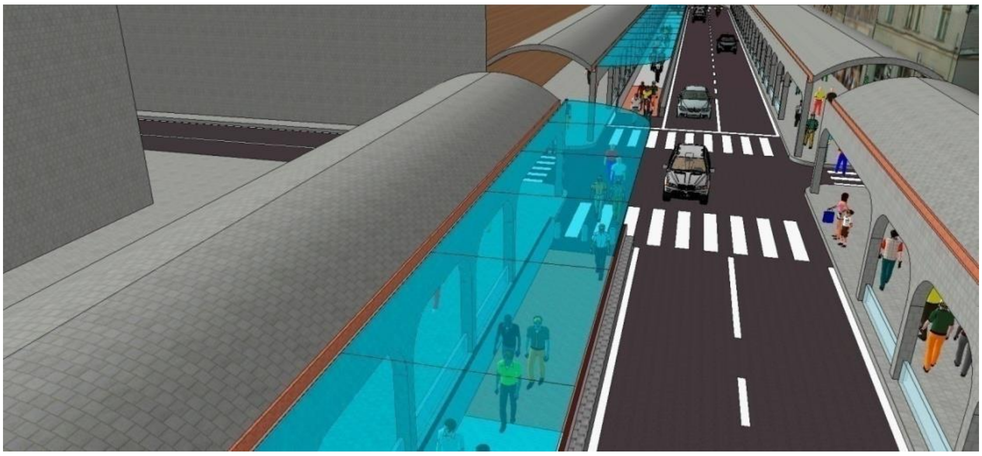

Figure 13: Display glass panels that cover the conveyor belt

Figure 14: Interception of the conveyor belt

5.2 Redesign of the city's pedestrian zone

The main area for walking, or street of Sarajevo, there is no infrastructure that protects pedestrians from the weather and therefore users are left to themselves to find protection from the rain and wind drift, and the sun. Innovative ideas final resolution envisions pedestrian retention pedestrians in pedestrian areas during storms. By placing the entire length of the movable panels allow pedestrian pedestrians normal pedestrian use in all weather conditions. Glass, slightly tinted panels to be mounted on nearby buildings with designed brackets that would be randomly automatically during inclement weather or excessive sun to protect.

Figure 15: View open the panel in front of the Cathedral

The modern layout the entire infrastructure will give citizens and walkers the opportunity to continue to enjoy the beauty of the streets for walking. Design form glass panels will allow users during bad weather protection from rain, wind and snow. Appearance panel closed with the entire frame is shown in Figure 16.

Figure 16: Pedestrian protections from the weather with a glass panel

In the period of bad weather panels would be widespread and thus would prevent the penetration of rain and snow in the pedestrian area, and during the heat of solar panels would be semi-open, opened and closed as needed to prevented from striking sunlight and thereby create additional shade for walkers .

Figure 17: Semi-open glass panels

Figure 18: Indoor glass panels

5.3 Redesign the pedestrian area along the main street

Street for a motor traffic on both sides are wide pedestrian area. There is no scientific infrastructure that protects pedestrians from the weather, and therefore users are left to themselves to seek protection from the rain and wind drift. Also during the heat, and heat stroke, there is no protection other than the surrounding buildings, which should provide natural shade for hikers, which is impossible to create a position for the walkways. The idea is to cover the whole pedestrian zone concrete domes that fit the look of the building that would allow walkers normally use pedestrian zone without fleeing for cover. Concrete domes with arches should be fixed to the building and would constitute an integral part of the infrastructure. In Figure 19th shows the locations where this idea is infrastructural presented. Open side of the pedestrian zone gives users display width and reduces the feeling of looks tunnel.

Figure 19: Pedestrian protections from a storm in the pedestrian zone Titova

Canopies would be in conjunction with the appearance of each building and its facade separately, will remain promenade in a lovely setting.

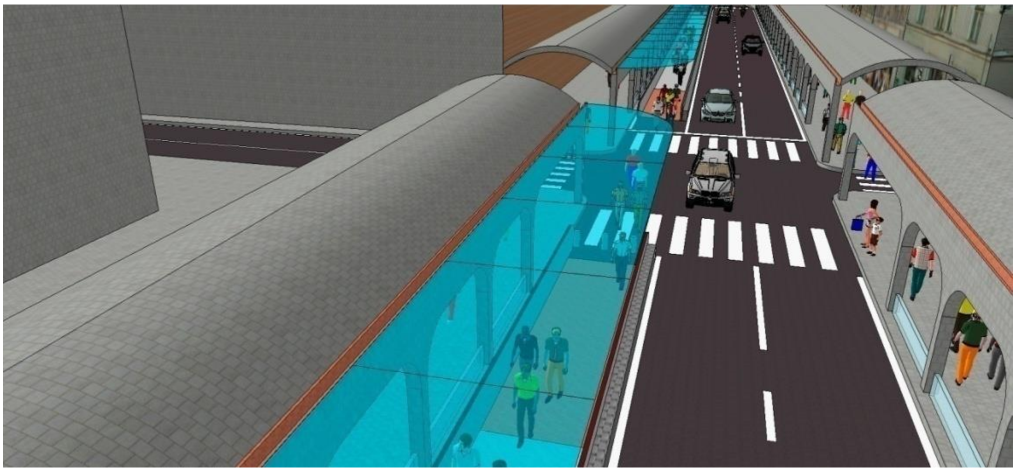

Figure 20: Showing intersection in the street Titova

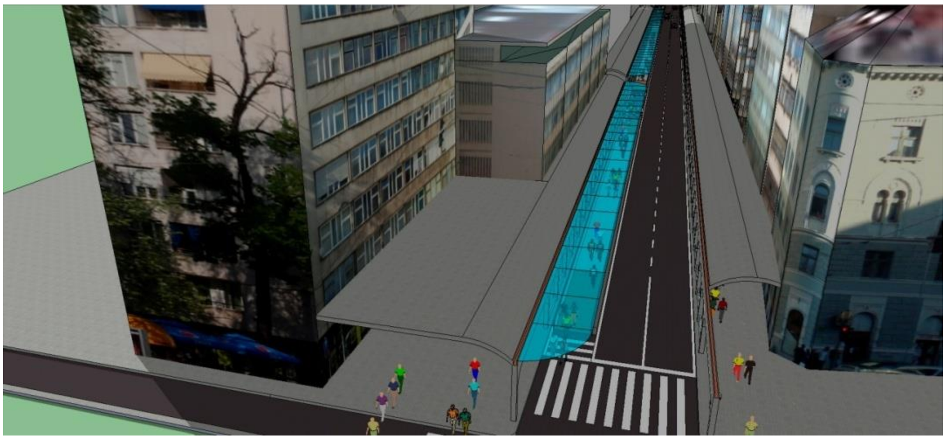

Figure 21: View to Titova Street from the Big park

6 CONCLUSION

This master thesis points to current problems in Sarajevo, capital of the future he has to develop in the direction of the great modern metropolis whose transport infrastructure meets all international and European standards. Innovative and futuristic ideas have never been to the first prehensile in society, but they eventually proved to be the right idea, and have become an integral part of our lives. This paper describes an idea that would have raised the overall transportation infrastructure of Sarajevo in a higher degree, as well as traffic safety.

When referred to the current problems are primarily talking about the lack of alternative forms of transportation, lack of bicycle and pedestrian area, lack of traffic culture, lack of road safety. Through this master work and the very idea of all these deficiencies can be remedied even rose to the level.

That would be the construction of a new redesigned Miljacka river bed got a brand new walking and cycling route that is physically separated from motor vehicle traffic. This idea does not get much eroded layout Miljacka river bed but would get quite sensitive to its construction.

Interment of the tram we would get a whole new image of Sarajevo, stylish and beautiful ambience. Inadequate pillars tram zone, representing a mockery of the substitution of bike paths and green space.

Travelator construction, conveyor belts, Sarajevo would obtain a futuristic look and a special mode of transportation of passengers and as such again to get coveted title of the first city that introduced a travelator in public transportation as was the case with the first electric tram in Europe.

Covering pedestrian zone in Titova and Ferhadija set to point to the "i" on the issue of pedestrian protection from the weather and deserted walks in the rain.

Everyday observation may notice an increase in traffic of cyclists, however, increase the number of cyclists is not followed by the development of appropriate cycling infrastructure in the city, so it is expected that due to the lack of bike lanes and paths, the number of accidents involving cyclists continue to increase. It is the safety of cyclists and other traffic participants basic reason why that should be up to date approach to problem solving.

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AVIATION HAZARDS IDENTIFICATION USING SAFETY MANAGEMENT SYSTEM (SMS) TECHNIQUES

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ABSTRACT

Hazard identification is very important for safety management system (SMS) implementation process. In aviation industry practice, hazards may be identified through a data-driven (quantitative) methodology or qualitative process such as discussions, interviews and brainstorming and can be grouped into three generic families: natural hazards, technical hazards and economic hazards. Since the scope of hazards in aviation is wide, this paper develops a quantitative methodology for assessing aviation hazards during the aircraft usual daily operations. The methodology is developed by estimating all related hazardous factors by their occurrence placement, nature and specific components related to timing, sequencing and mutual dependency. The use of the proposed methodology allows investigation of aviation safety factors and flexible assessment of aviation hazards. The results demonstrate that the proposed methodology has the potential of becoming very useful in practice facing further generalization of hazard identification process.

Keywords: Safety; Risk; Hazard, Aircraft

1 INTRODUCTION

Aviation industry defines hazard identification and safety risk management as the core processes involved in the management of safety. Traditional system safety is based on the consequences and the safety implications of technical aspects and particular components of the system under considerations whilst contemporary safety management recognizes system safety based on hazard identification and safety risk management as a key driver in aviation system design and operation issues which also includes the role of human factor.

The concept of safety in aviation may have different connotations like freedom from hazards or no accident (Waikar and Nichols, 1997). Therefore it is important to understand and identify those factors which cause or are likely to cause harm. Contemporary methods vary from statistical and trend analysis to cost analysis. The paper describes brainstorm methodology for conducting organizational factors which could cause serious incident or accident. Described case study which is based on everyday aircraft operations, demonstrated the methodology process. Nowadays, researches related to hazards in aviation or hazard methodologies implementation widely consider risk assessment as a part of safety management system process (Čokorilo et al., 2011a; Hurst et al. 1996; Lee, 2006; Shyur, 2008; Lawrence and Gill, 2007; Oztekin and Luxhoj, 2010). Decades of psychological and social scientific research have shown that the everyday processes of risk perception and risk evaluation rely on entirely different models to subjectively assess risks (Plattner et al., 2006; Paternòand and Santoro, 2002).

2 HAZARDS IN AVIATION

The scope of hazards existing in aviation activities is very wide since aviation environment is bounded by man-machine relationship. There are several most used hazard definitions in aviation. According to (FAA, 2006), a hazard is a condition that is a prerequisite to an accident or incident. According to (EUROCONTROL, 2001) a hazard is any condition, event, or circumstance which could induce an accident. Hazards can be grouped into three generic families: natural hazards, technical hazards and economic hazards.

Aviation industry recognized hazard identification as the process used to determine all possible situations, events and circumstances that may expose people to injury, illness, disease or death or may cause damage or loss of equipment and property, or damage to the environment. For example, well-known SHEL model generally describes relationship between software (S), hardware (H), environment (E) and liveware (L) include into all aviation activities. Therefore, hazard identification is necessary for understanding hazard treats from human actions, procedures, system design factors, regulatory and organizational factors, defences, etc. Hazard identification and safety risk management, are the core processes involved in the management of safety (ICAO, 2009). The complete elimination of risk in aviation operations obviously is an unachievable and impractical goal (being perfectly safe means to stop all aviation activities and to ground all aircraft). As not all risks can be removed, nor are all possible risk mitigation measures economically practical. In other words, it is accepted that there will be some residual risk of harm to people, property or environment, but this is considered to be acceptable or tolerable by the responsible authority and the society (Čokorilo et al., 2010; Čavka and Čokorilo, 2012).

3 HAZARD IDENTIFICATION METHODS

Hazard identification (FAA, 2000): the hazard analyses and assessments required in the plan shall identify the safety risks associated with the system or operations under evaluation. Nowadays, different methods and tools are used in safety analysis: statistical analysis, trend analysis, normative comparisons, simulation and testing, expert panel, cost-benefit analysis. All mentioned methods for hazard identification generally could be selected into two possible groups: 1) Reactive hazard identification methods where hazards are recognized through investigation of safety occurrences and trend monitoring; 2) Proactive hazard identification methods where hazards are identified analyzing systems' performance and functions for intrinsic threats and potential failures. The most commonly applied proactive methods are the safety assessments, operational safety audits, safety monitoring, etc. In order to obtain different techniques toolbox (FAA/EUROCONTROL, 2007) defined inventory of over 500 techniques. More popular techniques are: Air-MIDAS; Air Safety Database; ASRS (Aviation Safety Reporting System); Bias & Uncertainty Assessment; Bow-Tie Analysis; CCA (Common Cause Analysis); Collision Risk Models; ETA (Event Tree Analysis); External Events Analysis; FAST (Future Aviation Safety Team) Method; FMECA (Failure Modes Effects and Criticality Analysis); FTA (Fault Tree Analysis); Future Flight Central; HAZOP (Hazard and Operability study); HEART (Human Error Assessment and Reduction Technique); HERA (Human Error in ATM); HTA (Hierarchical Task Analysis); HTRR

(Hazard Tracking and Risk Resolution); Human Error Database; Human Factors Case; PDARS (Performance Data Analysis and Reporting System); SADT (Structured Analysis and Design Technique); SAFSIM (Safety in Simulations); SIMMOD Pro; TOPAZ accident risk assessment methodology; TRACER-Lite; Use of Expert Judgment.

Generally, hazard identification methods are used for safety factors identification. These factors are measured against more subjective standards and might be more difficult to quantify. Theoretically, safety factors are those most closely correlated with accidents and include casual factors such as (Wells et al., 2003): personnel capabilities (pilots, controllers, etc.); air traffic environment; aircraft capabilities (Čokorilo, 2011b); weather; unpredictable acts. The following case study presents mixture of all mentioned factors and could be used as a good practice for hazard identification process.

4 HAZARD IDENTIFICATION CASE STUDY

The presented case study considers problem of runway incursion. The problem describes proactive tool related not only to mentioned case study but to every similar aircraft operations. A runway incursion is any occurrence on an airport runway involving an aircraft, vehicle, person or object on the ground that creates a collision hazard, or results in a loss of required separation with an aircraft taking off, intending to take off, landing, or intending to land (Krause, 2003). The FAA four year study between 1997 and 2000 which included the over 450 towered airports in the U.S. National Airspace System resulted by the number of airport operations neared 266 million with a reported 1 369 runway incursions.

The scenario presented below is based on international airport three-phase construction project. This is a construction project to repave one of the two crossing runways at an international airport with approximate 100 000 movements a year (Fig. 1).

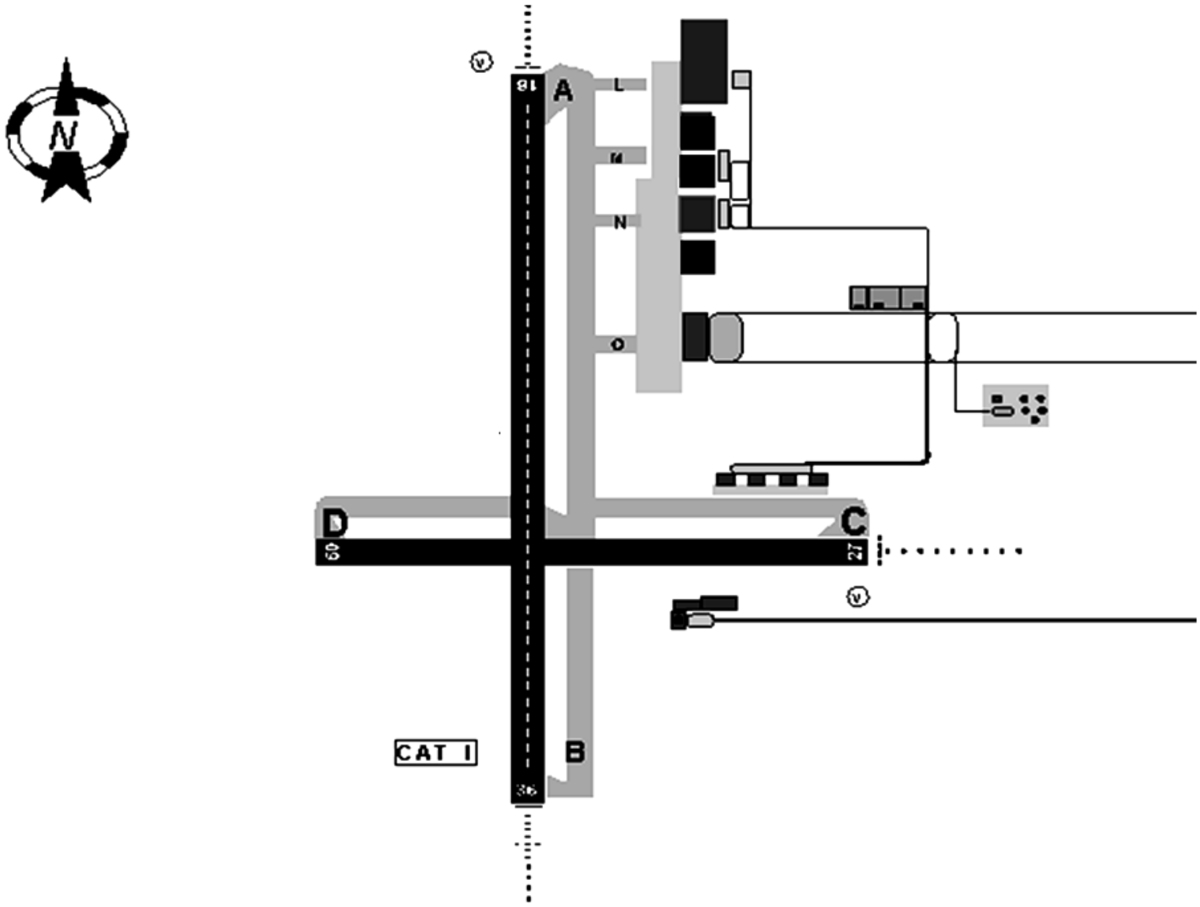

Figure 1: International Airport Layout

Based on initial airport layout, scope of construction works are defined into three phases as it is shown on Fig. 2. Assumptions for the runway utilization during the construction work are: 1) Continuous utilization of RWY 18-36 during the three-phase construction project; 2) RWY 18-36 length is 3 850 m and the distance available from threshold RWY 18 to intersection RWY 09-27 is 2 600 m; 3) Information must be provided to airport users.

Phase 1 includes: 1) Extend the length of RWY 09-27 by 900 meters westward and width from 30 to 45 meters from a point 100 m from the intersection with RWY 18-36, and strengthen the runway extension (from asphalt to concrete) to increase its Pavement Classification Number (PCN); 2) Extend the length of TWY Delta by 900 meters westward; 3) Estimated time to complete the work: seven months.

Phase 2 includes: 1) Construct and enlarge new threshold entrance and holding zone at TWY Charlie; 2) Extend the width of RWY 09-27 from 30 to 45 meters and strengthen (from asphalt to concrete) this part of the runway up to a point 200 m before intersection TWY A-B to increase its PCN; 3) Estimated time to complete the work: five months.

Phase 3 includes: 1) Complete the construction work of RWY 09-27 for the central area of the last 350 m at the intersection of RWY 09-27 and RWY 18-36 (from asphalt to concrete), increase its width from 30 to 45 meters and its PCN; 2) Estimated time to complete the work: two months.

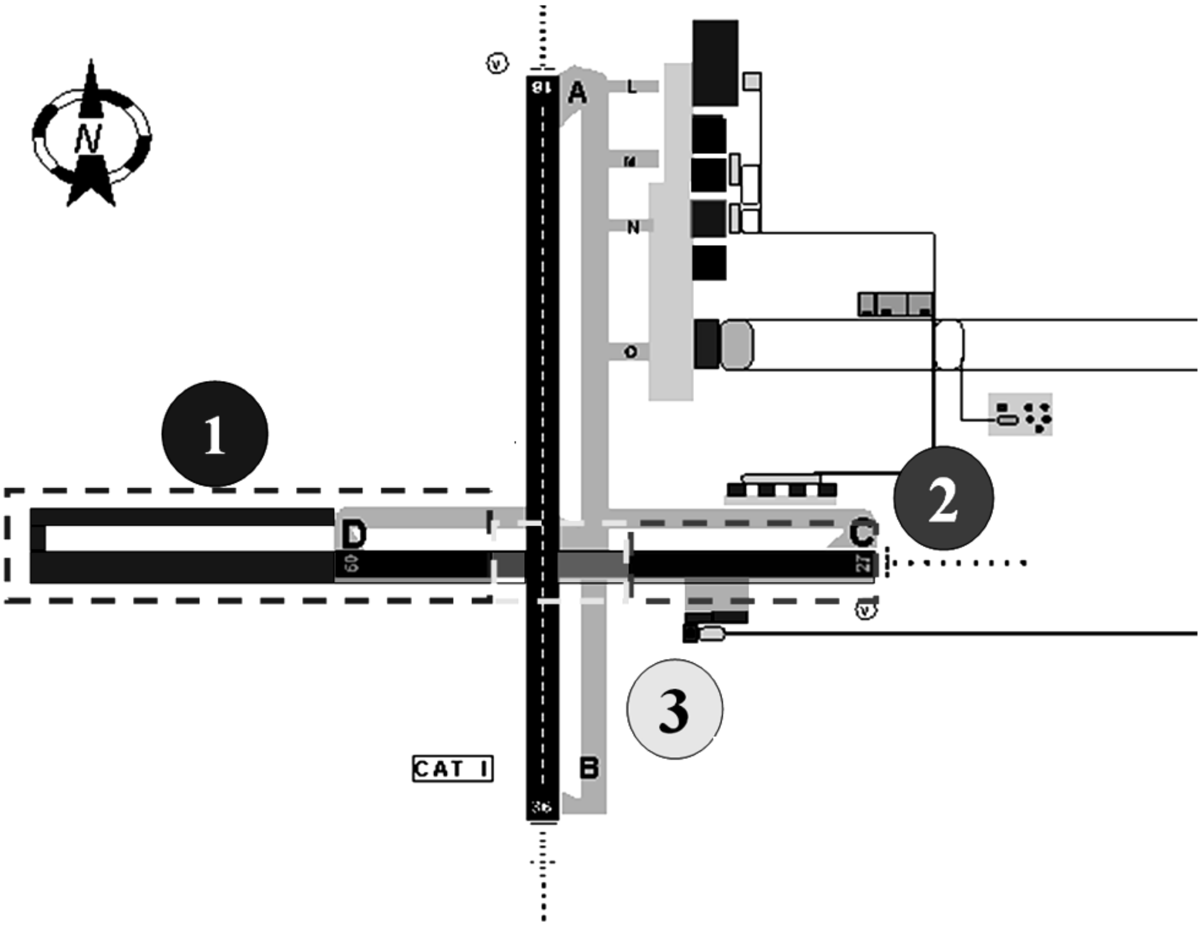

Figure 2: International Airport Construction Work Layout

4.1 Results

The presented case study was used for hazard identification. Author used brainstorming techniques for listing possible hazards avoiding possible misunderstanding between hazard and risk differences (Table 1). Described case study presents overall methodology for hazard identification which is based on following steps:

- list type of operation or activity;
- state the generic hazard (hazard statement);
- identify specific components of the hazard.

Analyzed sample was done based on conducting the analysis per phase of construction. This principle allowed systematic approach which ensures hidden hazard identification.

Table 1: Hazard Identification

Nº	Type of operation or activity	State the generic hazard (hazard statement)	Identify specific components of the hazard
1	Air Traffic Services	Air traffic considerations associated with single runway operation.	- Increased volume of traffic; - Separation issues; - Runway congestion; - Controller workload; - Changed departure and arrival flight procedures;

Nº	Type of operation or activity	State the generic hazard (hazard statement)	Identify specific components of the hazard
2	Construction works	Airport reconstruction	- Vehicles crossing runway in use; - Staff movements; - Not removed construction materials and equipment; - Access into prohibited airport areas; - Failure to comply with the deadlines;
3	Take off	Air traffic considerations associated with runway closure and available take off distance reduction	- Movements within construction works area; - Exiting into closed runway; - Use of closed taxiways; - Available take off distance reduction; - Changed procedures; - Take-off Weight – TOW limitations for particular airliners;
4	Landing	Air traffic considerations associated with runway closure and available landing distance reduction	- Use of closed runway; - Available landing distance reduction; - Changed procedures; - Landing Weight – LW limitations for particular airliners;
5	Airport activities	Movements of handling and landing vehicles	- Airport equipment and vehicles movements within construction works area; - Vehicle crossing runway in use;
		Airport signalization	- Inadequate marking of closed airport areas (construction works areas); - Inadequate marking of maneuvering areas; - Inadequate marking of relocated threshold; - Inadequate light signalization;
		Runway closure	- Increased number and time delays due to the capacity reduction and weather conditions (crosswind); - Rerouted flights into alternative airports;
6	Communication issues associated with ATC and airlines	Information on airport duty plans	- Not proceeded NOTAM and other relevant information about the changed conditions at the airport; - Navigation charts changes;
7	Aircraft operations departures/arrivals	Increasing number of operations per single runway	- Increased noise, emissions and complete environmental impact;

The importance of hazard identification lies in fact that well defined hazards are the basis for safety risks measurement. Safety risk is defined as the assessment, expressed in terms of predicted probability and severity, of the consequences of a hazard, taking as reference the worst foreseeable situation. In reality one generic hazard could lead to variety of risks with different probability and severity. For example “Not removed construction materials and equipment” described in activity number 2 is a typical hazard, while possible risks are: aircraft crash into equipment or facility; foreign objects ingestion into aircraft engine; FOD (foreign object damage). All noted risks are critical. If one could evaluate hazard and its circumstances (risks) then organization (airport, airline, ATM, etc.) would be able to make priority measures to bring defined risks into green or yellow zones, instead of red one. It means that good safety policy based on hazard identification could bring the organization operating in safety zone which is based on risk elimination or mitigation within acceptable limits.

5 CONCLUSIONS

The objective of this research was to establish an analytic methodology that uses data on organizational processes to quantify the aviation hazards which are caused by aircraft everyday operations during the airport construction works period. The use of the proposed methodology allows investigation of aviation safety factors and flexible assessment of aviation hazards. The results demonstrate that the proposed methodology has the potential of becoming very useful in practice facing further generalization of hazard identification.

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ADVANTAGES OF MODERN OBJECT ORIENTED PROGRAMMING LANGUAGES IN DEVELOPMENT OF COMPUTER SIMULATION MODELS FOR MARINE TRAFFIC SAFETY

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ABSTRACT

Computer simulation models represent important field in many aspects of vessel traffic, thus in a vessel collision occurrence aspect as well. Modern technology base and it's advantage in terms of functionality capabilities, graphics and user interface over some conventional approaches is pointed in this paper through a discrete – event vessel collision simulation model. Vessel collision simulation model is custom – developed using one of modern object oriented programming languages – C#. Special case of vessel collision occurrence in straits where two vessels approach from opposing directions is taken as an example to present this model's reliability. Results obtained by simulation are within the scope of verified analytical solutions..

Keywords: object-oriented, discrete-event simulation, ship collision.

1 INTRODUCTION

Computers are increasingly used for a variety of purposes in engineering and science including control, data analysis, simulations and design optimization. It is therefore becoming more important for marine engineering students to have a robust understanding of computing and to learn how to program.

Programming language should be chosen based on its strengths for performing certain task – the problem to solve should determine the language to use [8]. That refers to simulation model and its software development as well.

In classical thinking there are three types of simulation: discrete – event, continuous and Monte Carlo [7]. Many of models use stochastic simulations along with Monte Carlo approach when assessing the complex marine traffic systems [7], [2], [1]. Monte Carlo simulation utilizes models of uncertainty where representation of time is unnecessary. Marine traffic can be considered as complex and dynamic system that takes time as variable. It means that Monte Carlo approach alone won't be able to deal with marine traffic situations where time needs to be taken in account.

Logical and most commonly used alternative is discrete – event simulation. It is well known fact that discrete – event simulation and object oriented languages have a long common history [4]. Simula (1967) is generally considered to be first language with the primary features of an object oriented language. It was created for making simulation programs, in which what came to be called objects were the most important information representation. Smaltalk (1972 – 1980) is arguably the canonical example and the one with which much of the theory of object oriented programming was developed. Also, it was used to create the graphical user interface (GUI). Therefore, modern object oriented languages such as C#, Java, C++, Visual Basic.NET should seriously be considered as one of primary tools for building simulations, especially discrete – event ones [5]. Other alternative is usage of software simulation packages such as Arena, Extend, MODSIM III, Enterprise Dynamics and others, but they are usually more expensive solutions and not very flexible when dealing with some particular and detailed problems.

According to Nance (1993) [7] there are six characteristics of a discrete – event language. He proposed that discrete – event simulation programming languages must meet a minimum of six requirements:

- Generation of random numbers to represent uncertainty.
- Process transformers, to permit other than uniform random varieties to be used.
- List processing capability, so that objects can be created, manipulated and deleted.
- Statistical analysis routines, to provide the descriptive summary of model behavior.
- Report generation, to provide the presentation of potentially large reams of data in an effective way for decision making.
- A time executive or time flow mechanism.

All these requirements can be accomplished using powerful modern object oriented languages. In this paper, we outline the vessel collision simulation as one application of object oriented programming languages for marine engineer.

The problem of obtaining the number of ship collisions in waterways crossing situations is also dealt with. The main facts causing collision will be defined as mathematic model.

The paper is organized as follows. In the second chapter, object oriented programming languages and their advantages in simulation development are presented. The third chapter exposes main modelling and programming steps. The forth chapter presents specific collision problem in straits, test scenario and results. Final chapter is conclusion and discussion about the future work.

2 OBJECT ORIENTED PROGRAMMING LANGUAGES

OOP (Object – oriented programming) is a design philosophy. OOP uses a different set of programming languages (C#, C++, Java, Visual Basic.NET etc.). In OOP, everything is grouped as self sustainable "objects" [10]. Relationships between these objects can be created (e.g. objects can inherit characteristics from other objects). Main advantages of OOP techniques are that they enable programmers to create modules that do not need to be changed when a new type of object is added to a program. A new object can inherit many of its features from existing objects. This makes object – oriented programs easy to modify. Object oriented languages are especially effective and powerful thanks to class libraries. A class library is a pre – coded object oriented programming template collection [9]. Class libraries enhance code reuse by providing implementations of repetitive jobs so applications are not developed from scratch [9]. Different class libraries are developed for different purposes. To improve and speed up programming of simulations, several simulation libraries were developed for object oriented programming languages (e.g. SharpSim is a discrete – event simulation code library developed in C#).

Graphics and animations are especially important feature in modern simulations. Animation can increase the acceptance of discrete – event simulation as a legitimate problem – solving technique. With the animation usage, dynamic graphical images can be created that enhance verification, validation and development of simulation itself. This can easily be achieved using one of modern object oriented languages because there are class libraries that contain pre – coded templates for graphics and animation as well. Object oriented languages, while useful for writing complex programs, can be difficult to learn, so it can be considered as disadvantage.

3 VESSEL COLLISION SIMULATION MODEL – BASIC MODELING STEPS

This chapter contains the formulae used in our developed model that is based on discrete – event simulation [7] and molecular collision model used for marine purposes [6]. It estimates number of geometric collision candidates if no anti – collision maneuvers are initiated. Generally, object oriented simulation has objects that interact as simulation progresses through simulated time. In order to simplify the programming and still acquire correct number of collision occurrences, vessels are replaced with geometric circles that represent objects (in terms of programming languages) carrying information about the vessels position, direction, length, width and velocity in the simulated time. Hence, vessel motion in time period is approximated with discredited circle movement. In simulated time period, collision between two vessels (circles) is described as an overlap of two circles. Figure 1 illustrates the collision event.

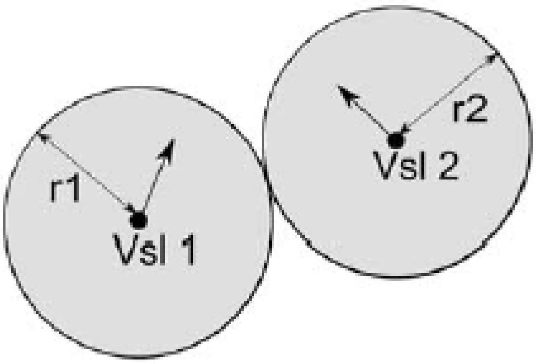

Figure 1: Definition of collision situation

Source: Montewka, J., Hinz, T., Kujala, P., & Matusiak, J. (2010). Probability modeling of vessel collisions. Reliability Engineering & System Safety (Volume 95, Issue 5, pp. 573-589). Helsinki: Aalto University, School of Science and Technology, Department of Applied Mechanics, Marine Technology.

As shown on Figure 1, a collision between two circles occurs when the sum of both radiuses is less or equal to the distance between two centers of the circles. Monte Carlo method [11] is used for the generation of random samples from normal (Gaussian) distribution. These random samples are used to place vessels (circles) on their initial positions. In other words, vessels (circles) are normally distributed across the width of the strait, or part of it. Vessels (circles) are generated linearly in a simulated time period.

4 PARTICULAR COLLISION PROBLEM IN STRAITS – HEAD ON MEETING OF THE VESSELS

As shown on Figure 2, vessels in straits usually move in opposing directions through parallel waterways. Vessels from both directions are almost always differently distributed across the straits width. It can be seen that the probability of the path of two meeting vessels will overlap depends on the distribution of the vessels across the straits width from each direction of the channel. The smaller η value is the greater becomes the probability of collision (η indicates the distance between central lines of the sailing routes). Distribution of the vessels across the straits width is normal (Gaussian). Mean value of the normal distribution, μ, and standard deviation σ are defined as necessary. Obviously, length of the vessels is not important in this particular case.

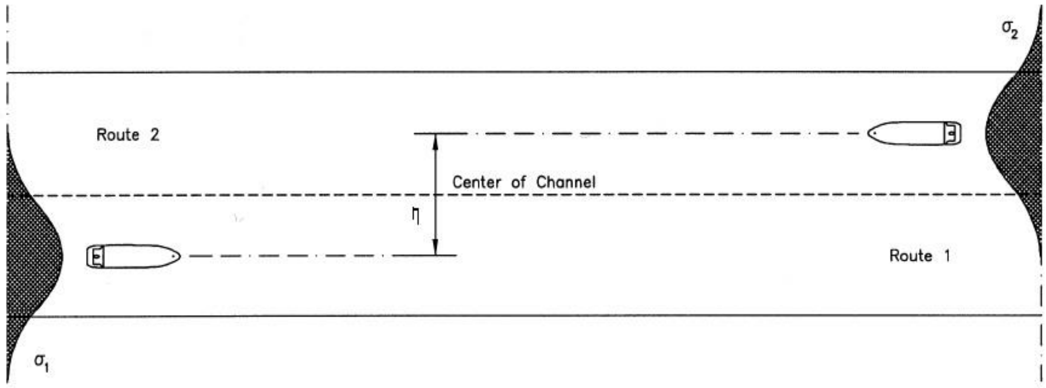

Figure 2: Head on meeting of the vessels in straits

Source: Hansen, P. F. (2000). ISESO Project 7 and 8 - Basic Modeling Principles and Validation of Software for prediction of frequencies, Denmark: ISESO – Information Technology for Enhanced Safety and Efficiency in Ship Design.

Number of geometric collision candidates depends of:

- The length, L_w, of the route.
- The number of vessels of class i passages in time unit per route 1, $Q_i^{(1)}$, number of vessels of class j passages in time unit per route 2, $Q_j^{(2)}$, and their velocities, $V_i^{(1)}$ and $V_j^{(2)}$.
- The geometrical probability distribution, $f_i^{\,1}(x)$ and $f_j^{\,2}(x)$, of the vessels distribution across the straits width, where x is normally distributed random variable.

According to Hansen [3], the number of geometric collision candidates, N_a, for the head on meeting of the vessels, is analytically expressed as:

$$N_a = L_w \sum_i \sum_j \frac{Q_i^{(1)} Q_i^{(2)}}{V_i^{(1)} V_j^{2}} \cdot \left(V_i^{(1)} + V_j^{(2)}\right) \cdot \left(B_i^{(i)} + B_j^{(j)}\right) \cdot \frac{1}{\sqrt{2\pi\left(\sigma_i^2 + \sigma_j^2\right)}} \cdot e^{-\frac{\eta^2}{2\cdot\left(\sigma_i^2+\sigma_j^2\right)}} \cdot \Delta t \qquad (1)$$

where parameters are described as follows:

- L_w is the length of the route.
- $Q_i^{(1)}$ is the number of vessels of class i passages in time unit per route 1.

- $Q_j^{(2)}$ is the number of vessels of class j passages in time unit per route 2.
- $V_i^{(1)}$ is the average speed of class i vessels on route 1.
- $V_j^{(2)}$ is the average speed of class j vessels on route 2.
- $B_i^{(i)}$ designates width of the class i vessels.
- $B_j^{(j)}$ designates width of the class j vessels.
- η designates the distance between central lines of the sailing routes.
- σ designates vessels average deviation from central lines of the sailing routes.

5 TEST EXAMPLE AND RESULTS

Vessel collision simulation model presented in this paper and (described in chapter 3) is actually realized as custom – developed software application. In other words, model is integrated in software application. Application is developed by using modern object oriented language – C#, and it consolidates modeling logic (see chapter 3), user interface and 2D graphic animation. User interface is used for inserting and controlling the input data for model, such as number of vessels, length of the observed sailing route, vessel dimensions, and etc. 2D graphic animation illustrates vessel movement and collision scenarios in simulated time period.

Software application with integrated modelling logic, 2D graphical animation and user interface built in C# is presented on Figure 3.

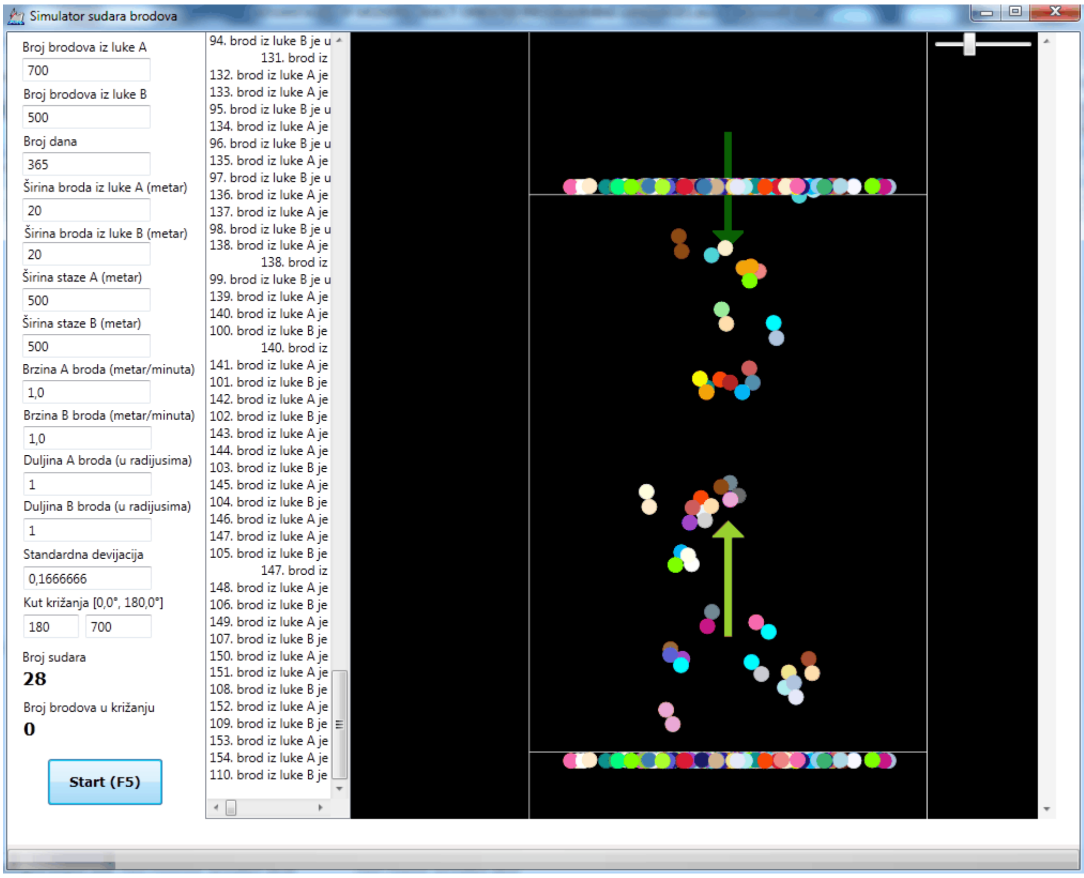

Figure 3: Vessel collision simulation application

Source: Authors:Mirko Čorić, Anita Gudelj, Maja Krčum

In current phase, developed model calculates number of geometric collision candidates in specific marine traffic situation where ships approach each other from opposing directions. This scenario is common for marine traffic in straits (as described in chapter 4). Anti – collision maneuverings were not taken into account when calculating number of geometric collision candidates.

Collision simulation model is tested through a next hypothetical example:

- Observed time period Δt is set to $365\ days$.
- Length of the route is set to $800\ m$.
- η is set to 0.
- σ_i and σ_j are set to $100\ m$.

Vessels of class i:

- $Q_i^{(1)} = 500/(365 \cdot 24 \cdot 3600)s$
- $V_i^{(1)} = 2\ m/s$
- $B_i^{(i)} = 20\ m$

Vessels of class j:

- $Q_j^{(2)} = 620/(365 \cdot 24 \cdot 3600)s$
- $V_j^{(2)} = 3.5\ m/s$
- $B_j^{(j)} = 20\ m$

Results of the hand calculation of this head on collision scenario obtained though expression (1): $N_a = 0.697$ collisions per 1 year.

Simulation results obtained through a several simulation repetitions of this head on collision scenario: $N_a \approx 0.697$ collisions per 1 year.

6 CONCLUSION

The advantage of pure Monte Carlo simulation is that it can be done very quickly because the time is not taken into account. By ignoring the time when designing the simulation, the system itself may often be oversimplified and hence could contribute to inaccurate results. With the advent of computer power, discrete – event simulations should not present holdback in simulating numerous marine traffic safety situations, because less and less time is needed for the execution of the simulated scenarios. The fact that majority of modern complex systems and applications are built by using today's object oriented languages is contribution to this thesis as well. From the programming aspect, usage of some non – object oriented language in development of marine safety model presented in this paper would require much more effort and would not be a straightforward task as in C#.

In this paper, discrete – event vessel collision simulation model is developed by using C# – modern object oriented programming language. The proposed model is developed as an intuitive application along with user friendly interface, graphic animation and comprehensible functionality. In current phase of development, model calculates number of collision candidates in head on meeting of the vessels in straits, when no anti – collision procedure is engaged. The results obtained through a simulated test scenario are compared with verified analytical results, and a good agreement is found. The proposed model is adaptable to more complex problems in marine traffic. Future work will deal with overtaking and crossing collision scenarios.

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THE PRICE DISCRIMINATION IN PERSONAL TRANSPORT

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ABSTRACT

This article describes the possibility of use of the price discrimination in personal transport, which aim is to obtain consumer surplus (price difference between the price, which would the consumer pay for transport service and its real price) and its conversion to firms additional profit.
Theoretical introduction describes the price discrimination as a method of determining different prices of partially monopol transport services without needing for rising the prices due to cost reasons. In the price discrimination, the knowledge of the price elasticity on the base of monitored mobility of the passengers is used. There are many forms of price discrimination in the market, which are going to be described and documented with practical applications.

Keywords: market, price discrimination, rail transport, price elasticity

1 THEORETICAL INTRODUCTION

Price discrimination or price differentiation [1] exists when sales of identical goods or services are transacted at different prices from the same provider [2]. In a theoretical market with perfect information, perfect substitutes, and no transaction costs or prohibition on secondary exchange (or re-selling) to prevent arbitrage, price discrimination can only be a feature of monopolistic and oligopolistic markets [3], where market power can be exercised. Otherwise, the moment the seller tries to sell the same good at different prices, the buyer at the lower price can arbitrage by selling to the consumer buying at the higher price but with a tiny discount. However, product heterogeneity, market frictions or high fixed costs (which make marginal-cost pricing unsustainable in the long run) can allow for some degree of differential pricing to different consumers, even in fully competitive retail or industrial markets. The effects of price discrimination on social efficiency are unclear. Output can be expanded when price discrimination is very efficient. Even if output remains constant, price discrimination can reduce efficiency by misallocating output among consumers. Price discrimination requires market segmentation and some means to discourage discount customers from becoming resellers and, by extension, competitors. This usually entails using one or more means of preventing any resale: keeping the different price groups separate, making price comparisons difficult, or restricting pricing information. The boundary set up by the marketer to keep segments separate is referred to as a rate fence. Price discrimination can also be seen where the requirement that goods be identical is relaxed. For example, so-called "premium products" (including relatively simple products, such as cappuccino compared to regular coffee with cream) have a price differential that is not explained by the cost of production. Some economists have argued that this is a form of price discrimination exercised by providing a means for consumers to reveal their willingness to pay.

2 TYPES OF PRICE DISCRIMINATION

2.1 First degree price discrimination

This type of price discrimination requires the monopoly seller of a good or service to know the absolute maximum price (or reservation price) that every consumer is willing to pay. By knowing the reservation price, the seller is able to absorb the entire consumer's surplus from the consumer and transform it into revenues. The seller produces more of his product than he would to achieve monopoly profits with no price discrimination, which means that there is no deadweight loss. Examples of where this might be observed are in markets where consumers bid for tenders, though, in this case, the practice of collusive tendering could reduce the market efficiency [4].

2.2 Second degree price discrimination

In second degree price discrimination, price varies according to quantity demanded. Larger quantities are available at a lower unit price. This is particularly widespread in sales to industrial customers, where bulk buyers enjoy higher discounts [5].

Additionally to second degree price discrimination, sellers are not able to differentiate between different types of consumers. Thus, the suppliers will provide incentives for the consumers to differentiate themselves according to preference. As above, quantity "discounts", or non-linear pricing, is a means by which suppliers use consumer preference to distinguish classes of consumers. This allows the supplier to set different prices to the different groups and capture a larger portion of the total market surplus.

In reality, different pricing may apply to differences in product quality as well as quantity. For example, airlines often offer multiple classes of seats on flights, such as first class and economy class. This is a way to differentiate consumers based on preference, and therefore allows the airline to capture more consumers’ surplus.

2.3 Third degree price discrimination

In third degree price discrimination, price varies by attributes such as location [6] or by customer segment, or in the most extreme case, by the individual customer's identity; where the attribute in question is used as a proxy for ability/willingness to pay.

Additionally to third degree price discrimination, the supplier(s) of a market where this type of discrimination is exhibited are capable of differentiating between consumer classes. Examples of this differentiation are student or senior discounts. For example, a student or a senior consumer will have a different willingness to pay than an average consumer, where the reservation price is presumably lower because of budget constraints. Thus, the supplier sets a lower price for that consumer because the student or senior has a more elastic Price elasticity of demand (see the discussion of Price elasticity of demand as it applies to revenues from the first degree price discrimination, above). The supplier is once again capable of capturing more market surplus than would be possible without price discrimination.

Note that it is not always advantageous to the company to price discriminate even if it is possible, especially for second and third degree discrimination. In some circumstances, the demands of different classes of consumers will encourage suppliers to ignore one or more classes and target entirely to the rest. Whether it is profitable to price discriminate is determined by the specifics of a particular market.

2.4 Fourth degree price discrimination

In fourth degree price discrimination, prices are the same for different customers, however costs to the organization may vary. For example, one may buy a plane ticket, but call ahead to order a vegetarian meal, possibly costing the company more to provide, but your ticket has no greater cost to you. This is also known as reverse price discrimination, as the effects are reflected on the producer.

2.5 Combination

These types are not mutually exclusive. Thus a company may vary pricing by location, but then offer bulk discounts as well. Airlines use several different types of price discrimination, including:

- Bulk discounts to wholesalers, consolidators, and tour operators,
- Incentive discounts for higher sales volumes to travel agents and corporate buyers,
- Seasonal discounts, incentive discounts, and even general prices that vary by location. The price of a flight from say, Singapore to Beijing can vary widely if one buys the ticket in Singapore compared to Beijing (or New York or Tokyo or elsewhere),
- Discounted tickets requiring advance purchase and/or Saturday stays. Both restrictions have the effect of excluding business travelers, who typically travel during the workweek and arrange trips on shorter notice,
- First degree price discrimination based on customer. It is not accidental that hotel or car rental firms may quote higher prices to their loyalty program's top tier members than to the general public.

The first/second/third degree taxonomy of price discrimination is due to Pigou (*Economics of Welfare*, 4th edition, 1932), suggests an alternative taxonomy:

- Complete discrimination - where each user purchases up to the point where the user's marginal benefit equals the marginal cost of the item;
- Direct segmentation - where the seller can condition price on some attribute (like age or gender) that directly segments the buyers;
- Indirect segmentation - where the seller relies on some proxy (e.g., package size, usage quantity, coupon) to structure a choice that indirectly segments the buyers.

The hierarchy - complete/direct/indirect - is in decreasing order of profitability and information requirement. Complete price discrimination is most profitable, and requires the seller to have the most information about buyers. Indirect segmentation is least profitable, and requires the seller to have the least information about buyers.

The two-part tariff is another form of price discrimination where the producer charges an initial fee then a secondary fee for the use of the product. An example of this is razors, you pay an initial cost for the razor and then pay for the replacement blades. This pricing strategy works because it shifts the demand curve to the right: since you have already paid for the initial blade holder you will buy the blades which are now cheaper than buying a disposable razor.

The purpose of price discrimination is generally to capture the market's consumer surplus. This surplus arises because, in a market with a single clearing price, some customers (the very low price elasticity segment) would have been prepared to pay more than the single market price [7]. Price discrimination transfers some of this surplus from the consumer to the producer/marketer.

Strictly, a consumer surplus need not exist, for example where some below-cost selling is beneficial due to fixed costs or economies of scale. An example is a high-speed internet connection shared by two consumers in a single building; if one is willing to pay less than half the cost, and the other willing to make up the rest but not to pay the entire cost, then price discrimination is necessary for the purchase to take place.

3 PRACTICAL APPLICATION ON AN RAILROAD TRANSPORT EXAMPLE

The most important railway connection in Slovakia is the rail track from the capital city Bratislava to the eastern metropolis Kosice through Zilina with its length of 445 Km. On this track are kept multiple types of standard train expresses and InterCity trains. The Passengers on this line have got relative low options of substitution, making this line the monopolistic one, therefore it matches the terms of use the price discrimination type – Two part tariff.

Til the end of the year 2011 tickets on this track where regulated by price. ZSS Slovakia had used price discrimination in non-regulated seat price, because all IC train tickets had an seat reservation requirement. The principle of this price discrimination was the uneven capacity utilization in ,,weak and hard days,, when the demand for transport was different due to different passenger demand (for ex. students, duty travels). 7 pairs of express trains where on this line. In the Table 1 are weak and busy days for each train. In this time in busy days was the price of the ticket +100% higher than in the weak days. The price was even for the first and second travel class.

Table 1: Calendar of strong and weak days mandatory IC trains timetable for 2010/2011

Train	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
IC 500/10500	S	W	S	S	S	W	S
;	S	W	S	W	S	S	W
IC 502/10502	S	S	S	W	S	W	W
IC 503/10503	W	S	S	S	S	W	S
IC 504/10504	S	S	S	S	S	S	S
IC 505/10505	S	S	S	S	S	S	S
IC 511/10511	W	W	S	S	S	S	S

Explanation: S – strong days, W– weak days.

Mentioned price discrimination was for the passengers with non-elastic demand, while an principle that students are traveling in the beginning and at the end of week, duty travelers in the middle of the week. The price of seat reservation was the combination of days and directions so that the price will mostly always be highest. This allowed the rail company to maximize revenue from the sale of seat, which is the complementary part of regulated train ticket price.

From the 1st of January 2012 IC trains on the track between BA and KE are operated as commercial trains of ZSS rail company Slovakia without regulated prices. The Tickets are sold in 5 price categories, specifically for the 1st and 2nd travel class.

The price level is determined according to the date of purchase of the ticket:

- 60 – 9 days before the train departure, lowest price, price category C,
- 8 – 1 days before the train departure, price category B,
- on the day of train departure, highest price category A.

The Price categories are divided according various criteria with the goal of segmenting customers and use their price elasticity by giving various prices. The Whole tickets on an IC train contain the seat reservation and the ticket itself. On IC trains tickets for standard express trains don't apply.

Distribution of passengers to different price categories:

- 1st price category, -full price, SKUPINY member or SKUPINY MINI member
- 2nd price category, - KLASIK RAILPLUS badge holder, SKUPINY member (6-99 persons group ticket) or SKUPINY MINI kids above 15 years
- 3rd price category, - JUNIOR RAILPLUS EUR0 <26; SENIOR RAILPLUS badge holders, kids to 15yrs and seniors above 70 years.
- 4th price category, - retires, seniors, ŽSR, ZSSK CARGO, ČD, FIP badge holders
- 5th price category, -MAXI KLASIK badge.

4 CONCLUSIONS

Changes in the price regulations on transport market allowed the ZSS to use modified tools of price discrimination. These tools are increasing sales on that route. For comparison see Table 2.

Table 2: Comparison of travel time and whole ticket price between regular express and IC train from Bratislava to Košice

	Distance	Travel time		Price €	
Regular	445 km	5,52 hod.	18,76	18,76	18,76
IC	445 km	4.59 hod.	A: 24	B: 22	C: 20
Difference		53 min.	5,24	3,24	1,24

Regular and IC trains are different products, the rate of substitution is 53 minutes (time savings) when IC is used. Difference of the substitution is from 5,24 -1,24€. Discrimination is also involved on the travel class. The price for 1st class is 60% higher. Next factor is the price category which has minor affect on the total price of the travel. The usage of price discrimination in this form provides appropriate information system, which allows the collection and analysis of data for the purpose of understanding the behavior of passengers. Knowing the demand of passengers on this specific track with the usage of price discrimination tools allowed the ZSS Slovakia to increase sales.

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DESIGNING A CAR SHARING SERVICE FOR SMALL CITIES

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ABSTRACT

Car sharing service is becoming popular in the large cities, with an high population density, since it seems to address the limits of both the private car and the public transport by offering the flexibility of the former combined with the reduced need of parking spaces of the latter.
While in large cities the car sharing becomes a new element of a range of alternatives, and it appears especially suitable to public transport users who seldom use the private car, it appears interesting to investigate whether such service could be attractive or not even in smaller cities, where public transport is less frequent and parking might not be an issue.
In this paper the elements to be evaluated when planning car sharing for small cities are presented and discussed, while an approach for designing it is introduced. First, the different ways of organizing and managing a car sharing service are presented, focusing on the use of electric vehicles and on the integration with the other modes, such as public transport and bike sharing. Moreover, the possibility of integration with the fleets of public administration is evaluated.
The elements to design the service, i.e. the number of vehicles, the number of parking areas and infrastructure, pricing policies, are estimated considering the cities of Gorizia and Nova Gorica.

Keywords: Car-sharing, small cities, design, electric vehicles, one-way

1 INTRODUCING CAR-SHARING

In the second half of the last century, as a result of the economic boom and an increase in per capita incomes, the mobility demand has changed so the modal split has been moving more and more towards the use of private vehicles, leading to the functional and financial crisis of public transport in small cities.

In response to the change in user requirements there hasn’t been a substantial adjustment by the offer; that has encouraged even more mobility through private vehicle.

Only in recent times, new mobility services have been introduced, aiming at limiting the use of private means, and therefore solving its issues.

Among these services, Car Sharing is gaining interest since it combines the flexibility of private car with the intelligent use of resources of public transport.

Car Sharing is a membership service intended to offer an alternative to car ownership. People who subscribe the service can use vehicles from the provider fleet, by paying a fee, related to the time of usage, or the distance driven with the car, or both.

The first idea of a company for sharing vehicles was born in Zurich in the later 40’s, named “Sefage” and build up as a cooperative organization, which had operated until 1998. Apart that isolated example, Car Sharing had been introduced largely in the 70’s in North and Center of Europe. The need of such a service came from two historical facts: the “UN Conference on Human Environment” (Stockholm 1972) e the Oil Crisis (1973-74) [1]. The aim of developing Car Sharing was the reduction of pollutant emissions and resources consumption, by reducing the number of vehicles and by optimizing their usage.

After some isolated pilot projects, car sharing has been developed in Europe since the 90's, with the growth of non-profit companies or cooperatives initially started by environmentally-friendly citizens. Since the rising of maintenance and usage costs of the private car, more and more drivers has subscribed car sharing and given up their own vehicle [1].

1.1 Why Car Sharing?

Car Sharing supplements the sustainable transport modes of walking, cycling and public transport providing an alternative to car ownership, without restricting the individual mobility. Benefits of Car Sharing are both environmental and economic.

Car-Sharing vehicles are appropriate to the purpose of the particular journey; furthermore they use less fuel and emit fewer pollutants than the majority of personal vehicles, since they are newer. In most observed cases, the difference in CO2 emission lies between 15% and 20% with the highest being almost 25%[1]. Alternative drive systems are frequently adopted in the fleet. In particular a major chance is offered for hybrid and electric vehicles[2].

Each Car-Sharing vehicle replaces an average of four to eight private cars. This is a key factor in big cities where the congestion levels are often as high that driving is seen as a real discomfort.

Consequently to the reduction of the total number of cars, Car Sharing reduces the usage of public space, since each parking lot occupies about 12 square meters of ground. Since each shared car replaces between 4 and 8 private ones, the reduction of parks need is estimated to be an area between 36 and 48 square meters for each shared car[3].

The price transparency of the service (given by the composition of fees) gives the user more consciousness about what is the real cost of car usage. It takes to a reduction of kilometers driven.

Generally, car sharing leads to environmentally friendly transport behaviors and promotes integration in using both Car-Sharing and public transports.

1.2 The features of car-sharing through its evolution

What mainly concerns cooperative and no-profit organizations, since they have governmental or members founding, is to offer an alternative service in the citizens range of mobility options. The service is needed to integrate the public transport supply, to give the people an economic and ecologic substitute of the private car. In this case, the diffusion of the service for reaching economic results is not the priority; fulfilling the users' mobility demand with a low use of vehicles is more important.

This was the scenario in which the first car sharing operators (such as Mobility Switzerland, Greenwheels Netherlands) had been established [1]. These providers settled the base features of the service, which has been adopted even by the first for-profit company (such as Cambio in German).

Providers adopted a set of cars in order to offer "the best vehicles for every situation"[8] i.e. for any kind of trip. In order to increase the attractiveness of the service, the strategy adopted by the providers has been to improve the variety of vehicles in the fleet, and consequently give flexible fares in relation to the car typology.

[1] Data from Momo (More options for energy efficient mobility throught Car-Sharing)-The State of European Car-Sharing.
[2] Momo research in Bruxell reveals an high willingness to drive with environmentally friendly cars, especially by car-sharing users.
[3] Slogan of Car Sharing societies in Italy.

As mentioned, various models and types of car are included in the fleets of car sharing operators. It is possible to divide them into four main groups: micro and city cars, urban cars, sport and comfort category, vans and transporters; basing on this division, providers have adopted different fares. The majority of CS companies adopt at least three of the following categories of vehicles.

The user has to book the use of a vehicle in a certain advance. While this operation, until a few years ago, was usually done by phoning a call center, it is now replaced by web-booking or smartphone apps. This evolution in service management allows to book the car just a few minutes before using it a; some providers offer drivers the possibility to extend the reservation while using the car, according to the other reservations.

When booking a car, the customer has to indicate also the return time. This limits the utilization of the car for a defined interval time; but it is very important for the service management because, in this way, the provider is able to reserve cars in advance.

In this sort of service, the car is offered for a round-trip-usage, meaning that the car must be left at the starting point, ready for the next user.

The fare system is made up by combining two fees, the first one depends on time usage (a definite amount for every hour of reservation), and the second one is based on trip length (an amount for every kilometer run). In addition, often providers apply a yearly or 'una-tantum' subscription fee.

This kind of service fits the requirements of occasional drivers, for example: people who drive less than 6,000 km each year and people not owning a private car, temporarily or for choice. The service should also satisfy the needs of families giving up the second car.

As mentioned before, the company form adopted by the providers is a key factor to define the main features of the service [2].

For a business company, the main objective is to extend the service to a larger population range, to increase the potential demand. The for-profit companies reach this goal by simplifying the use of car sharing by means of the most recent IT technologies and a flexible approach to parking options.

For example, Daimler Group has created a car-sharing service called 'Car2Go'[3] which implements a One-Way relocation policy with no fixed parking locations. More recently, Renault started to experiment the TwizyWay service, in which the easy-of-use of Car2go is combined with the even smaller and less expensive Twizy EV [4].

The main advantage of these "innovative" car sharing services are:

- The composition of the fleet. Small vehicles, with low consumptions and low emissions, are preferred. Electric vehicles seem to be the logical solution to these requirements.
- 'Instant Access' is the way of pick up these vehicles that means no reservation is required. Instant access also allows an "unlimited" (Open-End) use of the car, since the users doesn't have to respect any "rental time".
- The availability of a sharing car in the nearby could be checked on the website or with a smartphone app.
- The re-location policy (in general called 'One-Way'[4]) could be very permissive: the 'free floating parking location' introduced by Car2Go; or could set some restricted areas where the car must be parked after usage. The last case is called 'Station-based parking'[5]; the parking location could be chosen by the driver upon a bunch of available ones.[5]

[4] One-Way refers to how users are allowed to leave the car after usage. In particular, the car could be left in a destination which doesn't necessarily be the starting point.
[5] Station-based is the strategy adopted by Autolib' in France.

- In the end, another innovation key is the fee system, based only on usage time. Drivers only pay the effective usage of the car, measured for each minute. Driven kilometers are not evaluated.

1.3 Traditional versus innovative car sharing

Traditional car sharing usage is perfect both for big and medium size cities, since it gives the users a wide range of vehicles, which means a big flexibility both for urban and long term trips. The role of this kind of service is to complete the mobility supply, resolving the lacks of Public Transport by giving the citizens the opportunity of use a car without owning it, especially for mid and mid- and long distance trips or to carry large items.

Users are people which usually plan trips and which drive less than 6,000 kilometers in a year.

On the other hand, a so-called 'innovative' car-sharing service works properly within a city and for occasional users, who might need immediately a vehicle, for a short period and a mono-directional (One-Way) trip [5]. It could also effectively support the public transport.

Its main innovation, Instant Access and One-Way relocation policy, also represent the major issues of designing the service.

1.4 Sizing car sharing, introducing the demand problem

Designing a traditional type of car-sharing service is just a matter of restrains and parameters. The first parameter to start sizing, is the number of users to satisfy. At the same time, the number and the location of parking lots could be easily decided based on demographic criteria. After fixing parking lots and assuming the number of users to serve, the maximum number of cars composing the fleet should be a consequence of the budget for the vehicles defined by the CS Company. The booking policy and the round-trip-usage relocation modality are sufficient to avoid management issues such as unsatisfied demand or users waiting their booked car at an empty park location. In the end, the users should be easily counted by the provider, since they have to subscribe the service registration, and trip data could be also easily obtained by checking the reservation chronology.

On the other hand, thinking about an innovative service with One-Way Free floating relocation policy, the most obvious issue is to settle a sufficient number of cars to satisfy the demand. Any user should be able to reach a vehicle in brief time without a long walk. The time of usage and the relocation lot may not be known before the end of each trip. No reservation is required because of the 'open-end' modality of use, therefore the provider could not guarantee, with the booking service, the availability of a car for any user. This problem has been in part overtaken by inserting an huge amount of cars. Only big providers, with car producers' partnership, should apply this solution and offer One-Way Free-floating service.

In the end, focusing on One-Way Station based, the sizing problem, which should be dealt with firstly is to set the number and the location of parking lots (in analogy to the procedure for round-trip usage) and secondly, the minimum number of cars, which is able to satisfy the whole demand, has to be set. That means, in practice, that once a user comes to a parking lot, he shouldn't wait for the car to come.[5]

In both cases, standard car sharing, Free-floating or station-based, what always turns out is that for correctly designing the service, an estimation of Demand is fundamental.

2 LOOKING FOR CAR-SHARING POTENTIAL USERS IN SMALL AND MEDIUM CITIES

In small and medium cities (so called cities with more than 20 thousand up to 100 thousand inhabitants) the use and the possession of a car doesn't cost nor produce the same negative effects as in the big cities. Problems like air pollution, traffic congestion and lack of parking areas don't exceed (generally) acceptable levels. In these cities, the car is still the most flexible vehicle and its main weakness is its ownership and usage cost. [6]

Therefore, the public transport is used mainly by people who don't have the driving license or don't own a car. The public transport appears to be more convenient than private car only for people living and working close to a bus stop.

For the majority of users, public transport is not an effective alternative: people's preferences show, historically, a growing preference for the individual modes of transport, thanks to its higher comfort, flexibility and capillarity. Despite of a growing attention for the quality of service, public transport companies and local authorities show little capacity to adapt to the required standards. As a result, there is an increasing number of users dismisses the public transport and chooses the private vehicle; hence further decreasing economic sustainability for the public transport.[7]

Actually, mobility alternatives are emerging, designed specifically to supplement the PT itself; for small and medium-sized cities, these are: the dial-a-ride buses and bike sharing. Their aim is to contain the crisis of the PT, providing both a more flexible solution and cheaper one. The first seems to be an ideal solution to offer a public transport service on low-density areas, to serve weaker users demand and people not owning a car. Bike sharing is emerging as a flexible and low-cost alternative, but its effectiveness is still to be assessed.

2.1 Modal split in small and medium cities

As mentioned, in a small and medium-size city, there is at least a car in each household, in most cases two, depending on the number of members of the family with the driving license. But there is a part of population that couldn't access the private car, mainly:

- Students: they still have not the drive license, or they don't possess their own car;
- Weaker[6] users: old people, or in general everyone who has not the drive license;
- Others: anyone who, for any reason is temporally without a car.

These three categories of users can only use the public transport, that is, for medium and small cities, the bus service. as a result, analyzing qualitatively the modal split, as represented in Figure 1, the private car is used for most trips, while PT, taxi and bicycle are by far less adopted.

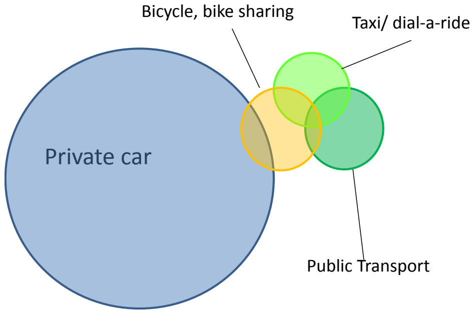

Figure 1: Qualitative Modal Split (in Small and Medium Cities)

[6] Here, weakness is considered the fact of not being able to drive.

2.2 Which scenarios shall be generated by introducing car sharing service?

Sharing a vehicle could be an useful alternative for car owners using the vehicle less than a certain mileage. Comparing the cost of private car (considering the possession for ten years) to the cost of a sharing one (the same model, with fuel motor), join car-sharing and giving up the private vehicle is estimated to be economically convenient for users that drive less than 9.000 kilometers in a year, as shown in Figure 2, by comparing the costs of private car to the car sharing ones.

Therefore, each car which is driven less than 9.000 kilometers in a year might be potentially replaced by shared vehicle.

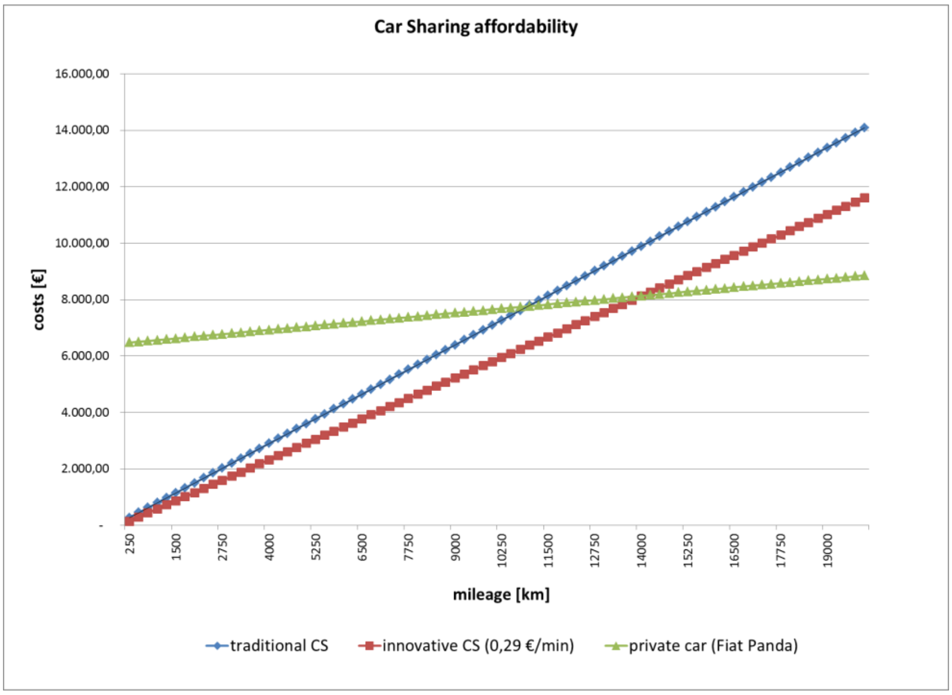

Figure 2: Car Sharing Affordability (A Comparison of Car Sharing and Private Car Cost-Effectiveness)

As a result, car-sharing should work properly for households which decide to give up one of their cars, since they use it a very little, or for households that own more than one or even two cars, but the second one or the third one are rarely used.

The three categories of users, explained earlier, are self-oriented on Public Transport. As known bus service in small cities is quite inefficient because of high operating costs and low occupation. Car Sharing could support the service, by giving opportunity to categories of users, able to drive, but without a private vehicle (temporally or for other reasons as coming to city by train) to shift from bus to car and vice versa, according to their necessity. For the weaker users a complementary service could be the dial-a-ride bus or taxi. While students will probably still need for a dedicated bus service, due to the high and concentrated demand. Obviously, this service might be limited on upon the school times.

Car sharing service should offer a supplementary service for habitual Public transport users and, at the same time, let the awareness of the mobility alternatives[7] to grown[8]. So, all those users, who give up their own car, have to make a modal choice for every trip. In their bunch of alternatives, they select every time the most convenient transportation means (bus, car-sharing, taxi,

[7] P. Muheim (1998) express this self-awareness phenomenon with 'Learning curve of Car Sharing' description.
[8] Growing trought the creation of **win-win** situations is possible. Momo (2009)-The state of European Car Sharing.

bicycle…). As represented in Figure 3, car sharing brings to a more equal distribution in modal choice, a higher level of interoperability and a reduction in private car use too.

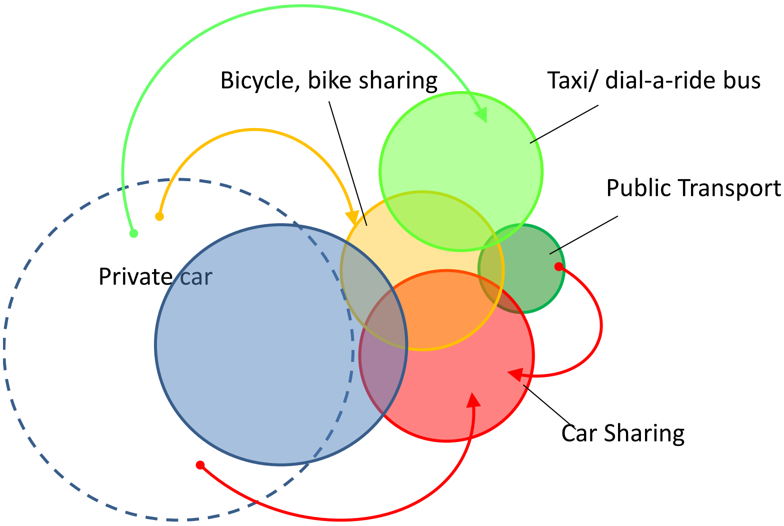

Figure 3: A Possible Evolution of Modal Split

2.3 The mission of Car Sharing in medium and small cities

Summarizing, Car Sharing in small cities (cities with more than 30.000 and less than 100.000 inhabitants) seems to be:

- A mobility solution for people who wants to give up one of their car, since they don't use it a lot (remember the kilometric threshold seen before). So, Car Sharing could develop in residential areas for best supporting families' demand.
- A mobility solution for people reaching the city by train. Give a flexible service, in the nearby of train stations, seems to be strategically important.
- A support to university students (in possess of the drive license) and all the young people who don't own a car, but might be in need to make short and quick trips inside the urban area.

Furthermore, car sharing could also replace partially, or even totally, the fleet of the public administration, providing a cost-effective solution and, at the same time, gaining a significant and reliable customer base. Therefore, local administrations and authorities represent a key role in Car-Sharing development towards small cities. The multiple work trips made daily are often undertaken with vehicles from a city-owned fleet that is not always exploited to its fullest potential. City administrations should thus be obtained as business Car-Sharing customers, allowing them to benefit from the potential financial relief of the service. The additional Car-Sharing services that will likely be added because of this would benefit Car-Sharing users outside of business hours as well.

Figure 4 resumes which might be the role and effect of car sharing in small and medium cities; it also points out the vocation of car sharing in replacing private car and in completing the public transport service.

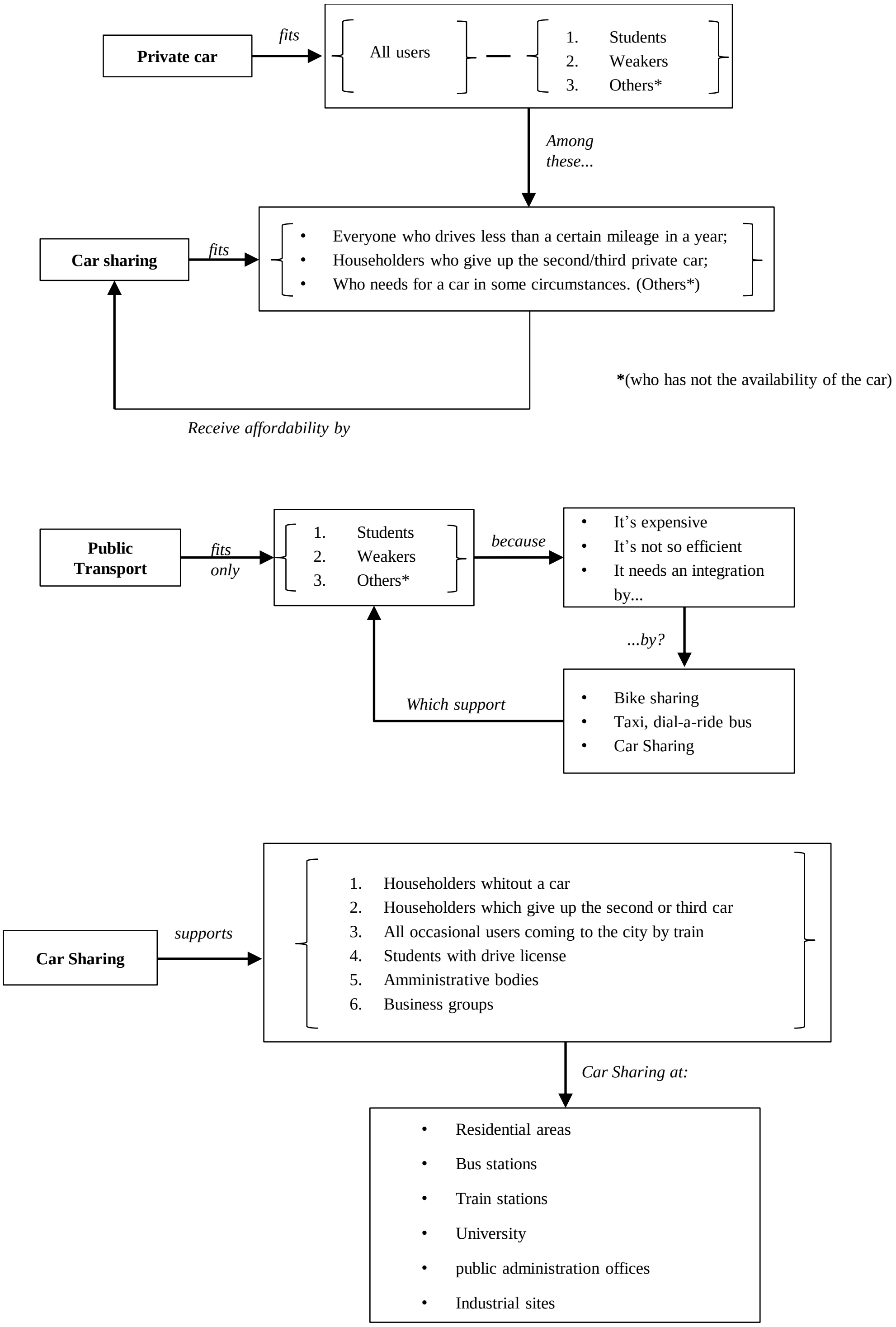

Figure 4: The Role of Car Sharing in Transport Supply (for Small and Medium Cities)

3 A METHOD TO DESIGN CAR SHARING SERVICE FOR SMALL AND MEDIUM CITIES

As explained in the previous section (see 1.4), one of the a-priori elements for correctly design an 'innovative' car sharing service is a Demand Model, that is the key to estimate the potential number of users. Once the demand is known, sizing the service by setting a number of parks and cars is quite simple [8].

The main issue is that Demand is rarely available and to obtain those data, careful surveys are needed.

In Figure 5 the proposed method to plan a car sharing service is shown in diagram form, underlining the iterative workflow.

A demand model makes it possible to set the basic parameters required to implement the simulation model. Those parameters are the number of users / number of trips and the origin-destination nodes. Therefore it must be included data about travel time for each trip.

The simulation model allows verifying the effectiveness of the system at variation of the number of vehicles and of the parking areas [9]. Consequently, by iterating the number of cars and the number of parking areas (in the simulation model), the configuration, which guarantees the service effectiveness, is to be found. The next paragraphs explain more in detail the processing phases of the Designing Method.

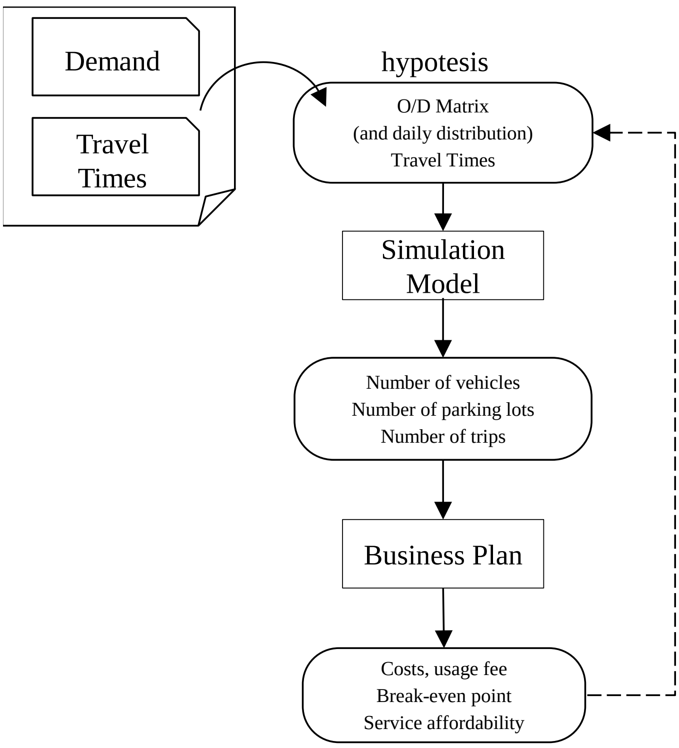

Figure 5: The Designing Method

3.1 Simulation Model - the operative feasibility

To address the problem, a simulative method has been developed. A discrete-events simulation, that reproduces how the service is running, was set up using the Anylogic software.

This approach is needed since the operation of the service is a dynamic process, where even if the Demand and the Travel times are known, the number of vehicles is a variable related to the goal of serving all the demand by employing the minimum number of cars (see 3.3). So here the three steps for finding out the dimensional data through the simulation:

- Step1: Create the network. The model consists of a number of parking spaces and a number of vehicles, which is the variable defined by the decision-maker. The demand and the travel times allow setting other parameters such as number of users, their daily distribution and time occurring for trips.

- Step2: Run the Model. The so settled model allows to the decision maker to perform a lot of What-if scenarios, by injecting a different number of vehicles, and observing how the system works (for instance how many users are served, if the cars don't reach some station, at what time the service is inefficient, etc.).
- Step3: Analysis of the results. At the end of the simulative process, it can be observed what the most efficient number of vehicles is; that is the minimum number which satisfies the demand with acceptable retards (it could be result of the number of users waiting at the station, or highs waiting times).

Once the number of vehicles in the fleet and the number and location of parking lots are obtained, the first phase of sizing is concluded. The operability of the service has been tested.

3.2 The simulation model and tool

The simulation of a process or system is an instrument, generally used to identify critical points of a system, it may also be a valid support in the selection of the best alternative, among a set of configurations. Through simulation, optimization of a system can be obtained, proceeding with successive iterations.

The strength of simulation models consists in taking into account the temporal distributions of variables value, to assume different solutions without realizing them physically; avoiding additional costs and wrong choices.

[10] AnyLogic is a software developed by XJ Technologies, which is used to create simulation models in each of the three traditional hierarchical levels (abstraction): Discrete Events, System Dynamics and Agent Based, or even combining them together (the name 'Anylogic' comes from the software's ability to use each of the three logical). These models are used to represent prototype systems to design or develop systems which are thus "virtually" studied: different aspects and scenarios related to the design or implementation of the system are explored in a simple way and without risks.

The strength of AnyLogic is to provide a user-friendly interface thanks to which, as an alternative to the Java language programming, modeling can be made by means of the drag-and-drop elements belonging to particular software libraries.

Therefore, the construction of the model is realized by combining graphical elements, in modules, following a hierarchical structure.

Furthermore, Anylogic provides an environment for animation and the graphical tools suited to represent the model by means of interactive animations (implemented in Java). Here, Figure 6 shows a piece of the logic diagram which performs the simulation for a car sharing service with only one origin and four destinations.

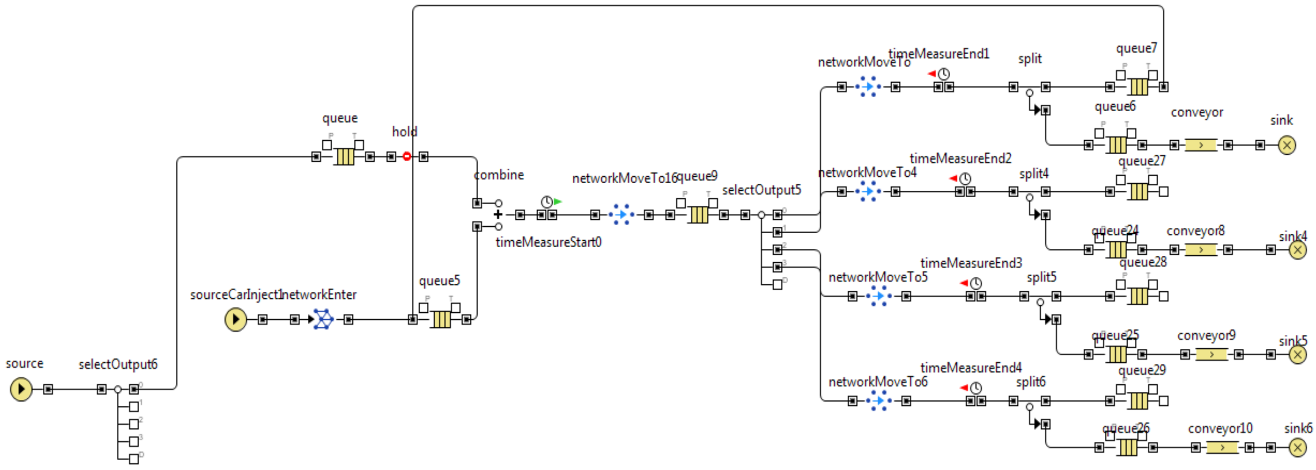

Figure 6: A Piece of Car Sharing Simulation Loop performed with Anylogic

3.3 Business Plan - the economic feasibility

The so planned car sharing service has now to be evaluated from the economic point of view.

At the end of this evaluation, taking into account costs, and wanting to ensure that the service is still efficient from the financial-economic point of view, the minimal fee to be imposed, or the minimum usage of fleet, for economic feasibility, should be found out. If this rate is compatible with market standards and with the customer's willingness-to-pay, then the size of the service is completed. Conversely, a too high cost rate is a symptom of poor profitability of the service. At this point, the designer should re-evaluate the service planning, and then return to the Simulation Model stage (in the scheme in Figure 5, the passage is evidenced by the dashed line) to vary the number and / or location of the parking spaces and the number of cars.

The proposed procedure for performing the business plan is here described in three steps:

- Step 1: Evaluating costs for provider. The unit costs for each CS service component are calculated; which include those related to vehicle, to staff, to technologies for management and to marketing.
- Step 2: the total cost of the service (generally expressed in a multiannual amortization plan) is calculated. The total amount depends on the number of vehicles and parking areas.
- Step3: Find out the break-even point. Since the Demand is given and so the Travel Times, the break-even point could lead to the minimum usage fee to be imposed for covering the costs, since the usage time is given. Otherwise, basing on a given fee, the break-even point could lead to the minimum usage of the service (in terms of hours/ minutes of use, since an 'innovative' service has to be designed), which is required to cover the costs. This last result is the one adopted in the pilot test exposed in par.4.1.

At this point, the sizing procedure could be considered ended. But as previously told, if the usage fee given by step 3, or if the usage time is not compatible with the reality, the designer should re-start the procedure from the simulation Model, by changing simulation variables.

4 A PILOT STUDY FOR PLANNING AN INNOVATIVE CAR-SHARING SERVICE, FOR SMALL TO MEDIUM CITIES, WHEN NO DEMAND MODEL IS PROVIDED

When the Demand is not available, the method (as exposed in par.3), thanks to its iterative structure, allows to perform a preventive sizing. The sizing could be performed by starting from the business plan to firstly define the break-even point in the service usage, and then entering the Simulation Model with hypotheses based on the financial equilibrium, instead of on the real Demand and Travel Times.

In fact, despite the lack of the Demand database, it is possible to obtain, by setting a usage fee, the minimal theoretical usage of the service (expressed in usage time, hours and minutes), which guarantees economic efficiency. To better understand the procedure adopted, this one has been split in two phases and, as mentioned, the first one to be processed, in this case, is the business plan.

Hence, in this case the procedure starts from the Business Plan, with a-priori evaluation about economic feasibility (with an assumed number of cars and parking lots).

At this point, the problem is to determine whether the sizing, made from the economic point of view (in the first phase), is valid from the operational point of view; i.e. it must be determine whether the number of vehicles and the number of parking lots are enough to guarantee the minimum desirable use. For testing the operative effectiveness of the service, the simulation model is applied.

4.1 A test for the method. The pilot study for Gorizia and Nova Gorica

The proposed method has been applied to design a car sharing service for medium-sized cities, i.e. Gorizia (and Nova Gorica), intended to be run by a hypothetical provider. The case study was carried out to obtain a very rough estimation of the possible costs and quality of service provided by car sharing. The positive acceptance of these first results by the public administrations of the cities appears a a pre-requisite for starting a survey that would result in a more detailed model of the demand to be used for in a more accurate planning phase.

As it was previously explained, since the lack of Demand and Travel Times, the method (look at par.3) has to be applied by starting from the Business Plane Phase.

The service to be sized is One-Way, station-based, that is, as explained earlier, characterized by a fixed number of parking spaces, in which the user can park the vehicle, without the restriction of having to bring it back to the starting station.

In the first hypothetic scenario, the fleet has been made up with 30 electric vehicles (all Renault Twizy) according to observed structure of similar examples of car sharing (TwizyWay). A usage fee per minute (€ 0.29 per minute, as well as car2go and TwizyWay) has been set.

From the point of view of management costs, to verify the economic feasibility, the number of parking area has only logistical relevance, in this phase is only used to quantify the number of charging stations that must be included. The cost of these units can be very variable, it is estimated, however, that its impact on the total cost does not exceed 15%.

The total costs of the service were split into a five-year amortization plan. Then the variable costs of the service, management and consumption, spent by the provider in a year, have been used as the basis to calculate the minimum usage of the service. Considering a rate of € 0.29 per minute, the result is a minimum usage, which is expressed in hours, that ensures the coverage of the operative costs.

By assuming a time of 10 minutes as the average usage for each trip, the estimate has led to almost 400 trips per day.

The number of users, at this stage, is expressed by the number of travels, so each user is the equivalent of one trip. Otherwise, the estimated number of users would come from a demand model.

According now to the Simulation Model Stage, there is the need to achieve the simulation which, as mentioned earlier, has been realized using the Anylogic software.

The model has been created with exploratory purposes; of course, its effectiveness is closely related to the accuracy in choosing the parameters, which in this case have been set without preventive surveys about the real parameters.

Anyway, the structure of the simulation has been defined by creating a network of nodes (points origin-destination and connection points) and arches (roads connecting the nodes).

Each of the source-destination nodes corresponds to a vehicle pick-up and vehicle drop-off area, in this pilot model, car parks are assumed to be 4.

The number of vehicles can be injected at decision-maker will, in each of the 4 parking areas. In our case it has been provided 30 cars, according to the business plan, in Figure 8 a screenshot of the running simulation is represented.

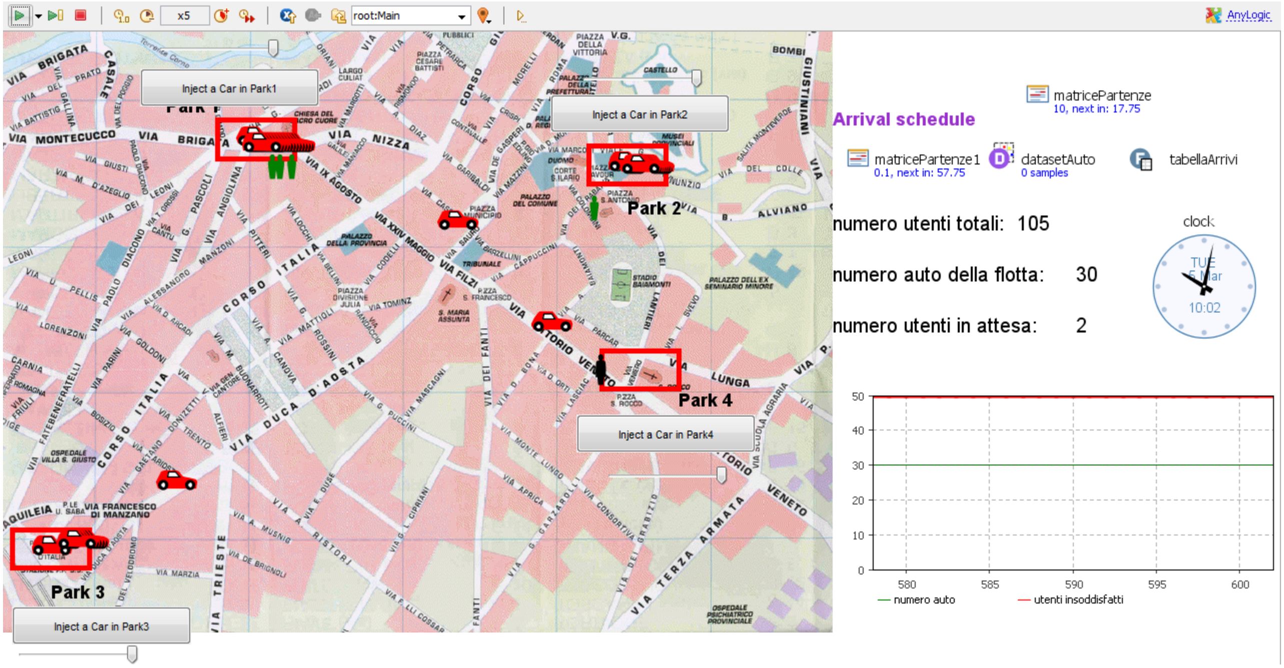

Figure 7: Screenshot of the Anylogic Simulation

The vehicle trips are generated when an user joins a car. A source continuously generates service users, who enter the system close to the 4 parking areas (according to an assumed statistical distribution, which replace the real O/D data).

Hence, the number of users to be included in the system is assumed to be an arbitrary parameter, the users generator reads the number of inputs (or the frequency of the same) by a matrix defined by the decision maker.

Such a matrix, in the case in example, has the daily entrance of about 400 users (each user perform one 10-minutes trip). The number is not precise because it has been preferred to insert a frequency-rate of arrivals per minute, according to a distribution that considers three daily peaks of a maximum about 20 users per hour for 3 consecutive hours, represented in Figure 8.

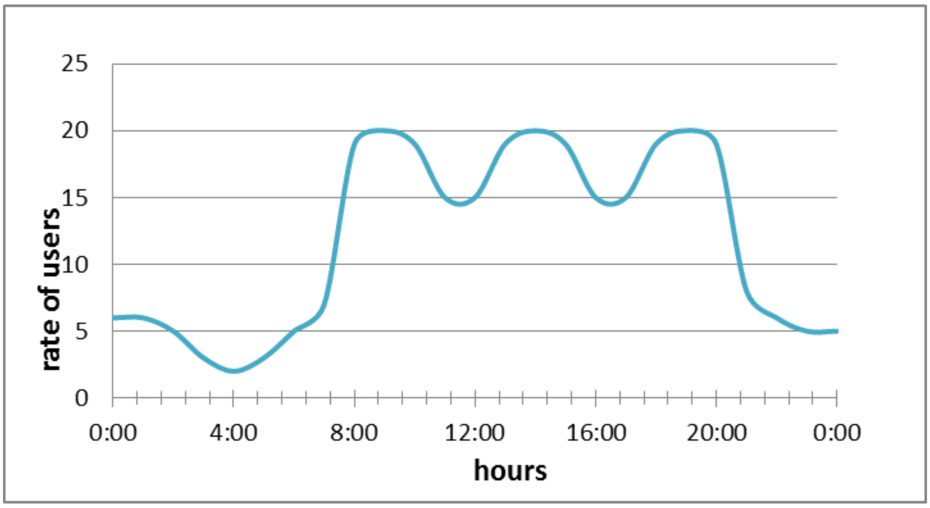

Figure 8: Hypothetic Daily Distribution of Users' Arrival

4.2 Results from the pilot test

Since the origin-destination points are only 4 and quite far from each other, if an user reaches a parking lot where there are no cars available, it will not move to the next parking area on foot, looking for an available car, but he will stand in a queue to wait for the car coming. The simulation has been set such to automatically crash when the system registers more than 10 users waiting for the car at a parking lot.

Assuming an hypothetic rate distribution of users' arrival, which is the one described in Figure 8; by iterating the simulation with different rates of vehicles, from 5 to 50, the simulation model shows the results displayed in the Figure 9. The figure shows an increment of satisfied users, according to a bigger number of vehicles. In this case, 30 is the minimum number of vehicles in the fleet which allows serving the sufficient number of users needed for covering the costs.

Linked to the growing in satisfied users' number also grows the daily income; while, the increasing of management costs shows a linear-growing tendency, which only depends on number of cars in the fleet.

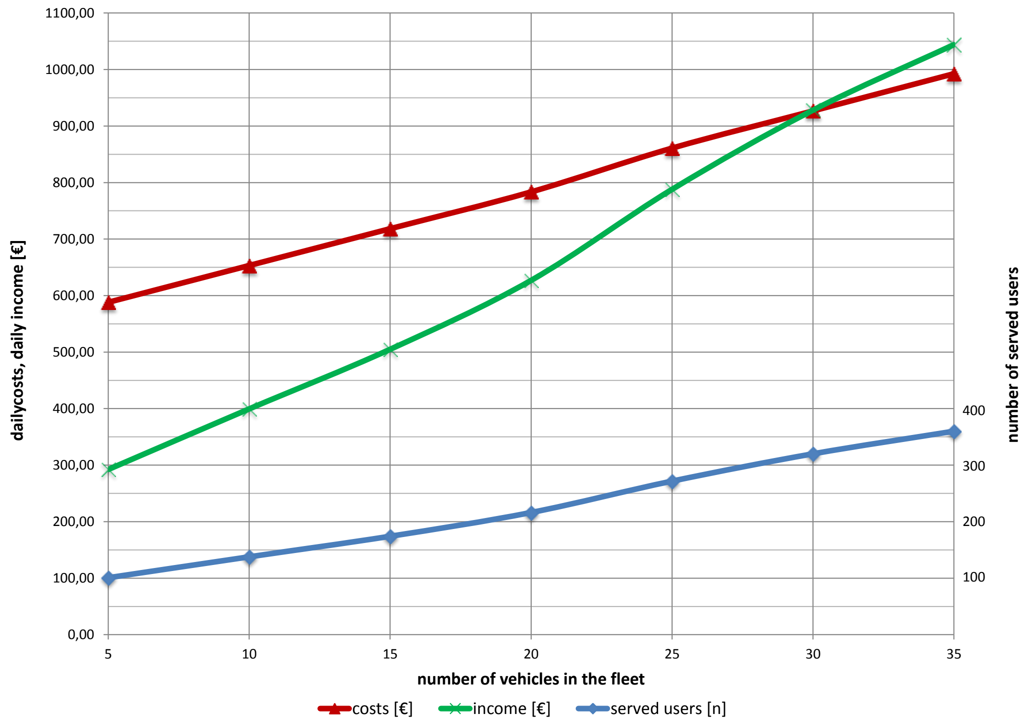

Figure 9: Simulation results: number of vehicles, users, costs and income

4.3 The role of Public Administrations in the start-up of Car Sharing

For a Car Sharing service, the start-up phase is known to be the most critical from a financial standpoint. In fact, customers have firstly to become aware of the benefits of car sharing, secondly have to evaluate the service effectiveness compared to their mobility habits and, in the end, possibly decide whether to join it or not.

For a newborn Car-Sharing service to rely on the partnership of a big customer means being able to bear the financial difficulties at start-up stage. Public administration and government bodies play a key role in this regard.

In order to quantify the importance of the accession by the Public Administration, the case of Gorizia has been considered; after an a priori sizing of a Car Sharing service with 30 electric vehicles (as seen before).

In Gorizia the fleet of private cars available to the various Public Agencies is about of 70 private vehicles.

Of course, not all vehicles can be conveniently replaced by the use of Car Sharing vehicles. An estimate has led to limit the number of vehicles to 20 replaceable units (only small vehicles has been considered, which can be replaced by electric ones).

Further, the estimate has showed an incidence of demand from the public administration that is equivalent to a percentage of about 8 to 10% of the total (demand to reach the break-even point in a year).

5 CONCLUSIONS

Car sharing is a very flexible transport service, its effectiveness is demonstrated so far in the big cities, where the problems related to traffic: parking, pollution and congestion, are not negligible. In the medium and small cities, where the main mobility issues are related to a lack in public transport offering , car sharing seems suitable to support all drivers with no own car, and all those who, although they have a private vehicle, they use it so rarely that costs connected to property are no sustainable. The latter could then decide to give up the private car for a sharing vehicle.

In this paper, the characteristics of the service have been analyzed. Then, a method of approach to the design of an 'innovative' car-sharing service, with suitable features for medium and small cities, has been proposed.

The core of the proposed approach is the implementation of a simulation model.

The effectiveness of the method has been tested by carrying out a study on Gorizia and Nova Gorica, where no demand was provided. Anyhow, the proposed method has shown great versatility in the creation of a number of what-if scenarios, mainly thank to the simulative component that incurs in the approach.

The results of this preliminary study will encourage the public administration to promote a demand survey to be used as an input for a more accurate estimation of the potentials of car sharing in Gorizia and Nova Gorica.

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PEDESTRAIN MICRO-SIMULATION APPROACH INTO FUNCTIONAL LAYOUT SELECTION

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ABSTRACT

The purpose of this research activity is the development of a combined analytical/simulative approach helpful to identify the best layout configuration into urban development and building realization.
Through analytical macroscopic method developed is possible analyze the quality of the movements, in a separate way, in the various elements that make up the infrastructure and so define a dimensional range for each element, that will be inputs into simulative process.
The micro-simulation process, starting from the input provided from analytical approach, through the most common algorithm implemented in commercial pedestrian software, social force, allow to identify the best qualitative layout configuration.
This approach was tested into real cases of studies, a rail station and a commercial centre. The results confirm that this approach is a very helpful for the choice of the best layout configuration.
In order to overtake the lack of data input available to increase the reliability of simulative process and develop a data base from which obtain statistical data about pedestrians an automatic system device is under development.
This method allow to the engineers to verify or project the best layout configuration according the capacity/potentiality that the same must be able to satisfy.

1 INTRODUCTION

In recent years we are witnessing a growing interest in the analysis of pedestrian dynamics in large buildings, whatever they may be.

Nowadays it is necessary that even before to do architectural design remarks aimed at identifying constraints and requirements requested by pedestrian mobility which should be taken into consideration in the design of functional layout, it may be developed a proper design that allows to satisfy the pedestrian flows related to the infrastructure and/or an assessment about the capacity and potentiality of nodal existing infrastructure (such as train stations, subways, airports) as well as any civil complex that may gather notable pedestrian flows (commercial centers, theaters, meeting rooms, skyscrapers, etc) and urban elements such as shopping streets, main important squares, pedestrian flows in case of exceptional events, etc.

The more careful minimization of spaces contextualized in the topics of saving money and energy jointly with the need to increase the quota of sustainable transport whilst ensuring users a dynamic, efficient, safe and highly frequent transport without bottlenecks are pushing the architectural design to take root and to integrate itself always in the inputs generated by an analysis approach of transport.

The integration of transport systems analysis in the design process and/or the evaluation of nodal infrastructures, civil buildings and urban elements are now becoming a very useful tool in order to predict and then to take into consideration phenomena of pedestrian flows concerning the elements under analysis.

The purpose of this work is to provide an analytical tool of calculation and evaluation of some parameters for pedestrian facilities, that could be solid background for further simulative analysis or simply parameters for technical draw of infrastructures.

This tool is easy to use, but at the same time give simple and reliable answers to the most common problems encountered in the study of pedestrian dynamics.

The final scope is to obtain the optimal solution of the problem through a continuous process of parameters refining, and optimization of the intermediate solutions obtained.

2 LITERATURE REVIEW

The issues concerning pedestrian flows have begun to have some relevance only in the last 40-50 years. In a first approximation, the studies concerning the analysis of the characteristics of pedestrian traffic can be divided into two broad categories (May, 1990): macroscopic and microscopic analysis.

The first studies were based on direct observation and on the use of photographic material or shooting with cameras in slow motion. These studies gave rise to the first macroscopic models: they consisted in the development of the concept of “Level of Service” (Fruin, 1971), in deducing design rules for optimal pedestrian infrastructure, or in the development of guidelines for planning and design of transport systems (HCM, 1985). The results of this work were usually translated into empirical relations between the various quantities involved, which, however, are ill-suited to the study of particular cases such as infrastructure and buildings with non “standard” geometries, or in the evacuation situations of particular complexity. Moreover, these models took into account the traffic flows in the aggregate, without taking into account the inevitable interactions that are established between individual pedestrians, and that influence their behavior.

Therefore, a further step forward was the introduction of so-called microscopic models: mathematical models of simulation of pedestrian behavior, both in normal and emergency conditions. One among the first and most important of these models assumed for the movement of pedestrians a behavior similar to that of the gases or fluids (Henderson, 1974): this model was born first as macroscopic model, then adapted to take into account the interactions between the different entities (Helbing, 1992). Later were further developed mathematical models, such as models of the “Code” (Yuhaski, Macgregor Smith, 1989), models in the transition matrix (Garbrecht, 1973), stochastic models (Ashford, O'Leary, McGinity, 1976).

In recent years have emerged models that currently constitutethe most used tools in the analysis in the field of pedestrian models: model with cellular automata (Blue and Adler, 2000; Muramatsu et al., 1999) and the model of social forces (Helbing, 1991) which, together with models based on artificial intelligence and research models of the path (way-finding algorithms), form the basis of modern simulation tools of pedestrian traffic.

Finally, hereinafter get a list of the main simulation models developed and published over the years by various authors, just analyzed. The list comprehends the above described models and many others that make up their evolution or variants. For each model it is described the type, the type of representation of the pedestrian traffic, the rules of behavior of the agents, the scale of representation and the scope.

Table 1: Principal Pedestrian Models

		Tm	Rapp	Rc	Sc	App
Model Name and Author	Aeneas (Petersen et al. 2003)	Mi	As	In	Di	Evac
	AlGadhi et al. (2001)	Mi	Fa	Col	Di	Gen
	Amanda (Dijkstra et al. 2002)	CA	As	In	Di	U
	Blue e Adler (2000)	CA	As	In	Di	Gen
	Burstedde et al. (2001)	CA	As	In	Di	Gen
	Di Gangi et al. (2003)	C	Fa	Col	Di	Evac
	Gordge e Veldsman (1998)	Mi	Fa	Col	Di	S
	Helbing (1992)	G	Fa	In	Con	Gen
	Helbing e Molnár (1995)	Mi	As	In	Con	Gen
	Jiang (1999)	Mi	As	In	Di	U
	Legion (Still, 2000)	Mi	As	In	Con	Gen
	Lovas (1994)	C	As	Col	Di	Gen
	Mipsim (Hoogendoorn e Bovy, 2000)	G	Fa	In	Di	Gen
	Nomad (Hoogendorn e Bovy, 2000)	Mi	As	In	Con	Gen
	Paxport (Birchall et al. 1994)	Co	Fa	Col	Di	A
	Pedflow (Willis et al. 2001)	Mi	As	In	Di	U
	PedGo (Klüpfel e Meyer-König, 2003)	CA	As	In	Di	Gen
	Pedroute (Maw e Dix, 1990)	Co	Fa	Col	Di	S
	Penn (2003)	Mi	As	In	Con	Gen
	Steps	Mi	As	In	Con	Gen
	Streets (Schelhorn et al. 1999)	Mi	As	In	Di	U
	Tajima e Nagatani (2001)	CA	As	In	Di	Gen
	Teknomo (2002)	Mi	As	In	Con	Gen
	Yuhaski e Smith (1989)	C	As	Col	Di	Gen
	Aeneas (Petersen et al. 2003)	Mi	As	In	Di	Evac
	AlGadhi et al. (2001)	Mi	Fa	Col	Di	Gen
	Amanda (Dijkstra et al. 2002)	CA	As	In	Di	U
	Blue e Adler (2000)	CA	As	In	Di	Gen
	Burstedde et al. (2001)	CA	As	In	Di	Gen
	Di Gangi et al. (2003)	C	Fa	Col	Di	Evac
	Gordge e Veldsman (1998)	Mi	Fa	Col	Di	S
	Helbing (1992)	G	Fa	In	Con	Gen
	Helbing e Molnár (1995)	Mi	As	In	Con	Gen
	Jiang (1999)	Mi	As	In	Di	U
	Legion (Still, 2000)	Mi	As	In	Con	Gen

Type of model (Tm): Cellular Automata (CA), Micro Simulation (Mi), Code (C), Continuous (Co), Model analogy gas-fluid (G)
Performance (Rapp): Flows aggregates (Fa), Individual Agent (As)
Rules of Conduct (Rc): Collective (Col), Individual (In)
Scale (Sc): Continue (Con), Fair (Di)
Scope (App): Stations (S), Airports (A), Buildings (E), Urban (U), General (Gen), Evacuation (Evac)

From the above analyzed models it is clear that an analytical simulation integrated approach finalized to the identification of correct design - as described in the previous section - appears today to be an innovative area on which there is still much work to be done.

3 ANALYTICAL APPROACH

In the case of macroscopic models, pedestrians are studied in the aggregate, similar to what happens in the models for the study of fluid dynamics; they are therefore characterized by global parameters such as flow, density and speed. In this way can be easily analyzed problems in large scale, even though from a qualitative point of view the results appear to be rather rough and approximate values.

In any case it is possible to obtain sufficient results for the evaluation of the infrastructure’s Level of Service (LOS, Level of Service) and for the evaluation about the quality of the offered service. Models of this type have been developed since the early 70s (Fruin, 1971; Pushkarev and Zupan, 1975) and have been adopted and updated by important design manuals, such as for example the HCM (Highway Capacity Manual, 1985).

The analytical model developed in Excel environment is structured in different spreadsheets, each focused in the analysis of a particular aspect. The methodology for the analysis of data in these spreadsheets derives from the procedures described in two American design manuals:

- Highway Capacity Manual 2000 (HCM 2000), famous and large utilized reference manual for the design and analysis of different phenomena in transports field;
- Transit Capacity and Quality of Service Manual (TCQSM), a specialized manual in studies of problems related to public transport.

The “Input-Output” spreadsheet is mainly developed for the calculation and evaluation of Level of Service (LOS) of different elements which constitute the most common pedestrian traffic facilities (pedestrian walkways, stairways, waiting and queue areas, signalized intersections).

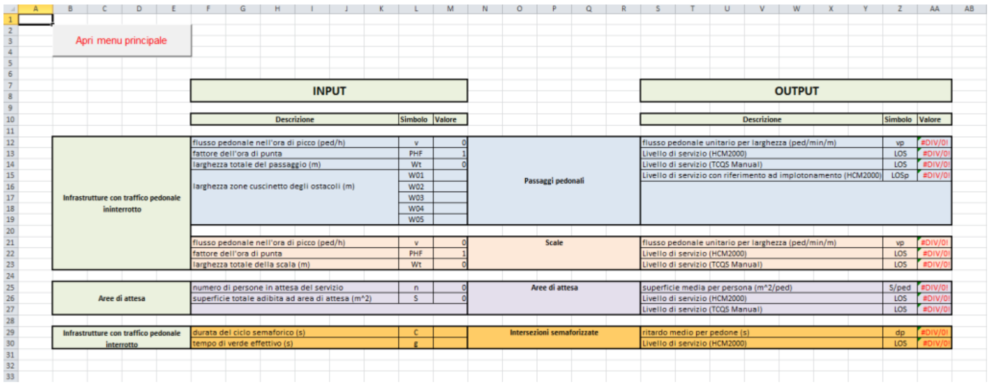

Figure 1: The “Input-Output” spreadsheet

In The “Design” spreadsheet the calculation procedure evaluates some values ranges related to geometric characteristics of the different elements constituting the common pedestrian infrastructures. These values depend on the Level of Service that analyst wants to achieve for the particular item, which is one of the model inputs. In addition to the calculation of geometric parameters related to the given Level of Service, this sheet also provides the evaluation of the capacity of the elements; in the case of stairs and escalators is also provided the evaluation of the waiting area required at the ends of the elements to meet the expected pedestrian demand if it exceeds the capacity.

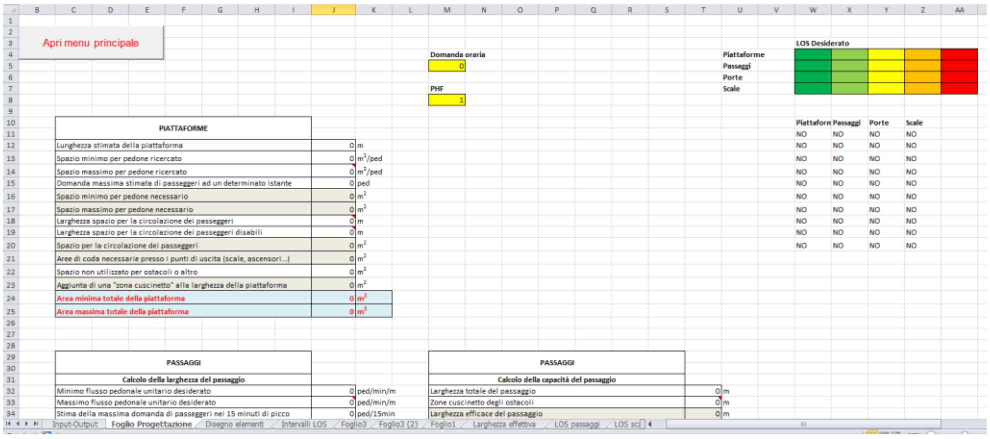

Figure 2: The "Design" spreadsheet

The "Elements drawing" spreadsheet provide to analysts an idea of the layout of the infrastructure required to satisfy the pedestrian demand at a given Level of Service. In this sheet input data are the geometric characteristics ranges, evaluated according to previous "Design" sheet, and also any other size of the element and the coordinates of insertion point in the layout. Once inputs are entered, VBA macro code returns an output file in AutoCAD format, in which are drawn, for each item, the minimum and maximum dimensions required according to desired LOS.

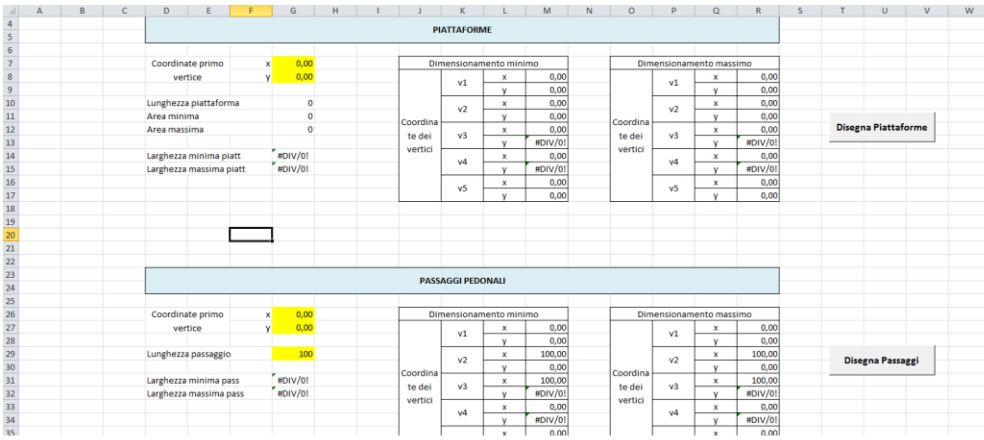

Figure 3: The "Elements drawing" spreadsheet

In the "LOS Intervals" spreadsheet the analysis is carried out in a similar way to the "Design" sheet, but there is a more "theoretical" scope; the analyst provides in input the desired Level of Service and eventually other data inputs, e.g. peak hour factor. The given output is a graph showing, reporting the hourly demand in the x - axis, the limit lines that represent upper and lower geometric dimensions of the element, according to desired LOS.

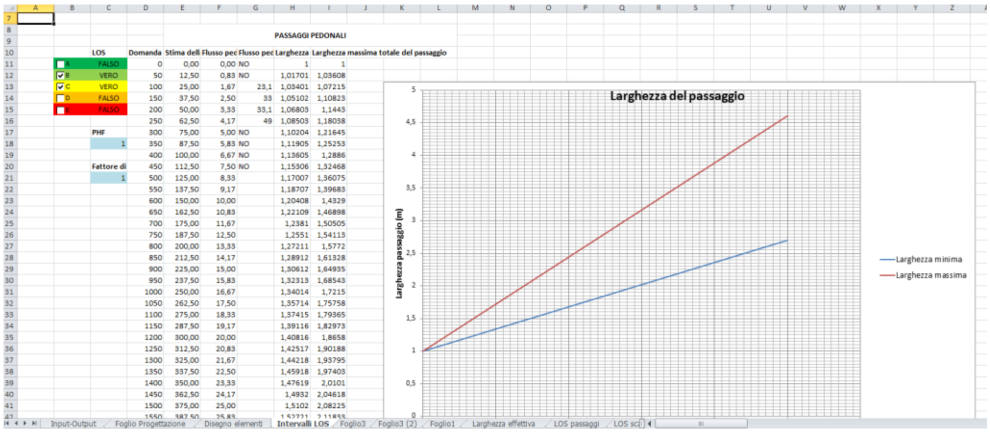

Figure 4: The "LOS Intervals" spreadsheet

The developed tool provides to users a simple graphical interface for input-output data. This interface and relative controls have been developed using VBA (Visual Basic for Applications) programming language, which is an outdated language but still easy to use and very popular, especially in Office applications environment.

Using VBA editor provided with Excel, graphical forms and related commands have been developed; the language code commands (called "macro") allows to switch from one form to another, and to interact with spreadsheets in background, which features have been previously described. Each form contains the command buttons, that allow user to start the calculation, reset input values and switch from one interface to another. For a better user's understanding, boxes containing input and output data are distinguished by different background colors: white for input data boxes, yellow for intermediate significant output boxes, green for final results data boxes.

The purpose of this analytical approach is to give a domain of acceptable solutions for the required purposes within which the simulation approach will make it possible to define the most appropriate solution.

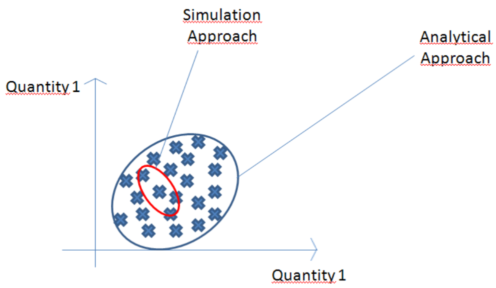

Figure 5: Way to proceed

In the two case studies taken into consideration, a railway station - where the mission was to compare the current state and a project scenario - and a shopping centre in the design phase - where the purpose was to check the size of the elements in the event of evacuation, it was carried out, knowing the layouts, an accurate integrated analysis about the components with the aim to obtain for each element the correct range of sizing as defined by LOS and acceptable in terms of single values and average values.

4 SIMULATION APPROACH

Once obtained the ranges from the analytical approach, the approach proceed with the simulation for the case studies conducted. After a thorough analysis of the commercial software available in the market, it was chosen Simwalk software, a micro-simulation software which allows to simulate the behavior and pedestrian movement in normal conditions and, with some limits, even in case of evacuation. In particular, it allows the simulation of every individual, based on a simplified version of the social forces model in combination with an algorithm of minimum path; the forces that guide and regulate the movement of pedestrians are calculated on the basis of a "potential field" created at the moment of the simulation layout's definition: such layout is divided into cells with pre-determined dimensions by the user. Pedestrians try to move to areas with minimum potential; considering that there may be several solutions to this problem; the goal is to find the right compromise between accuracy and computational speed (Savannah Simulations AG).

In the first case study analyzed (railway station) the aim was to compare the current scenario and the project scenario. After the validation and verification of the model constructed on the collected data, the simulation approach departing from the output solutions resulted from the analytic analysis of the base model has made it possible to make many useful considerations for the assessment of the urbanistic elements of the project scenario that with the analytical approach weren't considered.

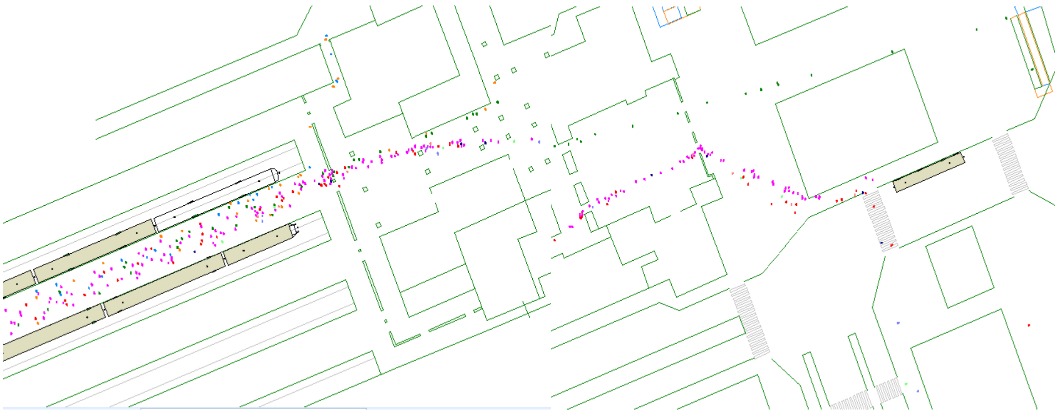

Figure 6: Some stages of the simulation approach

Quantitative and qualitative analysis were conducted. The study made it possible to state that the project scenario does not change the dynamics of pedestrian flows inside the terminal, but that it makes clear that the lack of an adequate space where to wait for the public transport in front of the terminal, during congestions moments, is not resolved, but moved.

In the project scenario the average density values recorded show a slight improvement of the obtainable Level of Service - inside the gaps identified by the analytical approach - while the maximum values are substantially the same as identified in the current scenario.

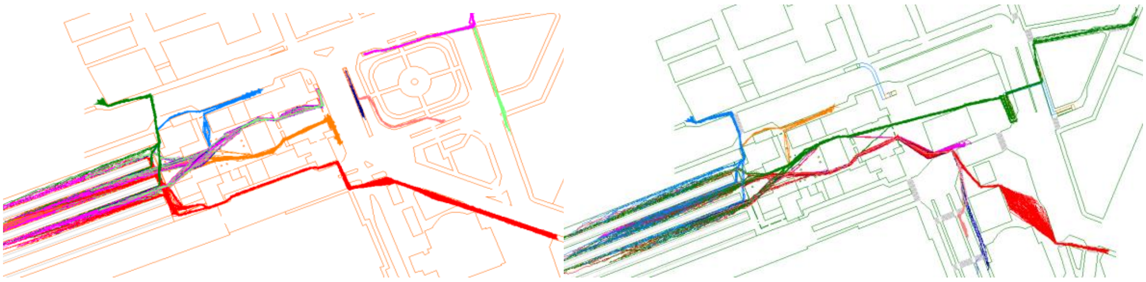

Figure 7: Trajectories followed into actual and hypothetical scenario

In the second case study, however, since the building is in the design phase and it is not existing, the dimensioning of the constituents elements been done within the gaps identified by the analytic approach based on indexed statistic flows.

Since in this case the purpose of the study evaluating changes to the design layout to enable a better evacuation in case of emergencies, the approach proceeded to test the designed layout in emergencies after having checked the compliance with the rule requirements with analytical approach. Although with analytical approach the results let us to conclude that the building had been correctly dimensioned with reference to the fire engineering methods, taking into account the particular layout of the structure and the class of fire resistance of its elements, the simulation approach carried out allowed us to identify the best layout to minimize the evacuation time which turned out to be simply verified with the analytical approach.

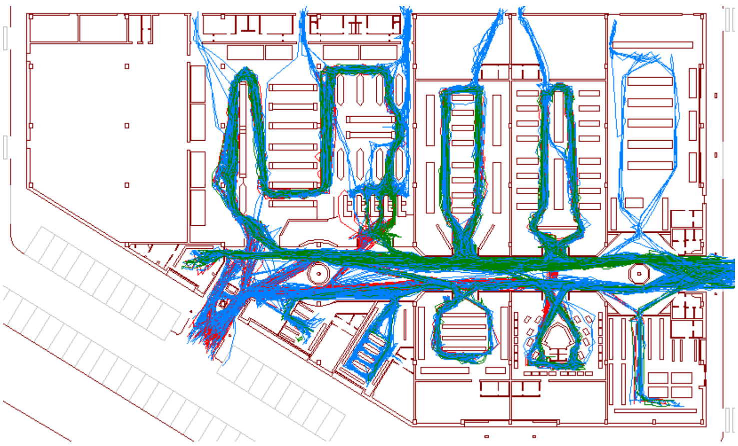

Figure 8: Trajectories during evacuation stage

Thanks to analysis and simulation results, the planner can easily evaluate the critical points of the system, bottlenecks, and act accordingly optimizing the layout of the structure to be designed, as in this case.

5 CONCLUSION

In conclusion we can say that the simulation approach, if properly validated and verified, it is a very good support for the identification of appropriate solutions on the basis of the proposed evaluation project purposes previously identified with the usual analytical approach.

The macroscopic analysis conducted using this analytical model could be useful for analyst and designer to get a first idea about the parameters involved in the problem, and it will also help in later stages of the project, as a background to check the correctness of the results obtained by more refined simulation techniques.

We absolutely don't consider that the analysis carried out and the approach followed may represent an absolute evaluation tool to define the convenience of a scenario over another, especially in complex cases in which the possible variables are numerous, but want to be a tool to support the design phase and the starting point for multi-criteria analysis that make it possible - taking into account other parameters that here have been not taken into consideration - to determine the optimal solution as concerns the necessary investment to solve the problem under analysis.

Finally we can say that the simulation is a very useful tool: fast, flexible and able to provide detailed analysis of the problems faced. It should not therefore be understood as an analysis tool for its own sake, but should assist designers in many phases of their work, from planning and design of new infrastructure to the evaluation of existing scenarios. The simulation can be used to identify the critical points of the system and consequently to adopt alternative solutions to assess the efficiency and the potentiality of current situation or in development scenarios. The proper use of simulative techniques would allow thus to save a lot of resources.

Possible future developments of this topic are different. In the first place there is the development of a technique for self-calibration of the simulation model through a stage of collection and implementation of automated data. Another important objective is the development of an automatic data collection system and statistical analysis.

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CORRELATION BETWEEN TRAFFIC AND PM_{10} CONCENTRATIONS IN THE AMBIENT AIR OF MARIBOR CITY

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ABSTRACT

Environmental pollution is increasingly becoming a major global problem. In Europe, about 90% urban population is periodically or continuously exposed to excessive concentrations of particulate matters. Pollutants from traffic are one of the main sources which on the level of PM_{10} concentrations in cities and adversely effects on human health. This article discusses and analyzes the correlation between data from different automatic traffic counting stations around the city center, which are not necessarily close to measuring sites for the quality of ambient air with PM_{10} particles in Maribor.
Initially, the observation analysis was conducted with on daily data graphs, which means that each day has been represented with hourly derived data from traffic flow and PM_{10} concentrations. Because there was no clearly observable connection between PM_{10} concentrations and traffic, we decided to examine the correlation. Data was divided into warm and cold season, because of heating season, which impacts air pollutants. Furthermore we subdivided the data into weekdays, Saturdays and Sundays. Based on fluctuations of correlations between weekdays and weekend days in the warm season, we could assume that traffic impacts the PM_{10} at the measurement site Center.
According to findings in our correlation analysis, there is no such significant correlation which uniquely demonstrates that traffic and air quality are related when longer distances are ubiquitous comparing between ambient air quality measuring sites and traffic counters which are not in direct vicinity of each other. To prove the latter, more coherent and detailed advanced statistical methods will be used in the future .

Keywords: traffic, Maribor, pollutants, particulate matter, correlation

1 INTRODUCTION

Although traffic is an invaluable and essential part of the functioning of modern society, it brings along many negative side effects for people, plants and animals. Besides the energy sector, it is one of the main sources of air pollution with greenhouse gases which enhance the greenhouse effect in the earth's atmosphere, as well as a source of local and global pollution of air with pollutants, which are responsible for acidification (NOx, NH_3, SO_2), formation of ground-level ozone (CO, NOx, NMVOC, CH4) and particulates PM_{10} and $PM_{2.5}$.

Pollution with particulate matters PM_{10} is increasingly becoming a growing concern to the public, mainly because of its recognized adverse health effects. Scientific findings in recent years are supported by the numerous epidemiological studies indicating a link between long-term and short-term exposure to fine particles, which are having a negative impact on human health with a variety of serious health effects and increased mortality as well [1,2,3,4]. Similar to particulate matters PM_{10}, emissions of nitrogen oxides emitted from road vehicles are receiving an increasing attention in recent years.

The problem of air pollution with particulate matter PM_{10} is reflected in many city centers, where the large part of urban population is exposed to the negative impacts of pollution. Measurements show that many European cities fail to reach the target values of pollutants, as defined in European legislation on ambient air quality. Exceedances of limit values usually occur in urban areas close to the roads. In Slovenian cities, one of the most pressuring environmental problems is excessive pollution by PM_{10}. In Maribor we are facing excessive environmental pollution with PM_{10}. In 2011 we had 65 exceedances (which is more than 35 legally permited) of the daily limit value on measurement site Center and 25 exceedances on measurement site Vrbanski plato, both in winter. Data from report of Identifying sources of PM_{10} in Slovenia (ARSO), clearly shows that traffic has the largest share of influence on PM_{10} levels at the monitoring site Center. We decided to find out if it's possible to prove these indications with the correlation between traffic counters and PM_{10} levels from air quality monitoring sites, which are not necessarily in immediate vicinity to each other.

2 MEASUREMENTS AND LOCATION OF COUNTING AND AIR POLLUTION SPOTS

2.1 Location of counting and measurements site

The subject of examination is a narrow area of the city of Maribor. Although we are interested exclusivelyin the city center, we need to look at what kind of roads surrounding Maribor as the city itself, and how much traffic they hold. We defined our study area ranging on the east - to the Motorway Maribor – Pesnica, on the south - to the crossings of Tržaška and Cesta proletarskih brigad road, on west - to the bridge Koroški most and on north - where Maribor is bounded with hills Piramida and Kalvarija.

For the purposes of the correlation analysis between traffic and PM_{10} concentrations, hourly data was obtained from the automatic traffic counters for the year 2011 (obtained from DRSC). In the surroundings of Maribor several automatic counters are located. For us, the suitable counters were only those which are located within Maribor municipality, are close to the city center and are also close to air quality measurement stations After the review, we

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[4] Autrup H., 2010. Ambient air pollution and adverwse health effects, Procedia Social and Behavioral Scineces 2

found that three counting stations correspond to conditions mentioned above and are shown on figure 1. The counting stations are the following:

- 15 Maribor HC (hereafter reffered as PLDP_15), road section Pobrežje-MB (TEZNO),
- 16 Meljska HC (hereafter reffered as PLDP_16), road section Pesnica – Maribor in
- 18 MB Koroški most (hereafter reffered as PLDP_18), road section Koroški most – Cesta proletarskih brigad.

The counting standpoint PLDP_15 is located on the highway Maribor- Tezno, which is known as a city radial road, specifically on road section Pobrežje – Maribor (Tezno) approximately 750 m northeast from the non-level crosings, where Ptujska road crosses the highway. The standpoint PLDP_16 is located on the highway Maribor – Pesnica approximately 450 m north of the non – level road crossings of Meljska and expressways. The standpoint PLDP_18 Koroški most is located on the road section Koroški most- Cesta proletarskih brigad and more precisely, 90m south from the roundabout on the road Gosposvetska cesta.

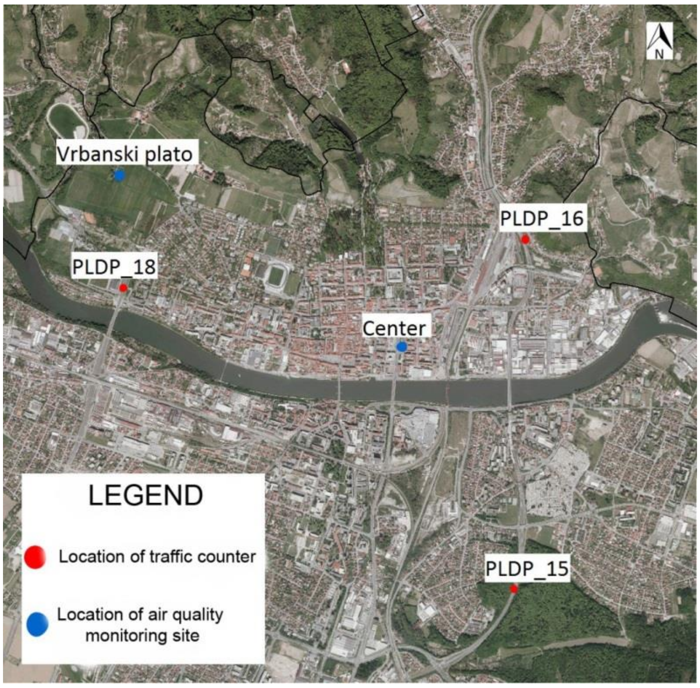

Figure 1: Location map of the study area

2.2 Location

The available data on ambient air quality pollutants of the PM_{10}, are conducted with continuos measurements at locations in the center of Maribor - Center (hereafter reffered as Center) and Vrbanski plato (figure 1).

The site Center is regarded as a typical traffic location located right next to Tito's road, which is a busy traffic road with 18.900 vehicles[5] per day according to data from the traffic

[5] Prometni model 2010, Fakulteta za gradbeništvo, Katedra za prometno tehniko in varnost v Prometu, Maribor 2011

model. The site is placed in the city center in densely populated area with higher buildings in 10 m distance from the bus stop. On the opposite site of the road another bus stop for urban and suburban buses is located. It can be argued that traffic is having direct impact on PM_{10} levels at the measurement site Center.

The site Vrbanski plato is managed by municipality of Maribor. It is located on northwestern part of Maribor more specifically on the water protection zone, where is no presence of direct emissions from pollution sources. The site Vrbanski plato is located 150 m away from the Vrbanska road with aproximately 338 vehicles per day according to the data from traffic model[6]. The measuring site is located 650 m north from the roundabout at Gosposvetska road and Koroški most bridge which carries 28.000 vehicels per day [DRSC].[7]

2.3 PM_{10} measurements

The data for PM_{10} was obtained from the TEOM 1400 monitor, where the particles are detected by a non-reference method. The PM_{10} meter carries out real-time continous measurements which are based on direct mass measures of the airborne particles using an oscilating microbalance and it measures both the volatile and non-volatile fractions of the particulate matter. A pump with continous flow draws the air sample through the entire route. Inlet air flow is separated after the sampling head on part that goes into additional sampling part (ACCU) which consist special filters for subsequent analysis and on the part that goes into the meter.Particles are stopped on the filter (glass fiber coated with teflon). The filter is weighted every two seconds, difference between the current mass and the weight of empty filter gives the total mass of retained particles on filter. From measured masses of particles and a constant flow through the device, the unit evaluates the current concentration of PM_{10} in the air. The changing mass of glass elements, which is finished with a filter causes a change in the frequency of its oscillations on the basis of which the change in weight of the filter element is determined. TEOM meter provides also high accuracy PM_{10} mass concentrations for short term average (1h) as well as daily averages (24h). TEOM meter operates at a temperature of 30^0 C, the main flow through the inlet chamber for PM_{10} is 16.67 l / min, flow rate through the filter head 3 l / min and a bypass flow of 13.67 l / min. Once a year the continuity of flow and concentration accuracy are checked (the mass of the reference filter). By using various sampling heads it can measure the size fraction of PM_{10} and $PM_{2.5}$. At measurement point Center the TEOM meter differs from the one at the measurement point Vrbanski plato. In addition TEOM at measurement point Center uses additional features at the operating mode named FDMS (Filter Dynamic Measurement System) which means that the meter itself compensates for any manual correction (correction factor), which would otherwise be necessary due to loss of volatile substances (summarized by[8] and [9]).

3 METHODS

A data analysis was carried out on a daily basis, which means that each day is presented by data which consist of hourly PM_{10} concentrations and traffic. The comparison was made with a graphical analysis of PM_{10} hourly profiles and correlations between the latter and

[6] Ibidem 4
[7] Publikacija promet 2011, Ministrstvo za promet, Direkcija Republike Slovenije za ceste, Ljubljana 2012
[8] Kakovost zraka v Mariboru – letno poročilo 2011, Zavod za zdravstveno varstvo, Maribor, 2012
[9] Green, D., Fuller, G., 2009, Development and validation of the volatile correction model for PM_{10} –An empirical method for adjusting TEOM measuremnts for their loss of volatile particulate matter

traffic. Traffic data and concentrations considered were processed for the period from 1.1.2011 to 31.12.2011. All data are on the sun clock, traffic data were re-adjusted to the sun clock.

4 RESULTS AND DISCUSSION

4.1 Daily profiles of the PM_{10} concentrations and traffic

The presented daily profiles of PM_{10} concentrations and traffic (in figure 2 and 3) provide an interesting comparison between the reduction of traffic and pollutant concentrations on weekdays and weekend days in both seasons. Traffic volumes in the winter and summer are approximately equal. The average traffic on Sunday is reduced by 49 % in comparison with the traffic (PLDP_15, PLDP_16) on weekdays. Analog to that, concentrations at the PM_{10} Center are reduced by 15% on Sunday. Similar reductions at Vrbanski plato have not been observed. Traffic reduction at counting site PLDP_18 on Sundays decreased on 40 % in comparison with weekdays which is less than the other two described above.

Analysis of traffic flows at the counters PLDP_15, PLDP_16 and PLDP_18 based on daily profiles from these counters showed traffic reduction only on the weekend. Comparison of traffic peak hours on weekdays, Saturdays and Sundays for counting points PLDP_15 and PLDP_16 shows that on Saturday is 28% less traffic in the morning peak and 48 % less traffic in the afternoon peak. Reduction is generally smaller at the counting site PLDP_18 with 13% less traffic at morning and 43% less at the afternoon peak. On Sunday in comparison with weekdays the traffic is reduced on counting site PLDP_15 and PLDP_16 at morning peaks by 45% and by 53 % at the afternoon peaks. The Sunday reduction of traffic at counting site PLDP_18 is by 34% at morning peaks and by 46% at afternoon peaks. After reviewing the daily profiles of counting stations, PLDP 18 can be characterised as a counter on the radial road with a certain percentage of transit traffic. In comparison with reductions on other traffic counters (PLDP_15 and-PLDP_16) a smaller reduction can be observed on weekend days. The reason for this could be in the location because the traffic counter lies on the main road connection between Maribor –Koroška where all transit traffic is destined for this region.

On counting sites PLDP_15 and PLDP_16 traffic reduction over the weekend is higher, since most transit traffic is no longer on this road section, but a few kilometers on the east at the highway, therefore more evident impact of the local traffic can be observed. In general, more cars are caught in transport at the counting site PLDP_15 than at counting site PLDP_16. At counting site PLDP_16 a smaller fraction of the local transit traffic can be seen. Daily profiles of traffic are bimodal on all counting sites at weekdays showing two (peaks) rush hours. Morning rush hour occurs between 6 and 7 am while afternoon rush hour occurs between 2 and 3 pm. Weekend daily profiles indicate later rush hours which last in the morning from 9 am to 12 pm and in the afternoon from 5 to 6 pm.

4.2 Correlations between traffic and PM_{10} concentrations in the warm and cold season

Data was divided into cold season (1.1.2011 to 31.3.2011 and from 1.10.2011 to 31.12.2011) and warm season (1.4.2011 to 31.10.2011). We decided to divide data on the cold and warm season mainly because during the cold season besides the traffic other influental sources are present such as road salting, domestic heating and district heating systems, which affecting the PM_{10} levels particularly in urban environment. At the distribution of data we oriented after the heating season, which begins when temperature at 9 pm is below 12^0 C three consecutive days and analogue to this also ends when the temperature is above 12^0 C for three consecutive days. Correlations were calculated between counting sites PLDP_15, PLDP_16, PLDP_18 and PM_{10} concentrations from monitoring sites Center and Vrbanski plato.

In the following text, we simplified the concentrations of PM_{10} into PM_{10} and counting sites PLDP_15, PLDP_16, PLDP_18 into the traffic (if it's not the same for all is mentioned and explained).

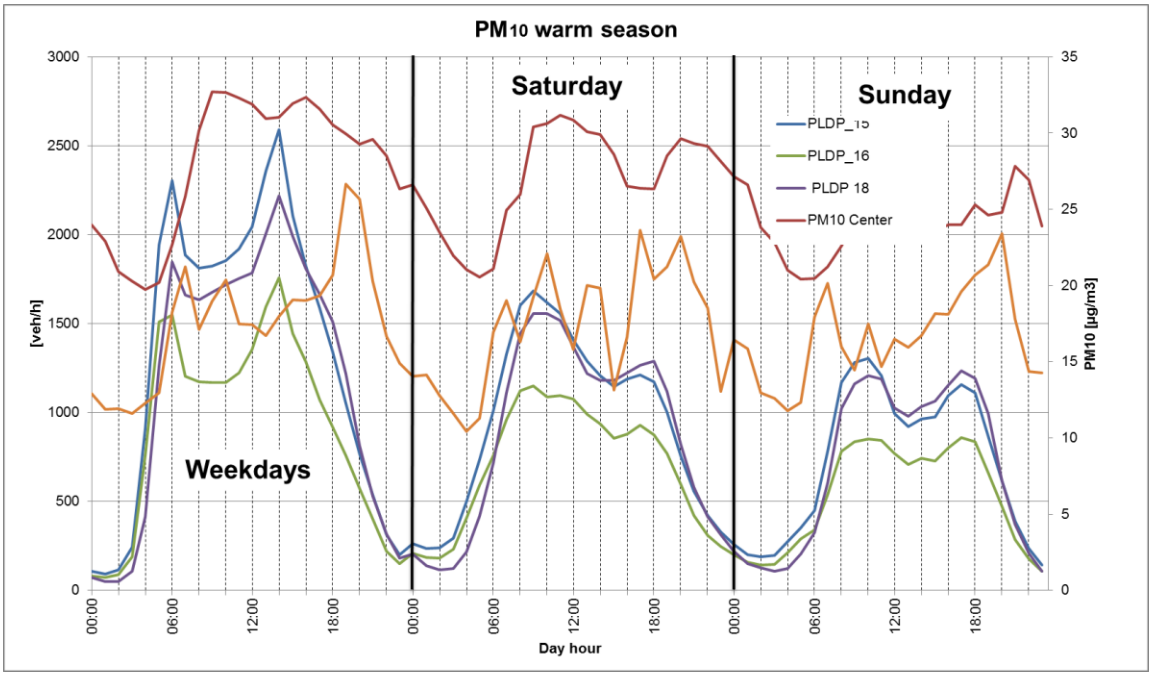

Figure 2: Daily profiles of the PM10 concentrations in the warm season

The analysis of the correlations between traffic and PM_{10} Center shows that correlations are insignificant in the cold and very low in the warm season. Nevertheless the correlation in the warm season is 50% higher than in the cold. Correlations between traffic and PM_{10} Vrbanski plato are also weak in the warm, while in the cold season there is no correlation. Monitoring sites Center and Vrbanski plato during the cold season show a high correlation (R=0.83) and moderate connectivity in the warm season (R=0.54). We may assume that in the cold season on PM_{10} most likely impact the factor, which is absent or less active in the warm season (domestic heating, distict heating). We should not forget that also modified atmospheric meteorological features are different in the cold weather than in warm.

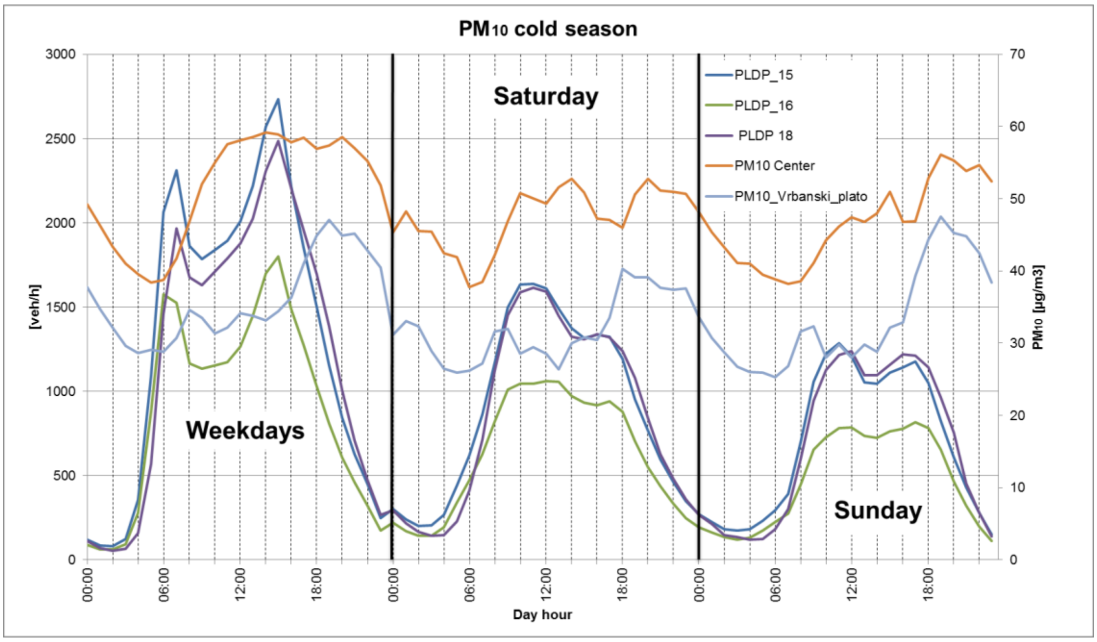

Figure 3: Daily profiles of the PM10 concentrations in the warm season

This suggests that the correlation in the cold season is higher mainly due to the heating season and the pattern of burning fuels by people. Due to the economic crisis a big portion of people replace the heating oil with wood (»from cleaner to less clean«), which is reflected as an increased concentration of PM resulting in the higher correlations at cold season at city background Vrbanski plato. We should not forget that also modified atmospheric meteorological features are different in the cold weather than in warm.

4.3 Comparison of correlations between traffic and PM_{10} concentrations on weekdays, Saturdays and Sundays

Since the traffic, as we described above, is the only anthropogenic activity that is significantly reduced during the weekend, we performed correlations between weekday, Saturdays and Sundays for warm and cold season in 2011. About reduced traffic activity reported also several other authors, which called this effect »weekend effect«[10,11,12,13].

Despite the correlations between traffic and sites PM_{10} Center are generally low, the warm season show a higher correlation conection between weekdays ($0.21 \leq R=0.31$) than over the weekend days (Saturday ($0.12 \leq R \leq 0.25$) and Sunday ($0.02 \leq R \leq 0.1$)). During the cold season correlation between traffic and PM_{10} are negligible. Based on this it may be concluded that traffic impact on PM_{10} concentration at the Center in a certain proportion but direct relationship or significance can't be prooved with this method. Thus we should use statistically more reliable methods. Correlations between the site PM_{10} Vrbanski plato and traffic are in warm season negligible on weekdays ($0.11 \leq R \leq 0.17$), slightly rise on

[10] Lonati, G., Giugliano, M., Cernuschi, S., 2006. The role of traffic emissions from weekends' and weekdays' fine PM data in Milan.
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[12] Rattigan, O.V., Felton, H.D., Bae, M.S., Schwab, J.J., Demerjian, K.L., 2010. Multi-year hourly PM2.5 carbon measurements in New York: diurnal, day of week and seasonal patterns
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Saturdays ($0.15 \leq R \leq 0.22$) and falling back on Sundays ($0.13 \leq R \leq 0.15$). In the cold season all correlations between traffic and PM_{10} Vrbanski plato are negative and insignificant.

Occuring the higher PM_{10} concentrations during the cold season is most likely due to the high atmospheric stability, reduced ability of air mixing on the cold winter days and domestic heating which are significant sources of particulate matters. In the warm season domestic heating is not present and the depth of atmospheric air mixing layer increases which enables better dispersion of pollutants within this layer.

Table 1: Correlation between Weekdays Saturdays an Sundays and PM_{10} Center /PM_{10} Vrbanski plato

PM_{10}Center/Vrbanski plato	weekdays		saturdays		sundays	
	warm	cold	warm	cold	warm	cold
PLDP_15	0,23 / 0,12	0,10 / -0,07	0,15 / 0,16	-0,05 / -0,14	0,02 / 0,13	-0,02 / -0,04
PLDP_16	0,21 / 0,11	0,09 / -0,08	0,12 / 0,15	-0,06 / -0,15	0,01 / 0,13	-0,01 / -0,02
PLDP_18	0,31 / 0,17	0,16 / -0,02	0,25 / 0,22	-0,01 / -0,11	0,06 / 0,14	0,03 / 0,02
Center_PM_{10}	1 / 0,56	1 / 0,80	1 / 0,44	1 / 0,88	1 / 0,50	1 / 0,89
Vrbanski plato PM_{10}	0,56 / 1	0,80 / 1	0,44 / 1	0,88 / 1	0,50 / 1	0,89 / 1

Compared to the cold season the daily profiles are characterised with the lower concentrations of pollutants and more narrow peaks and consequently smaller duration of daily peak concentration values for whole area.

Although there is no direct correlation between the distant traffic counters PLDP_15, PLDP_16, PLDP_18 and measurement sites for ambient air quality, it can be observed based on the correlation changes (fluctuations) between warm and cold season on weekdays, Saturdays and Sundays that traffic could have an impact on PM_{10} concentrations. As long as the traffic counters are at large distance it is not possible to proove that are however directly conected to the PM_{10} concentrations on site Center and Vrbanski plato. The similarity is more likely to find, because due to traffic increase and decrease based on usual repeating pattern which appears due to the mobility needs of commuters and residentials.

5 CONCLUSIONS

In this paper we present the correlation analysis between traffic counters and PM_{10} concentrations which are measured at the ambient air quality sites and are not necessarily in vicinity to each other. Hourly data concentrations of the PM_{10} were measured on principle of oscilating microweighting. Data analysis was carried out on a daily basis, where we graphically show daily profiles of the PM_{10} concentrations in relation to the traffic. In calculating the correlations the individual data was divided into the cold and warm season with later subdivision on weekdays, Saturdays and Sundays. After calculating individual correlations, we found the strong correlation between traffic counters themselves, because traffic profiles at all road section follow a similar pattern. Between ambient air quality sites of PM_{10} (Center, Vrbanski plato) the correlations are moderate in warm season and high during the cold season. Correlations between traffic and PM_{10} Center are insignificant in the cold and very low in the warm season; while at the Vrbanski plato they aren’t exist at all. Correlations between the ambient air quality site PM_{10} Center and traffic are negligible in cold while at warm season they are low with slightly more distinctive connection during the weekdays as through the weekend. Correlations between the ambient air quality site PM_{10} Vrbanski plato and traffic are in cold season negative and insignificant through all days; while in the warm season there are negative and insignificant during the weekdays with slightly increase on Saturdays and decline on Sundays. After examination of the correlations we can conclude that it can not be observed any significant connection between traffic and pollutants at ambient air quality site Vrbanski plato in both season. Changes at the ambient air quality site Center can be observed between weekdays, Saturday and particular on Sundays, when traffic is lower for 49%. In relation to the traffic, concentrations of PM_{10} Center on Sunday drops for 15%, but reason for the decrease can't be uniquely attributed based on correlations only to traffic because decrease may be due to the several reduced anthropogenic activities during the weekend. More coherent and detailed research with detailed statistical methods will be used in the future for examination the connection between traffic and ambient air quality on the area of Maribor.

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NEW METHODS AND TOOLS FOR NAVIGATION SAFETY INCREASE

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ABSTRACT

The paper presents new approach in the methods used for navigation safety increase. Real-time simulation with mixed reality modules, including Human Machine Interface realized in augmented technologies, are used for increasing the navigational situation awareness and safety of vessels maneuvering. Due to new solutions, uncommon functionalities and possibilities are available onboard as an aid to navigation. Eye tracking methods are proposed for efficiency assessment of newly designed tools.

Keywords: Real-time simulation, Mixed reality, Augmented Reality, Augmented Virtuality, HMI, Safety of navigation

1 INTRODUCTION

For several years in the maritime field, we distinguish the "eNavigation" term. The IMO's eNavigation initiative has as its goal the seamless integration of information: "eNavigation is the harmonized collection, integration, exchange, presentation and analysis of maritime information onboard 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".

The decision support systems (aids to navigation) also enroll into this area, which covering the broad field of information to assist the navigator in the safe passage of the ship. These include:

- classified hydro-meteorological information
- anti-collision and alarm systems
- ship handling and cargo handling operations systems
- systems to monitor ship traffic parameters
- route monitoring systems
- systems for presentation of vessel's location in space
- others.

We note the tendency to simultaneously integrate multiple systems together, with the properly selected, multi-level form of presentation of navigational information, forming the Integrated Bridge Systems (IBS). Software, a variety of features, technical capabilities used in these solutions go hand in hand with technological advances in these fields.

Analysis of the evolutionary process of modern ship's equipment have shown, that the final, executive element, in the Human Machine Interaction (HMI), which is software interface, practically remains unchanged for years. Except technical parameters, such as: the type of backlight, resolution, material and shape of the matrix, etc., it still remains as a two-dimensional isometric, top view, predominantly showing the alphanumeric data, less dynamic, two-dimensional geometric models (only used in ECDIS, ARPA. DP Conning Display, pilot-docking systems). From the subject's point of view, which was taken into consideration in this paper, it is a method of presentation that uses augmented virtual reality technology, with simple two-dimensional models applied (e.g., two-dimensional waterline, coastline).

Technologies for information presentation such as Augmented Reality (AR) and Augmented Virtuality (AV) with three-dimensional models applied, and the displays other than standalone computer graphic (CG), such as see-through (Head-Up Display - HUD, Head Mounted Display - HMD, Virtual Retinal Display - VRD) have no utility in decision support systems designed for conventional vessels.

Based on such solutions used for years in the aerospace, medicine and more recently in the automotive industry, the authors of this paper tried to enunciate some of the benefits and opportunities of using aforementioned technologies in the navigating and ship handling processes to increase the navigation safety.

2 MARINE MIXED REALITY

2.1 Definition

As shown in figure 1, Mixed Reality (MR) encompasses the continuum of possible combinations of elements from both virtual and real environments, the continuum between fully real and fully virtual. Augmented Virtuality and Augmented Reality are the two major subsets lying within the MR range of the Reality-Virtuality (RV) continuum.

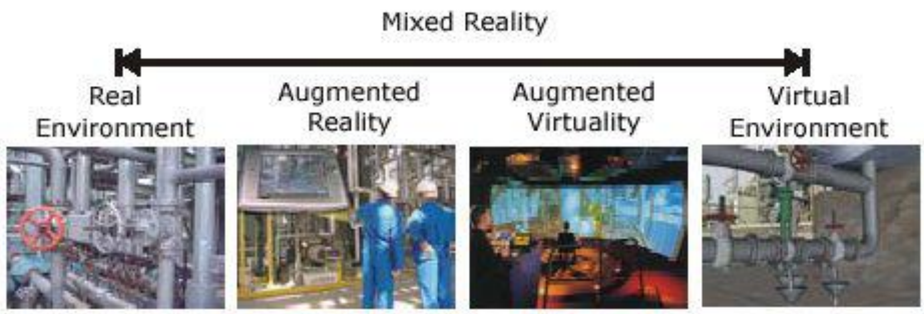

Figure 1: Mixed Reality Continuum

Source: Traskback, 2004

AV describes cases where some real object/data is inserted into a predominantly computer-generated environment, which has been explored in safety programs and manufacturing. The converse case on the MR continuum is AR, which is a technology or an environment where the additional information generated by a computer is inserted into the user's view of a real world scene. AR allows a user to work in a real world environment while visually receiving additional computer-generated or modeled information to support the task at hand. (Wang & Dunston, 2011).

2.2 Architecture

MR applications are the systems that combine real environments and virtual objects together. The system aligns real and virtual objects with each other in real time and it offers real time interaction (Azuma, 2001).

To realize all tasks MR application must be in cooperation with 4 main subsystems: Geometric 3D virtual world, Real-time background, Input sensors and Output display.

2.2.1 Geometric 3D virtual world

It is necessary to create a virtual world that is interactive and in real time. It describes the spatial relationships of virtual and real objects. The model particularly describes where, in relation to real objects, the virtual objects shall be placed or to provide a correct depth perception by giving the illusion of real objects occluding virtual objects.

The creation of a virtual world is the main issue of mixed reality: modeling, digitalizing and computer processing of the virtual world. Mostly, it is performed with Computer Aided Design (CAD) software (figure 2).

Databases, which are contained in Electronic Navigation Charts, are mainly use to create the synthetic, 3D virtual world, in marine applications. From the navigation safety point of view, the virtual world must include sub-models of such databases: hydrotechnic, seabed, marks, buoys and beacons, and vessels database.

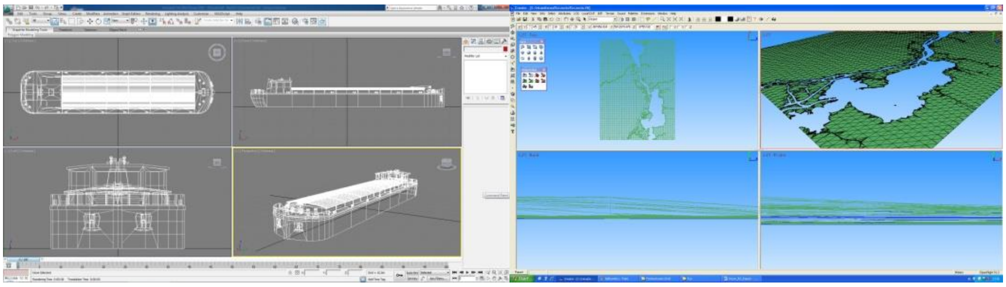

Figure 2: 3D geometric models creation process

Source: Authors

2.2.2 Real-time background

Depending on the intended use of the system and the type of assigned output display, the image of the real world can be digitized using a variety of techniques or remain unchanged in perception by the human eye. The most popular method is to digitize the image with the DVC cameras, infrared cameras or CCTV cameras. For see-through displays (HUD, HMD, VRD) the digitalization is not provided.

In all cases, it is necessary to track the coordinates of the point of view (POV) and field of view (FOV), which is in the feedback loop with position, rotation, and virtual camera FOV matrixes.

2.2.3 Input sensors

In terms of subjects, which have been taken into consideration and the use of MR technology in the IBS, input sensors, which link the worlds included among RV Continuum can be divided into 3 groups: positioning sensors, HMI sensors and additional, depend of particular system destination.

To ensure full alignment between real-world and virtual objects, especially those which are moveable, it is necessary to provide their exact position in space. In maritime terms, we can distinguish the following areas: own vessel positioning, point of view positioning (navigator's head) and surrounding objects positioning .

Vessel's positioning in its 6 DOF can be carried out by using various methods. Depending on the ambient conditions, the availability of positioning systems, purpose of the system (port, restricted area, open waters), we can distinguish among others:

- satellite positioning systems: dual DGPS Real-Time Kinematics (RTK)
- acoustic positioning systems: long base line (LBL), short base line (SBL), super short base line (SSBL), ultra-short baseline systems (USBL)
- optical positioning systems: with markers, no markers, laser
- inertial positioning systems: gyroscopes, accelerometers
- microwave positioning systems
- hybrid positioning systems

Positioning of the point of view, in the MR technology, is realized inside the navigation bridge or other closed space, according to needs. Similar to vessel positioning, it is possible to use most of the aforementioned technique, in its personal variants. The relative positioning is provided, with the coordinate's origin equal to the position of ownship. Due to the high magnetic field interference from other ships' devices, solutions based on magnetic positioning are avoided.

Positioning of floating units other than ownship can be done by using similar methods. Additionally, the movable objects, which cannot be tracked by its own sensors (e.g. buoy located at open waters), can be positioned relatively with microwaves emitted by the radar installed on the ownship.

HMI sensors are utilized to provide constant communication between the system and the operator. Through computer peripherals such as mouse, trackball, keyboard (standard/virtual), voice commands, virtual gesture, the operator can interfere with the virtual world's variables and control the software through the user interface.

Depending on the needs and capabilities of the system, changes in the virtual world may also be reflected in the real world (e.g. control of vessel's automatic). To implement these functionalities, it is necessary to use additional sensors to provide application's feedback.

2.2.4 Output displays

According to Azumas' criteria (Azuma, 1997), the augmentation can be of any form, but most Mixed Reality systems only make use of visual augmentations. To generate such an augmented view, displays are required which provide a method to combine the view of the real world with virtual objects in the form of computer generated graphics.

If we classify these displays by the technology and position where the augmented image is displayed, the following three classes exist: the combination is either done in the user's eye (retina projection /semi-transparent monitor, a.k.a. optical see-through display), in front of the users eye (overlaying a video with the computer graphics on a monitor, a.k.a. video see-through display) or in the real world (projection on the real world/or on a special surfaces) (Schwerdtfeger, 2009). Additionally, visual Augmented Reality displays by their spatial location can be classifiedas: Head-attached (Head-mounted), Hand-held and Spatial Displays (Bimber, & Raskar, 2011).

According to above classifications, several classes of existing hybrid display environments can be found, which could reasonably be considered to constitute MR interfaces according to definition:

1. monitor-based (non-immersive) AR displays, upon which computer graphic (CG) images are overlaid.
2. Same as 1, but using immersive HMD-based displays, rather than WoW monitors.
3. HMD-based AR systems incorporating optical see-through (ST).
4. HMD-based AR systems incorporating video ST.
5. Monitor-based AV systems, with CG world substratum, employing superimposed video reality.
6. immersive or partially immersive (e.g. large screen display) AV systems, with CG substratum, employing superimposed video or texture mapped reality.

partially immersive AV systems, which allow additional real-object interactions, such as “reaching in” and “grabbing” with one’s own (real) hand (Miligram, & Kishino 1994).

Table 1: MR systems immersiveness comparison

Main Features	SYSTEMS		
	DESK-TOP	SEMI-IMMERSIVE	IMMERSIVE
Resolution	Higher	High	Low-Medium
Perception/Situation Awareness	Low	Mid-High	High
Field Of View	Low (Typ. 50°)	Medium (Typ. 150°)	High (Typ. 360°)
Immersion	Low	Medium	High
Price	Low	Medium	High

Source: Fernando, 2005

Classes 2 and 4 for IBS realized in MR technology should be avoided, due to their total immersion (video ST). Complete isolation of navigator’s sight from the outside world and relying only on digital communications, significantly reduce the level of navigation safety.

3 MIXED REALITY MARINE SOLUTIONS ACCORDING TO E-NAVIGATION

3.1 Presentation of vessel’s location in space

One of the important VR attributes that facilitates these successful applications is the 3D graphical environment in which users can freely navigate around and interact with virtual objects (table 2). This is especially useful for the applications that require real-time involvement with task environment e.g. berthing maneuvers, since human tend to understand graphical information faster and more easily than text data. With virtual reality, all navigational situation data can be transformed into 3D synthetic scenario of the vessel in relation to its surrounding environment based on its geometrical model. This relieves the navigator from imaging the vessel’s spatial location based on the sensor data. (Lin & Kuo, 1998).

Table 2: Comparison of visual and virtual worlds observation

	Visual	Virtual
Image	Real	Synthetic
Interaction	Real world	3D model
POV	Fixed	Controlled by operator
FOV	Limited	360 deg
Image quality	Visibility dependent	Visibility independent

Source: Miligram, P., Takemura, H., Utsumi A., & Kishino F., 1994

By using this method, it is possible to obtain a complete picture of the current navigation and maneuvering situation, regardless of the visibility level. The values of position, rotation and FOV of each virtual defined viewpoint, can be changed by the navigator (figure 3). Virtual POV selection preview is made on a two-dimensional map.

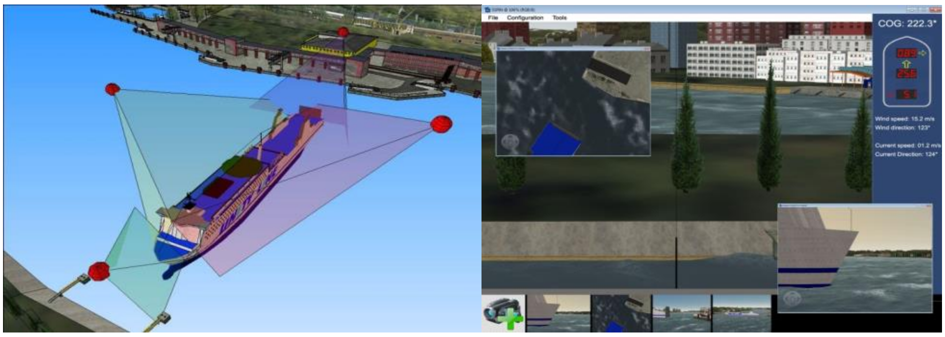

Figure 3: Augmented Virtuality Enhanced Conning Display

Source: Authors

The system interface is designed to reflect, as closely as possible, the current, actual navigation and maneuvering situation in a virtual environment, and due to its features enhance the navigation safety in restricted areas.

Optimization and ergonomics of CG interface has been developed basing on the results of real-time simulations with Eye Tracking techniques applied, carried out in Maritime Traffic Engineering Centre located at Maritime University of Szczecin.

3.2 Classified information

Presentation performed in MR technology, allows primarily, to integrate and overlay multiple alphanumeric data and images obtained from different IBS devices. Due to hybrid displays utilizing, it is possible to present CG navigational information, for instance directly on the ship's bridge windows. An example of such a solution is used by Ulstein Bridge Vision™ (figure 4).

An optical projections were used as an eye-catching element of the system. These allow to pop up information directly on the windows, as a full frame head-up display on the aft bridge and on seamless monitors directly below the windows on the front bridge. The intuitive touch-commands and gestures are used for HMI sensors to control the application.

Figure 4: Ulstein Bridge Vision™

Source: Window on the future, 2012

The optical projection of information provides the users with all relevant details related to an operation in their line of vision, improving their ability to safely operate the vessel. It also makes coordination between crew members performing interdependent operations much simpler, as they can see the same information even though they positioned apart from one another.

The system prioritizes information based on the operation and situation of the ship. For example, when the ship is in transit mode, illustrations will be presented on a large, seamless surface below the windows on the front bridge. A real-time overlay is also possible, where the head-up display provides information on operationally critical tasks by showing elements the user cannot spot directly, such as fog, darkness or elements hidden behind objects (Window on the future, 2012).

3.3 Ship handling and cargo handling operations

Systems developed in MR technology can be successfully used to increase the efficiency and safety of ship handling and cargo handling operations, from both: the navigation bridge and machinery side, indirectly increasing the navigation safety.

Operations which require specific procedures and conduct checklist, the use of AR technology allows to instruct the operator, step by step, what actions should be performed. Examples of such systems are applications from MAN (to replace of marine engines) and from BMW (to repair of cars).

Using special data goggles and wireless access to a powerful computer, operators have all the information at their disposal, precisely where they need it at the vessel or vehicle (figure 5).

Figure 5: Augmented Reality Repair Systems

Source: MAN, 2010 and BMW, 2008

By applying a computer-generated, virtual geometric model of ship’s equipment on the real-world image, checking of its status and operation can be performed. For example, by comparing the readings of analog or digital indicators, position of lever, valves, lighting status, etc. for different states of its working cycle.

Providing an appropriate amount of automation systems to its control by the user, connected to the MR application, allows direct manipulation of devices with optimized, personalized, customized to specific situations interfaces, such as anchoring, mooring operations.

3.4 Anti-collision and alarms

Conducting of anti-collision maneuvers, particularly in reduced visibility, may also be aided by the use of the system realized in the MR technology. The concept provides to the automatic generation of target synthetic model and it’s overlaying on the vessel navigator's field of view (AR or AV).

Based on coupling the information about its position via AIS (or relative via ARPA), and the MMSI number, the identification of its 3D geometric model is performed. Then, the textured mesh is rendered in the display system. Rendered collision warning and information are located in space and specifically assigned to the object (figure 6).

The major advantage of MR technology in the field of anti-collision warning and alerting on board of the merchant vessels is to integrate all the information in one place and possibility to display them directly in the field of view of the navigator. In this way the segmentation of alarms (displaying on separate IBS devices) is avoided, thereby the probability of unnoticed them by the navigator or engineer is reduced.

Figure 6: Anti-collision and alarms rendered with MR technology

Source: *Window on the future, 2012*

3.5 Route and ship’s traffic parameters monitoring

The creation of synthetic 3D model of the area, based on data from the electronic vector map ENC, allows for the presentation of navigation information with MR technology in 6 DOF (instead of 2 DOF in standard ECDIS).

Such technology increases situational awareness in all conditions by taking a wide variety of information and rendering it into a real-world view, in 3D and in real time. In effect, MR effectively enhances native senses, maximizes awareness by limiting unnecessary mental processing time. The operator’s view is enhanced by route related information, such as guide rails (fairway boundaries), object markers, bottom bathymetry, which allow to navigate around otherwise invisible objects in any conditions (figure 7).

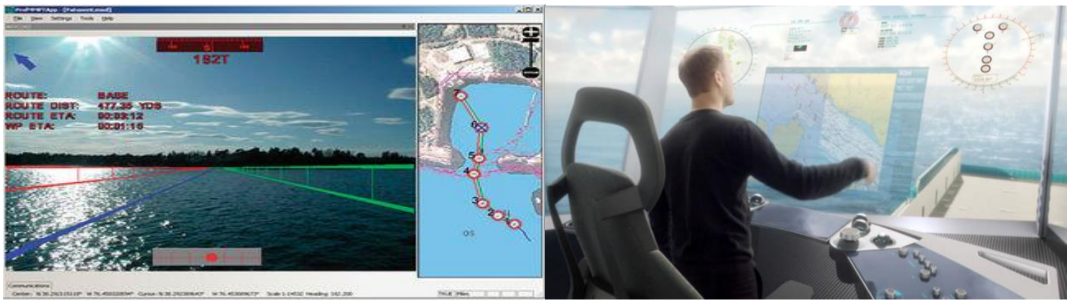

Figure 7: Route and ship's traffic parameters monitoring with MR technology

Source: *AVCOP, 2011*

During route planning operation, the navigator can move the viewpoint in the synthetic world, read the terms of navigation on the site, receive interactive aids to navigation from sailing directions, also radio procedures, etc.

In addition, if the parameters of geometric models are defined for such objects like fenders and hull, it is possible to implement mathematical calculations, which might be useful in the navigation process. For example: minimum distance from the hull to the nearest obstacle, the maximum transverse velocity to contact with fender, etc.

Conjunction of MR technology with wireless teletransmission is a perfect tool for handling a remote pilotage service, run from the pilot's land based center.

4 EYE TRACKING

Eye-tracking is concerned with methods and techniques used for registering eyes' movements and points of gaze with the use of specially designed equipment – an eye tracker. In one of its most basic form, eye tracker uses one or more cameras to register so called Purkinje images or Purkinje reflections and based on this data, calculates Point of Regard (POR). This allows for precise identification of visual scene's elements on which subject focuses his/her attention (Duchowski, 2007).

The use of the eye-tracker on the navigation bridge makes it possible to objectively measure the ergonomics of the individual interfaces as well as to evaluate the decision-making process itself, including the mental workload and stress (figure 8).

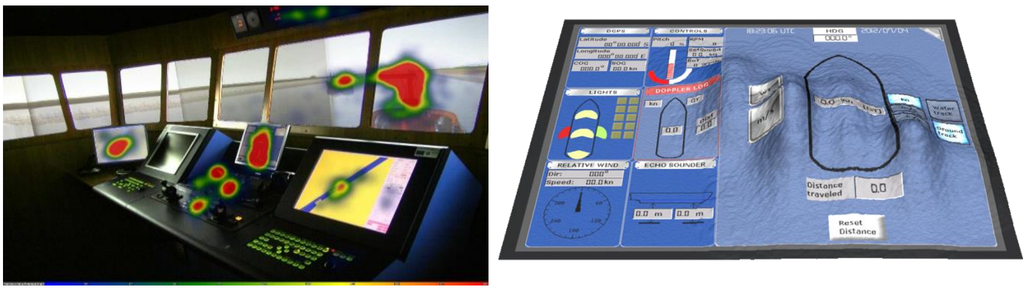

Figure 8: Evaluation of IBS interface design in ergonomic aspect

Source: *Muczyński, Gucma, Bilewski, & Zalewski, 2012*

Eye trackers are widely used in cognitive processing researches, human-computer interfaces usability and in marketing (website and advertisement design). Few researchers pointed out usefulness of gaze tracking data in predicting skill-level differences in collaborative tasks, assessing situational awareness of VTS's operators and evaluation of interruption modality influence on task resumption.

Such approach could be modified and used on the full-mission navigational bridge simulators. Such study could lead to several conclusions:

- Evaluation of bridge design in ergonomic aspect
- Evaluation of radar, ECDIS and conning interfaces in usability and ergonomics aspects
- Evaluation of Officer of the Watch situational awareness
- Evaluation of differences in decision making process and information analysis between experienced and junior officers
- Evaluation of simulator training efficiency (Muczyński, Gucma, Bilewski, & Zalewski, 2012)

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CONCEPTION AND STAGES OF NAVIGATION OF THE VÁH RIVER ROUTE

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ABSTRACT

The Slovac republic is located in central Europe and shares borders with Austria, the Czech Republic, Hungarym, Poland and Ukraine. The country covers 49 034 km², and nearly all oft his area - 47 084 km² or 96% oft he country lies in the Danube River Basin.
Transport is amongst the most important factors influencing the economical development of Slovakia and will continue to be also in the future. Slovakia due to its position in the Central Europe, is a connection between the Black Sea and western river ports via the river Danube. Váh, Danube´s tributary becomes a part of this connection.
The purpose of the current paper is not to solve all technical problems associated with the development of inland waterway transport for navigation on the Vah river, but rather, to begin to establish which conception and stages would be most useful and desirable for inland waterway system in Slovakia.

Keywords: Vah river route, navigation stages, legislative framework, project.

1 INTRODUCTION

Vah River, tributary of the Danube River in Slovakia. Rising in the Tatra Mountains as the Biely Váh (in the High Tatras) and Čierny Váh (in the Low Tatras), the river describes a long arc to the west and south. It joins the Little Danube to become the Váh Danube (Vážský Dunaj), which forms the eastern limit of Great Rye Island, and after several miles enters the Danube River at Komárno, in extreme southern Slovakia, after a course of 242 miles (390 km). The area of its drainage basin is 4,109 square miles (10,641square km). The Váh has a large number of tributaries, many of which fallsteeply off the Tatras and the outer ranges of the Carpathians. The east-west valley formed by its upper course provides a natural transportation route across Slovakia that is followed by major road and rail arteries; the river's north-south valley between Žilina and Bratislava similarly serves as a corridor. The river flows rapidly—particularly when swollen by seasonal meltwater, since the Tatras have few storage lakes—through a picturesque valley. There are numerous small hydroelectric-power stations along the Váh.

The river Váh, by its course creates a natural North-South river route. Therefore the significance of this waterway is in reinforcing the North-South transport corridor and creating a unique connection between Danube and the navigable waterways of North and Eastern Europe. Connection of this nature does not yet exist in central European region.

Slovakia has been a signatory state to the Danube River Protection Convention since 1994 and has been a party to the Convention on the Protection and Use of Transboundary Waterresourses and International Lakes since 1999. The Slovak republic joined the European Union in 2004.

2 CONTEMPORARY USE OF VÁH AND ITS WATERWAY

There is a general assumption about the potential uses of Váh river in the transport area – based on the greater volumes of transferred goods in its direction, and also in the energy area in connection with the anticipated growth of electricity consumption in the future .

The construction Váh river dams began in the 1930s, the main motivation being energy resources, but also area protection and navigability. The first dam to become operational was the power plant in Ladce in 1936 [1].

In 1995, the hydroenergetical potential of Slovakia covered 19% of energy consumption in Slovakia, and the Váh cascade was responsible for 8%. On the installed overall electrical output of all the power plants in the Slovak electrification system, water power plants participated with 33%, Váh river dams alone with 25% [2]..

In a simplified statement it is possible to say that all power plants on river Váh were built and are used as maximum or semi-maximum demand plants. The management of these plants has gradually become automatic, run by the energy dispatching centre in Žilina in way so that the whole cascade works as a single source of energy.

Despite these positive indicators, from navigation point of view, the whole reality of energy use of the river stands against the partial usage of navigations in the specific sections – due to the shifting water level which depends on the through flow and waves originated by the power plant onset.

In the present, level of using the river for navigation and water transport is very low. Navigation is only possible under restricted conditions between the estuary of Váh into Danube and the water dam of Kráľová, depending on the through flow, which in turn depends on the regime of the dam itself. In the first section, from Komárno to Sereď, navigation is possible for the VIa class of ship formations, in the remaining sections for the class Va.

Public use of river Váh is mainly based on the protection against floods, but it also has an effect on other areas of life. Under the term public we understand “beneficial” for the general public.

Areas of public use and benefits:

- Water resources – safety and protection dikes/dams, drainage and anti-leaking precautions,
- Transport – reconstruction of bridges, transport connections to ports,
- Agricultural – irrigation,
- Tourist – sport and recreational sailing.

3 LEGISLATIVE FRAMEWORK FOR THE VÁH RIVER ROUTE

The Slovak government, through its ministry of transport, post offices and telecommunications has in its resolution n. 469 from the 21. 6. 2000 approved the Conception of development of water transport in the Slovak republic. This document also contains a plan of constructing the Váh river route, because in the international context of Slovak republic, this route is of a strategic importance, and its realization is being prepared since the half of the 20th century. Two years later the government of Slovak republic, in the resolution n. 463 from 9th of May 2002 has approved the proposal of the project of Váh river route and its connection to the Odra river. This was not yet a detailed technical project for construction purposes; its goal was to create a stable concept of building the water way by constructing additional water dams, finishing the existing ones and other objects for navigational purposes. It also aimed to state the basic parameters and especially the direction / location of the routes for the water connection between Váh and other water ways in Poland and Czech Republic [3,4]. Approval of this intention created the basic preconditions for the Slovak government to enter negotiations with its Polish and Czech counterparts, about the realization of connecting the waterway of Váh with the waterways of participating countries. Amongst the Slovak, Czech and Polish navigation and water resources specialists, the proposed route for the planned water connection included Váh and Odra and it would pass through the territory of Slovak republic, in the Kysuce region, in Czech republic the Ostrava agglomeration and in Poland the region of Upper Silesia.

4 THE VÁH RIVER ROUTE PROJECT

Project of the Váh river route, as a part of an integrated network of international waterways according the AGN is a long-term investment of strategic importance, which includes all the features of dynamic development program. The implementation of this invesment could have a positive impact on many areas of economic and public life of society [3,4].

The Permanent committee for inland waterway transport under the European economic committee of the UN in Geneva, designated in 1995 the Váh river route as a part of the future international routes and it was assigned the international identification code of E81 with the recommended gabarites of international waterway class VIa up to the town of Sereď and Va up to Žilina. Two years later, as part of the III. Paneuropean Conference of Ministers of Transport in Helsinki, at which the routes of the European transport corridors were defined, there was also a European agreement on Main Inland Waterways of International Importance (AGN) with the river Váh being part of it [5]. The navigability of Váh is the sole responsibility of Slovak Republic and the prolonging of Danube waterway inlands is in the competence of the corresponding governmental bodies of SR.

In the present, level of using the river for navigation and water transport is very low. Navigation is only possible under restricted conditions between the estuary of Váh into Danube and the water dam of Kráľová, depending on the through flow, which in turn depends on the regime of the dam itself. In the first section, from Komárno to Sereď, navigation is possible for the VIa class of ship formations, in the remaining sections for the class Va [6,7].

Váh river is from Liptovsky Mikuláš expect of the section Vrútky-Žilina, Hlohovec – Sereď, Komárno – Selice equipped with the hydro-energy constructions of which only some have builded shipping locks for navigation. Any extension of the navigability increased its national importance, but the whole goal of the project will be achieved by linking the Váh to the rivers of Poland and Czech Republic.

Váh river route has a strategic direction, which coincides with the orientation of multimodal transport corridors no. Va and VI. Region along the Váh river route is the dominant industrial region of Slovakia produced nearly half of GDP [8]. The existing road and railway network already exhausted land options. Waterways has not many territorial claims except of some ports neccesaries.

5 STAGES OF NAVIGATION AT THE VÁH RIVER ROUTE

Váh river route is long-term investment, therefore it is expected the implementation in stages. Each stage will be completed with port connected to the other transport modes (road and railway). It provides comprehensive services in the field of transport. Port of Sereď, Púchov and Žilina was established as the main transport and transhipment point in the whole project [9].

Váh river route is 250 km long from Komárno up to the Žilina. The whole river route is from the bigger part already builded. It is neccessary to completed the dam of Kolárovo, several kilometers long section along the Sereď and completed and reconstructed navigation lock chambers at severals other dams.

Table 2: Stages of the Váh river route

Stage	Section	years	km
1st stage	Komárno – Sereď	1993 – 2002	75 km
2nd stage	Sereď – Púchov	2003 – 2013	124 km
3rd stage	Púchov – Žilina	2010 – 2016	51 km
4th stage	Žilina – Odra	2025 - 2035	98 km

Source: http://www.telecom.gov.sk, arranged by authors

Stage 1, Komárno – Sereď: Navigation on this section started in 1998 after completion of the dam of Selice. In this section there are two dams: Selice (river km 43,9) and Kráľová (river km 63,2). They have two lock chambers of the navigability dimensions 110 x 24 m, which corresponded to class VIa of navigation according AGN. Currently, navigation works only in limited regime, which is only **2,0 meters draft** (according AGN should be at least 2,5m). This situation is as a result of the unfinished the lower part of the system Gabčíkovo-Nagymaros. Its implementation would provide the neccessary depth at the whole section up to the Kolárovo. As an alternative plan is to built water dam Kolárovo, which will provide required navigation depth [9,10].

Stage 2, Sereď – Púchov: With the completion of the Váh river route is the most difficult section. Currently is derivation channel of water dam Sereď - Hlohovec under the progress. From Hlohovec to Púchov can be navigation implemented in shipping channels of the Váh cascade and in the dams of Sĺňava, Trenčianské Biskupice a Dolné Kočkovce. Locks in Madunice, Horná Streda, Nové Mesto nad Váhom, Kostolná and Trenčín are only partly built. In Dubnica, Ladce and Ilava are only locks for small recreational vessels, so it has to be reconstructed or build new lock chambers to suit navigation of class Va for minimum **draft 2,5 m** [9].

Stage 3, Púchov – Žilina: Navigation could lead as in stage 2 in the channels of the Váh cascade and in the dams of Nosice and Hričov. At the dams Nosice, Považská Bystrica, Mikšová and Hričov have to be built lock chambers [9,10]. According to the AGN classification of waterways, the section should be guaranted navigation class Va with a minimum navigable **depth of 2,5 m.**

Stage 4 Žilina – Bohumín: In this section, followed to the Váh river route is about linking the Váh river route with Czech Republic and Poland throught the river of Kysuca, Olša. It will provide a perspective river route linked Danube, Váh and Odra [9,10].

Table 2: Classification requirements of the Váh river route according AGN

section	class	weight [t]	lenght of convoy [m]	widht of convoy [m]	draft [m]	min. hight under the bridges [m]
Komárno - Sereď	VIa	3 200 – 6 000	95 –110	22,8	2,5 – 4,5	7,0 – 9,1
Sereď - Žilina	Va	1 600 – 3000	95 –110	11,4	2,5 – 4,5	5,25 – 7,0 – 9,1

Source: http://www.telecom.gov.sk, arranged by authors

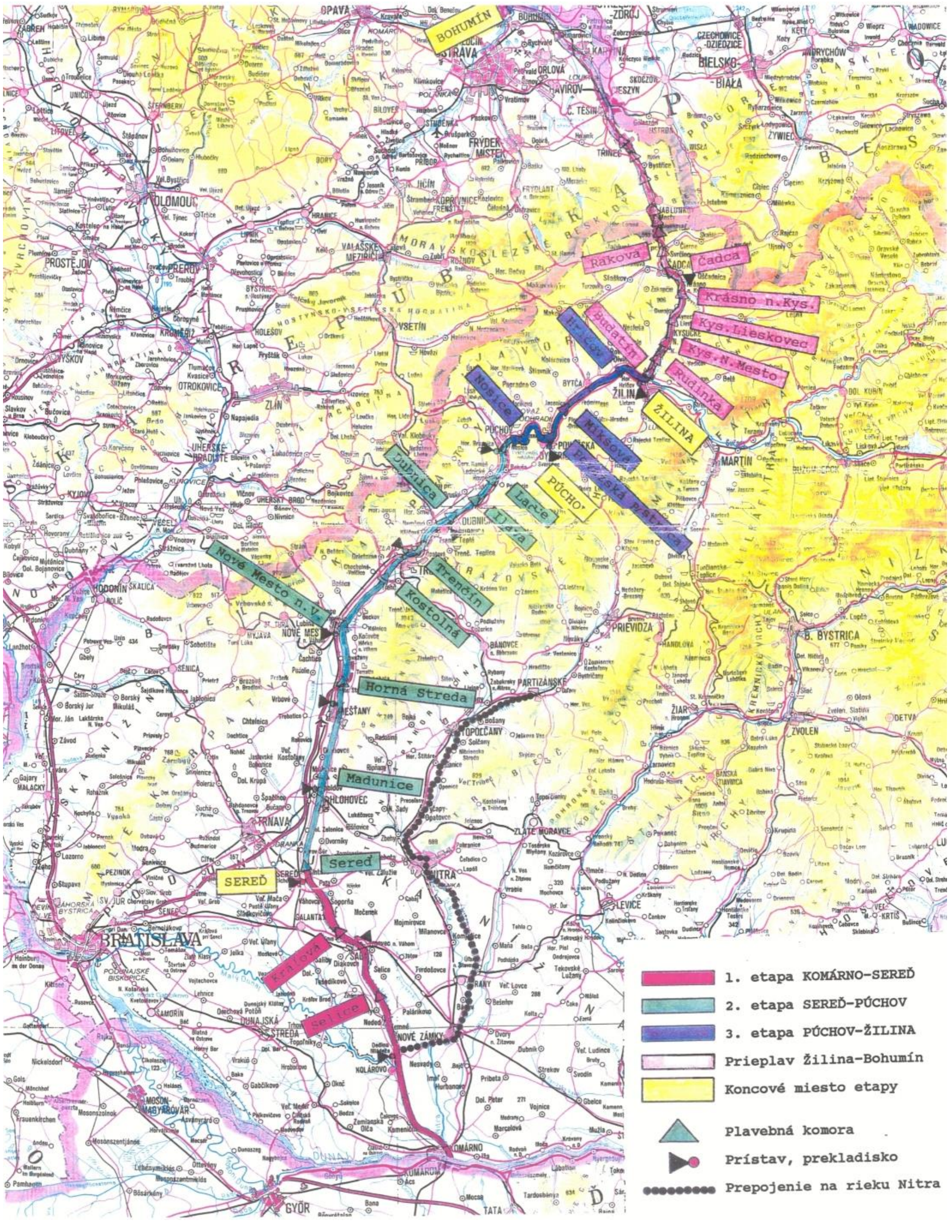

Figure 3: Váh river route

Source: http://www.telecom.gov.sk

6 CONCLUSION

Priorities in area of transport are clearly defined in Slovakia. Completion of the D1 highway is clearly a priority and right to be so, but it is also very important not to neglect completely other areas of transport, including the water transport. The potential of Váh river route is publicly well known and its navigability all the way up to Žilina and subsequent use would help to redirect some of the traffic from the extremely strained road transport to more ecological Váh waterway. The reality unfortunately points to the fact that the completion of its construction is a matter of distant future. This pessimistic view was further supported after the talks of Prime Minister Iveta Radičová with the head of the EU Commission José Manuel Barroso in March 2011, where they agreed on the relocation of resources from Operations Program of Transport with the exception of railways and relocation of idle resources from other operation programs. It would be naive to think that this relocation of resources would avoid the water transport. In terms of finishing the D1 Highway this probably is a positive message.

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CRITERIA OF SUSTAINABLE UNIVERSAL POSTAL SERVICE FINANCING

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ABSTRACT

Liberalization of postal market influences the development and quality of postal services. Universal postal service is defined as a continuing provision of quality basic postal services to all citizens throughout the country on affordable prices. Obligation of providing universal postal service demands clear criteria to be identified in order to ensure efficient realization of the service. This paper analyses different criteria and models for financing and providing sustainable universal postal service.

Keywords: Universal postal service, criteria, financing model

1 UNIVERSAL POSTAL SERVICE

Special significance in the development of postal services traffic has had a universal postal service, due to the characteristics of universality, which is reflected in the provision of services to anyone in the world, regardless of their location, race, religion, social status, etc. World countries are required to enable the provision of services under specific conditions satisfying a certain level of quality, at prices that are affordable for all segments of society. The concept of a universal postal service refers to the profitable and non-profit service and the service that is provided in urban and densely populated areas as well as the service provided in rural areas. This leads to another important feature of the universal postal service - availability. Spatial or territorial availability means that any user is granted access to the network of postal provider, at a reasonable distance, where the provider of the universal service has the obligation to ensure that the density of access points meet the needs of users, according to the technological and economic development. Time availability implies working hours of postal network units and transmission deadlines, which are closely related to the quality and performance of the universal postal service. Quality standards are determined by the state, and are related to the transmission time, regularity and reliability of the service provision. Financial availability relates to provision of universal service at affordable and reasonable prices. Universal Postal Convention defines the obligations relating to the universal postal service by common rules mandatory for all Member States. The Convention defines the services that are guaranteed throughout the single postal area.

2 MODELS FOR FINANCING UNIVERSAL POSTAL SERVICE

There is a number of models for financing universal service, and the main task of these models is to help the universal service provider in the further performance of the service. These models have already been established and used in many countries and in the industry sectors where there is also a duty of providing the universal service. Some models that have been implemented in other sectors, for instance railway transport, show considerable success. Compared to other transport sectors, postal sector has following characteristics:

- users of postal services do not have to pay a fee to get the right and access to postal services, which is the case in energy and telecommunications sectors,
- postal network is better by the means of labor intensity, than networks in the energy or telecommunications sectors,
- the possibility of growth and development of postal services is much lower than in other sectors, which is caused by much greater possibilities of alternative means of communication (Internet, e-mail, etc.), which reduces the incentives for the use of postal services.

There are several different models and approaches in solving the problems of insurance and financing the universal postal service:

- reserved services or monopoly designed to create a fund to cover the additional costs incurred with the obligation to provide universal service. Use of this model requires a precise calculation of costs with the prior definition of calculation methods. In the case that the additional costs are less than revenues from the monopoly it is necessary to reduce it, otherwise it is needed to expand it in order to equalize the revenue with the additional costs. If this is not enough (especially in developing countries), then certain government grants are necessary,
- compensation costs where the basic idea is to establish a fund to finance the service fee, and from which then universal postal service is subsidized. Some states have already implemented this model,
- directly assisting provider of the universal postal service where all providers on the postal market must fund universal service,
- there are some alternative approaches, based on the fact that the service gives the possibility to work on the principle of minimum costs to meet the defined obligations.

3 CRITERIA FOR CHOOSING THE MODEL OF FINANCING UNIVERSAL POSTAL SERVICE

Any assessment of the effectiveness of a particular model of financing the universal postal service should be based on clearly defined criteria. The impact and importance of the criteria depends on the individual market and specific policy objectives in a particular country. These criteria are as follows [4]:

- efficiency;
- competitive neutrality (fair competition);
- social equality;
- compliance with state aid rules;
- transparency;
- proportionality;
- practicality;
- security.

Efficiency - the application of a certain financing method should reduce irregularities in economic efficiency and to improve it. In practice, there are three main aspects that can be used to support the concept of efficiency: allocative, productive and dynamic efficiency. Funding model that promotes allocative efficiency allows service pricing to reflect the cost of providing services, including an appropriate return on invested capital. It is in conflict with the basic idea of providing universal postal services on non-discriminatory insurance pricing. Productive efficiency is based on the fact that providers provide services at the lowest possible cost, with the optimum use of all available resources. In this context, financing mechanisms should provide certain benefits and incentives for the purchase and implementation of the technology available to maximize the utilization of resources and acceptable costs, and also to facilitate the selection of the most effective service for the provision of universal postal services, and so to avoid increasing fixed cost services. Finally, the dynamic performance is related to the promotion of innovation processes, which inevitably leads to the provision of new services and improvement of existing ones. Its potential will be realized through development of new ways of providing services, or creating entirely new services.

Competitive neutrality - funding mechanisms can affect the viability of existing providers, but also the input process by favoring one service providers over another. For the funding to be neutral with respect to competition, means for compensating the loss of providing universal postal services should be avoid for the competition which involves, among other things, non-discrimination in respect to payments to a compensation fund. This criterion facilitates entry into the market of efficient and competitive service providers, and prevents the entry of inefficient. Funding model should be well-balanced, to allow fair competition.

Social equity - based on the concept of justice and fairness, presents concept that determines the criteria and judgments made of society layers that should be privileged over other. Method of financing should allow users to charge similar prices with similar capabilities. It also implies the provider contributions to fund universal service.

Compliance with state aid rules - each of the financing models that involve some form of state aid must be in accordance with national and later with other accepted (for example European) rules and laws concerning state subsidies. Transfer of state funds, either directly or indirectly, that in any way gives a competitive advantage to the recipient of these funds or distorts competition in a liberalized market is considered to be illegal state aid. However, this does not mean that any state aid provider of universal service can be regarded as illegal, under certain conditions.

Transparency - according to this criterion principles and functioning of the model should be clear and known to all market participants and their roles and responsibilities. Principles on how the model works, who can contribute to the financing, and how to determine the contribution of each participant, how to manage funds have to be clear. All information should be publicly available.

Proportionality instrument is one of the key principles of regulatory practice, and a major aspect of this criterion is that the model primarily operates on clearly defined objectives to be achieved. Ensuring sustainability of the universal postal service should be available, and if the financing of the universal postal service is ensured by service providers, contribution must be proportional. Contributions should be non-discriminatory and providers with a small market share may be released from this obligation. Proportionality also means that the given model of financing achieves a reasonable balance between the objectives and goals of the global market.

Practicality - the complexity of schemes and the information required for the financing should be kept to a necessary minimum. Administration, implementation and monitoring of complex models, can lead to less efficiency.

Security - funding model must be sustainable and stable in order to enable funding and provision of universal postal services.

These criteria are identified for evaluation of six possible mechanisms for financing the universal postal service.

4 CHOOSING A MODEL FOR FINANCING UNIVERSAL POSTAL SERVICE

Given the possible models of financing the universal postal service, influence of each of the identified criteria of the financing model will be examined: reserved area, compensation fund, financing from the State budget, pay or play model, network access charges, public tender.

4.1 Reserved area

Reserved area is the main and most effective funding model for the traditional approach of ensuring universal postal service. Funding is based on the funds received from the provision of reserved services. This model creates a monopoly in order for the provider to set up a single average price in a particular geographical area without competing approaches. The criterion of the efficiency of this model should be viewed in three segments: allocative efficiency is relatively poor results on this criterion; productive efficiency consequently leads to a reduction in the reserved area and the appearance of competition, while the dynamic performance is negligible. From the aspect of competitive neutrality results of this model are against fair competition because they make it impossible to enter the market. If this criterion is interpreted as ensuring that, regardless of the location of the sender or recipient, the unit cost of the service remains the same, reserved area on the criteria of social equity can be well assessed. On the aspect of compliance with the rules of state aid this model does not include any direct or indirect transfer of funds from the state to the universal service provider. The transparency of this model can be achieved when the model is already established and is then relatively transparent and easy to understand, but on the other hand, if it is in a development stage, there is a certain contradiction. The problem with proportionality of the reserved area is when the reserved area inappropriately defined. From the point of practicality, the model results are very good because the experience of reserved area in many European countries shows its practicality. For safety criterion reserved area achieves good results, because the creation of a monopoly over certain services eliminates the threat of competition.

4.2 Compensation fund

Compensation funds are one of the models that are commonly used to finance public services, especially in the telecommunications and energy sectors. In postal sector compensation funds have not yet found their wider application, which has been limited. There are four main ways of fundraising: compensation payment from the income, payment from the profits, payment from the amount of services, fixed amount. From the aspect of efficiency, more efficient are the models that do not affect the final product, therefore collecting a fixed amount is more effective than the other compensation methods. Fees for service users are competitively neutral because providers should contribute to the fund, while in terms of social equity compensation funds should not have an impact. Also, a model based on the compensation fund will not lead to problems in relation to compliance with state aid because the funds are financed from fees from the provider or user. However, there are some problems with transparency that can be reduced with the requirements for the providers on preparing independently regulatory accounts. The existence of opportunities to adjust the base for fundraising can guarantee proportionality, while in terms of practicality the main problem is to define the basis for compensation. Safety criterion has a relatively low result because the compensation fund based on fees from income, profit or compensation to the number of services is problematic if the funding is subject to change.

4.3 Financing from the State budget

Financing universal postal service, directly or indirectly from the state budget, which is convenient for the countries in which the burden of providing universal postal services is greater than the funds collected by other means of financing. This method is applied in Russia, Belarus, Ukraine, Bulgaria, etc. Efficiency criteria in this model depends on the success of the national tax system, while in terms of competitive neutrality, there are no reasons which prevent the entry of more efficient service to the market. In terms of redistribution from the state budget, if it is financed by taxes on high-income beneficiaries, social equity is present. Compliance with state aid rules is important when financing from the state budget and must be fully harmonized. From the aspect of transparency, possible management problems are possible, due to the dual role of the state: as an investor and supervisory bodies. It is necessary to ensure that the level of funding is proportional to the level of universal service charges that have incurred as a result of providing the universal service. General taxation would eliminate the administrative costs incurred when determining which provider should contribute to funding, but it would be politically impossible in the case of certain political reasons. Security problems can occur funding from the state treasury cannot be guaranteed.

4.4 Pay or play model

This model represents more sophisticated approach for financing universal postal service. Providers who operate exclusively in highly profitable areas (low cost/high volume services) are obliged to pay certain funds in the compensation fund. This model provides the ability for multiple service providers to provide universal postal service in areas with a high cost. In practice this means that each service on the market can decide whether to provide universal service (play) or charge fund (pay). The biggest potential benefit of this model is to open the possibility of introducing competition in areas with high costs and maximizing performance. From the aspect of competitive neutrality, the choice to compete in areas with high costs shows good results. However, when taking into account the difficulties that arise in determining costs in postal sector, results are not optimal. Criterion of social equality is important in areas with high costs of allowing lower prices. In contrast to the conventional compensation fund where the funds are collected from all providers in the market, the results of this model are neither worse nor better in terms of compliance with state aid rules. On the other hand, the determination of basis for taxation may lead to some problems in transparency. The extent to which this model is proportional depends on the efforts that have been undertaken in determining the basis for taxation and scope of the game. Several problems need to be addressed to make this a good model in terms of practicality: select high-tax and the scope of the games and interoperability between providers. There may also be problems with the safety criteria if the model takes participants to play on inefficiently high levels.

4.5 Network access charges

The basic feature of this model is that potential new providers entering the market must pay a certain fee to the existing provider (national or public). In practice, the fee for access to the network is determined by a certain level, which is sufficient to finance the cost of providing universal postal services. From the aspect of efficiency, fee charge approach could have effect similar to those of a compensation fund because it can affect the marginal costs of the participants. The lack of essential facilities in the postal services means that access charges are in line with the costs that will undermine decisions that affect the criteria of competitive equality. Network access charges can be transferred to users, which is a problem from the aspect of social equity, while it is unlikely that it will create any problems regarding compliance with state aid rules. The model can be transparent by the extent that providers are aligned with the revised regulatory accounts. From the aspect of proportionality, if network access charges significantly influences circumvent, this can seriously affect the ability of the current universal service funding. It is relatively easy and practical to implement, because it is only necessary to determine the amount of compensation for this criteria. Possible problems in terms of security are present if the tax base is small and/or access charges result in high levels of entry from end-to-end.

4.6 Public tender

Using different models for financing universal service showed the possibility of using certain economic models that in other areas have good results. One of them is a model of public tenders. This model implies that the universal service provider is selected on the basis of the best competitor. Tender ensures providing the universal service from the most efficient service provider, which could help reducing the amount of resources required for ensuring the provision of universal service. However, the advantages of this method depend on a number of aspects, including risks of tender frauds. Depending on how the tender will be designed and on the market characteristics, this model has the potential to be competitively neutral. From the aspect of social equity model has a very good results that will depend on several aspects, including access to public bidding, distribution of users with low-to high-income across different competitions areas. It is unlikely to create any problems with compliance with the state aid rules. This model has the potential to be very transparent in terms of the level of resources and users. Problems can arise in the case of an administrative determination of the level of subsidies and if the universal service provider must disclose commercially sensitive information. The model also can be proportional, if service provider reveals real costs of providing the universal service. From the point of practicality, this model can avoid the information requirements for determining the cost of providing the universal service, but the application of this model would be conditional on market structure, characteristics of the industry and legal requirements. Well designed tender can guarantee the performance of long-term financing of the universal postal service, which meets the requirement of security.

4.7 Model for choosing method of financing universal postal service

Using the Analytic Hierarchy Process (AHP), a method of multi-criteria decision making process, model for choosing the best method for financing the universal postal service has been created. Initial step is to define the hierarchical model with two levels (goal on top, criteria and alternatives). After that, at every level of the hierarchical structure elements are compared to each other, where decision maker express preferences using Saaty scale of relative importance. Then, the assessment of the relative importance of the elements using a mathematical model to calculate local priorities (weights) of criteria and alternatives is carried out. This is then synthesized into the overall priorities of the alternatives At the end of the sensitivity analysis is carried out. Following model is set up for financing the universal postal service:

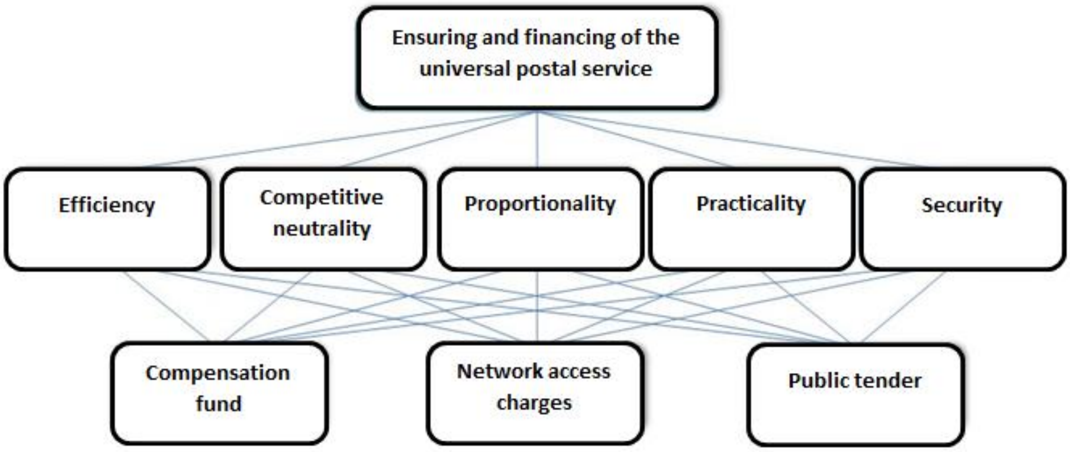

Figure 1: AHP model in the function of selection model for ensuring and financing the universal postal service

After analysis, the criteria relevant to the creation of the model of financing the universal postal service are: efficiency, competitive neutrality and fair competition, proportionality, convenience and safety. Criteria that are eliminated are: social equity, compliance with state aid rules and transparency. Compliance with state aid rules is eliminated due to it insignificance to models. Social equality and transparency criteria, should be clear and known to all market participants, and be a prerequisite for all models of ensuring and financing, so they should not be discussed separately and were therefore eliminated from further analysis. Following alternatives are identified: compensation fund, network access charges and public tender, while other alternatives were eliminated. The reason for this lies partially in the fact that Postal Directive identifies some of these methods as possible solution for ensuring and financing the universal postal service. Model of the reserved area was eliminated because it is prohibited in the terms of open market in the European Union and Republic of Croatia. Although the budget funding is very popular way of financing the universal service, it is eliminated because the free market seeks to reduce it, ensuring the competitive climate in the market. Pay or Play model was eliminated because of its complexity and high administrative and supervisory costs and questionable practicality, transparency and security.

Comparing criteria at first level, weight values have been given, as shown in figure 2.

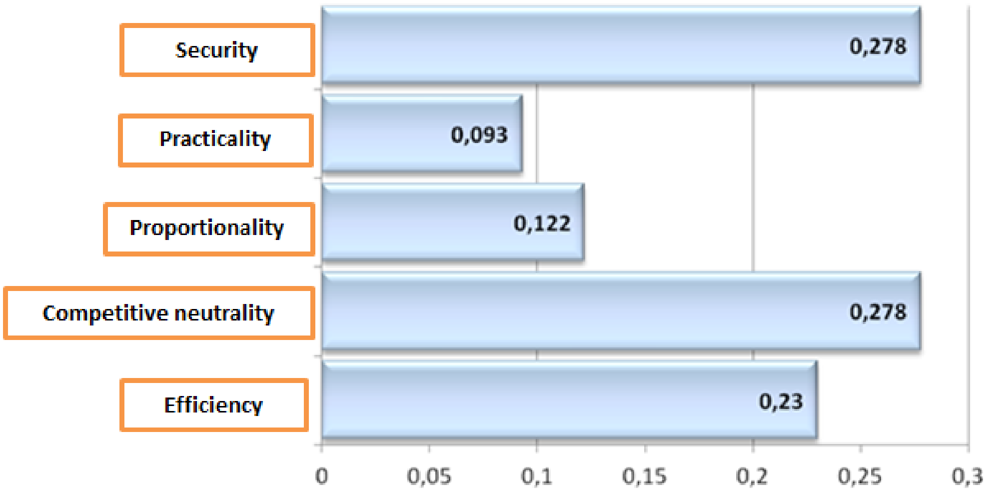

Figure 2: Weight values of the given criteria

Following figure shows weight values of criteria for each of the alternatives. It can be noticed that each alternative has two dominant criteria.

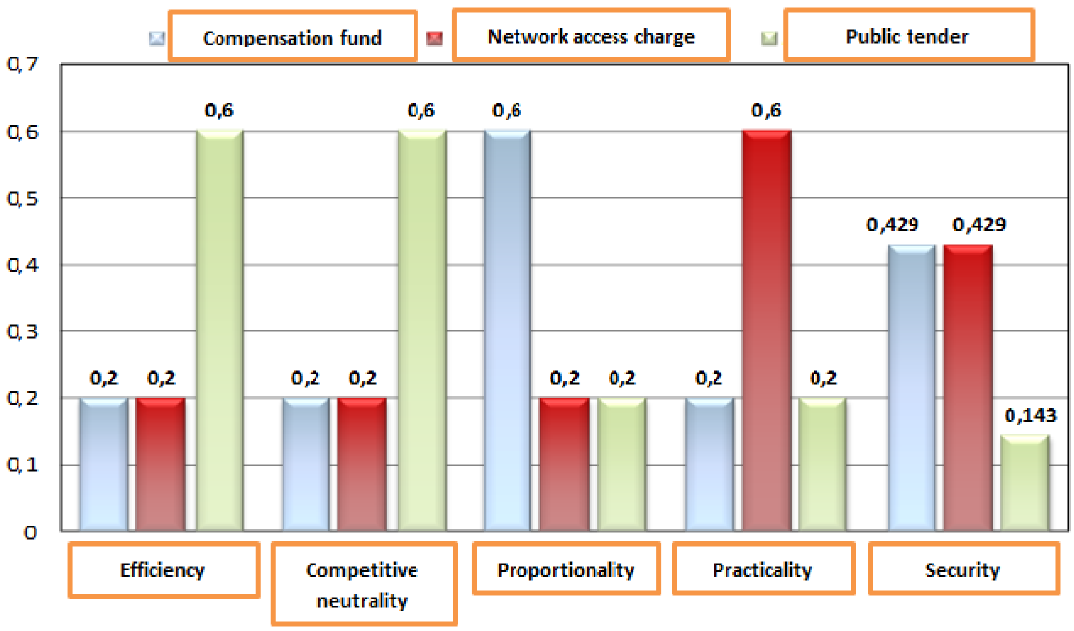

Figure 3: Weight values of criteria in relation to each alternative

5 CONCLUSION

Obligation of providing universal postal service is mandatory in order to ensure global postal market. Obtaining such service is an obligation, not just for the service provider, but also for the country. It is in interest of every country that the functioning of the universal postal service is guaranteed. Problem of financing such service of public interest can be discussed through several methods of financing: compensation fund, network access charge, public tender, reserved area, financing from the State budget, pay or play model. These models have already been tested and implemented in other sectors with obligation of universal service. Criteria that influence and determine each financing method can also be identified: efficiency, competitive neutrality, proportionality, practicality, security, etc.

Model for choosing the best solution in financing universal postal service can be best described through multi-criteria decision process, which allows identifying and comparing several criteria and alternatives in order to gain best results, with respect to the goal to be achieved. This method allows sophisticated compares of criteria on one level, alternatives on other, and relations between criteria and alternatives.

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ABSTRACT

The operating of a cargo or cruise ship are affected by the motions and forces due to rolling, which can cause ship/cargo damage and discomfort to the crew and passengers. In naval vessels, heavy rolling may affect the accuracy of the weapon system or prevent the landing or take off of helicopters or airplanes. In severe sea conditions, rolling may make it necessary for a ship to deviate from her planned course to avoid the rough sea with consequent loss of time and money. Different kinds of devices, known as stabilizers, have been developed for the purpose of reducing the rolling motion of ships. Stabilizer has become increasingly popular as standard equipment for ships, especially on passenger/ vehicle carrying ships, on certain classes of warships and yachts. In general these appliances are of the passive or of the active type. Active fin stabilizers are fins mounted beneath the waterline and emerging laterally. An active stabilizer has present control whereby the corrective action in the form of a counteracting movement is programmed to take place simultaneously with the occurrence of the disturbing movement that causes the rolling of the ship. In contemporary vessels, they may be gyroscopically controlled active fins, which have the capacity to change their angle of attack to counteract roll caused by wind or waves acting on the ship. The active fin stabilizers are most effective when a ship has relatively high speed (above 10-15 knots), while reduction of ship rolling can be up to 90% by using the generating lift of the fins extended to both sides of a ship. The active fins can be withdrawn into the hull when the ship operates in calm weather conditions to eliminate their small resistance with the water.
The active fin stabilizers are able to ensure a drastic reduction in roll with the consequent advantages in terms of passengers and crew comfort; of ship stability; of course holding; etc.

Keywords: roll, wind, active fins, stabilizers, gyro.

1 INTRODUCTION

Various stabilization methods have been used throughout history to reduce rolling motion on commercial, military, and, more recently, recreational vessels.Attempts to reduce the rolling motion of a ship date back more than a century but not until 1936 was fully practical solution to the problem achieved when Brown Bros of Edinburgh and William Denny and Bros of Dumbarton successfully installed fin stabilizers on the steamer “Isle of Sark”. Following this, the design rapidly gained favor over the clumsier, bulkier and less practical devices of earlier years. During the 1939-45 War, for instance, over one hundred ships in the UK Royal Navy were fitted with stabilizers to improve gunnery. After 1950, stabilizers were installed in increasing numbers on merchant ships. Over the past twenty-five years, the stabilizer has become increasingly popular as a standard fitment for ships, especially on passenger / vehicle carrying ships and on certain classes of warships. [1]

Several methods exist for improving the seagoing stability of the ship and include, but not limited to, fin stabilizers, roll tanks, (movable ballast) and bilge-keels, and may be used together or individually. Modern, active fin stabilizers have today largely replaced these techniques.Various advantages and disadvantages exist for each of these methods and must be considered when determining a particular method to be used.

This paper surveys the principal methods of fin stabilizers which are now being used for roll stabilization of a vessels including application of passive fins. The method of operation is described, together with practical details for operational effectiveness and advantages and disadvantages of the methods.

2 ADD-ON STABILITY SYSTEMS

Sometimes large roll motion may cause unwanted dangerous situation to sea going vessels even under not so harsh environment because roll motion is very sensitive to resonant frequency. Very large resonant roll motion is mainly due to its very small inherent damping comparing to other motions such as heave and pitch, of which radiation damping is sufficiently large to suppress high resonant response. This property of roll motion gives an idea that roll motion can be controlled providing additional damping force.[2] Anti-rolling tanks and fin-stabilizers are typical examples of roll stabilizing devices. These systems are designed to reduce the effects of waves or wind gusts. They do not increase the stability of the vessel in a calm sea. The International Maritime Organization International Convention on Load Lines does not mention active stability systems as a method of ensuring stability. The hull must be stable without active systems.

Many vessels are fitted with active stability systems. Active stability systems are defined by the need to input energy to the system in the form of a pump, hydraulic piston, or electric actuator. These systems include stabilizer fins attached to the side of the vessel or tanks in which fluid is pumped around to counteract the motion of the vessel.

3 FIN STABILIZERS

Fin stabilisers are lightweight and occupy a small volume but there is a penalty for the added drag. A major disadvantage of the fin-type stabilizers is that they depend upon the forward movement of the vessel in order to give the necessary lift, and this lift reduces very rapidly as the speed drops (approximately by the square of the speed). For speeds less than 6 knots fins have almost no effect.[3] Many vessels have occasions to operate at low speed (mine countermeasures ships, floating production, storage and offloading - FPSO vessels, ships during launching or recovering boats or loads, cable layers, and survey ships). Relying merely on fins leaves the ship at the mercy of the waves. Therefore ships operating at low speeds require an alternative system for stabilization; one solution is antiroll tanks.

3.1 Active Fin Stabilizers

The active fin stabilizers - at present universally recognized as the most efficient system for marine technology - are able to ensure a drastic reduction in roll with the consequent advantages in terms of passengers and crew comfort; of ship stability; of course holding; etc. The fin stabilizer is most effective when a ship has relatively high speed by help of its active control, Active fins have the capability of reducing the roll by up to 90%.

The fins extend beyond the hull of the vessel below the waterline and alter their angle of attack depending upon heel angle and rate-of-roll of the vessel.

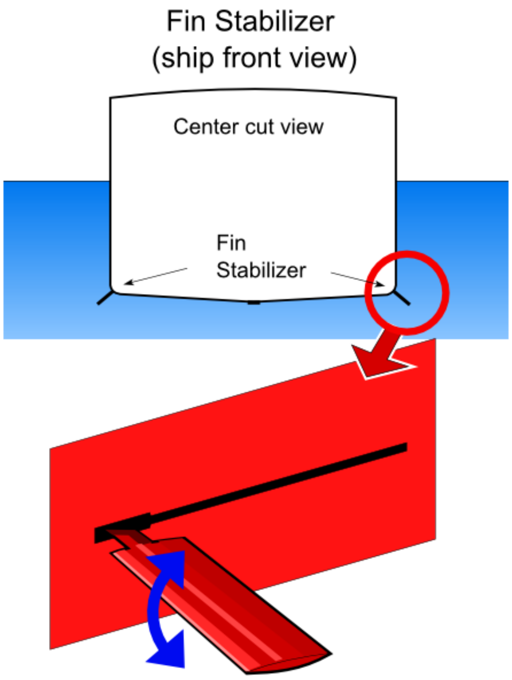

Figure1: Location of Active Fin Stabilizer on a hull

The stabilizing power of fins is generated by the “lift” on “airfoil” sections which may be all-moveable, with or without flaps or partly fixed, partly moveable. These fins are tilted, usually hydraulically.

The control system for the fin stabilizer can be classified as electro-hydraulic. On the electrical side, it includes heavy electrical gear (motors, starters, solenoid valves, etc.), very sensitive electromechanical sensors and sophisticated electronic circuitry.

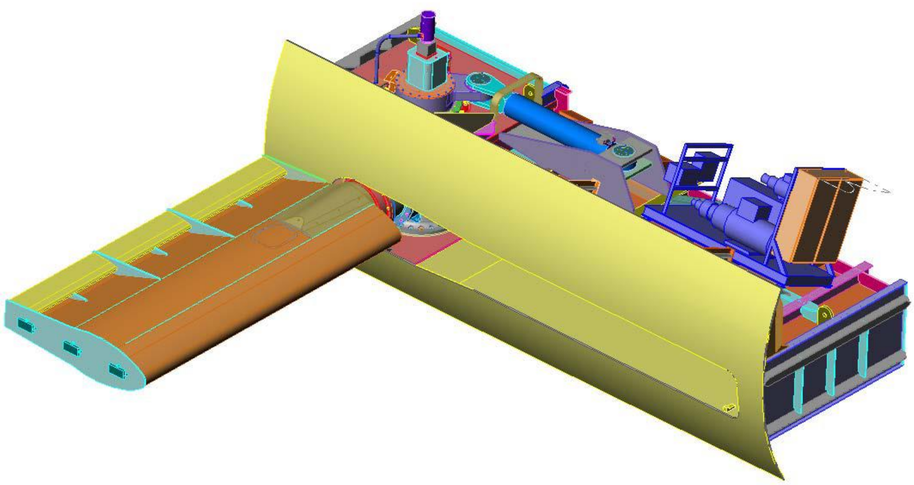

Figure 2. Folding Fin Anti-roll Stabilizers

Source: Fouré Lagadec Marine, (www.fourelagadec.com) 2012

Control of fin movement is automatic and is usually derived from gyroscopic sensing gear which, in its simplest form, Velocity Control, is based on one small, electrically driven gyroscope mounted horizontally with its axis athwart-ships. The angular velocity of roll of the ship causes the gyroscope to process against centralizing springs to an amount proportional to the velocity and generates a small force which is hydraulically amplified by a hydraulic relay unit to provide power sufficient to operate the controls of the variable delivery pump via suitable linkage. Part of the linkage is coupled to the fin-shaft to transmit a canceling signal to the pump control and to bring the fin to rest at the angle of tilt demanded by the sensing unit. This type of control is often fitted in small installations, usually for economic reasons, and is most effective against resonant rolling.

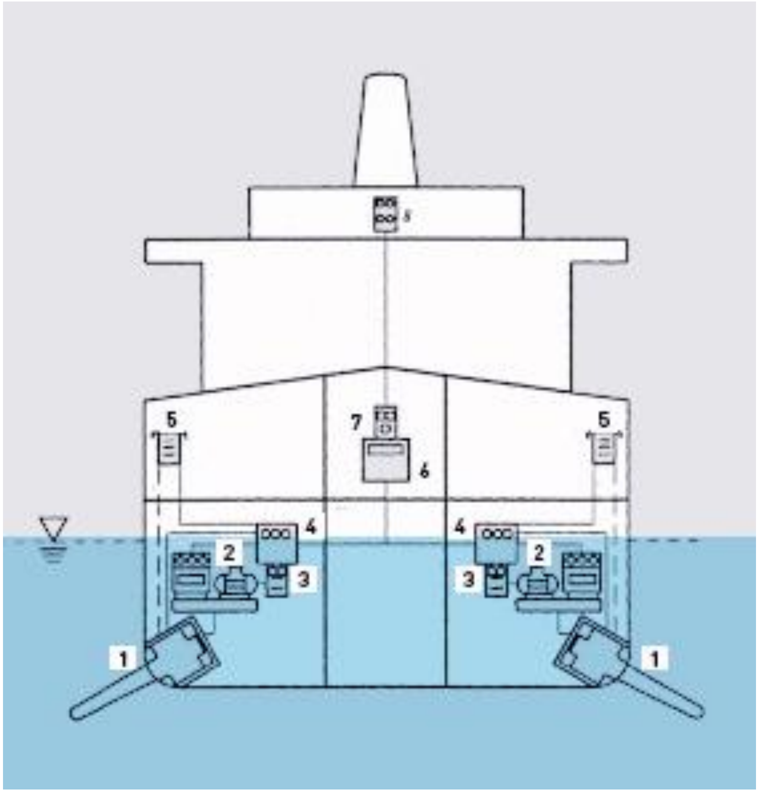

Figure 3: The main parts of the Active Fine Stabilisers

(1. Fin; 2. HPU 3. Motor switchbox ; 4. Local control unit; 5. Gravity oil tank; 6. Main control unit; 7. Central switchbox; 8. Bridge control panel.)

Ships seldom roll in a purely resonant mode: the sea state is often highly confused. More elaborate, and more expensive, control systems are required to deal with suddenly applied

roll, rolling at periods off resonance and rolling in conditions arising from the combination of several wave frequencies. A sensing unit based on a vertical-keeping gyroscope coupled into differentiating and summation units enables fin movement to be controlled by a composite function derived from roll angle roll velocity and roll acceleration. By adding a “natural list” unit, stabilization is achieved about the mean point of roll and so reduces both propulsion and stabilizing power demand. This is known as a compensated control system, (Figure4), and is generally used in large installations. In the active fin stabilizer control systems, fin movement is a function of :

1. roll angle.
2. roll velocity.
3. roll acceleration.
4. natural list.
5. ship speed, if a speed control unit is employed.[1]

These produce a controlled roll moment where the phase and amplitude is such that it counteracts the external heel moment.

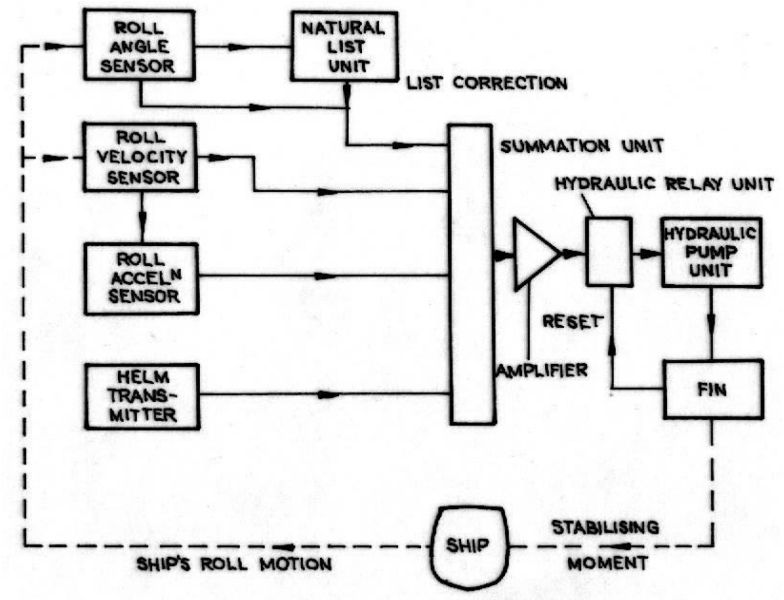

Figure 4. Principles of Active Fin Stabiliser Control Systems

Source: Samoilescu G., Radu S., "Stabilisers and Stabilising Systems on Ships",2002.

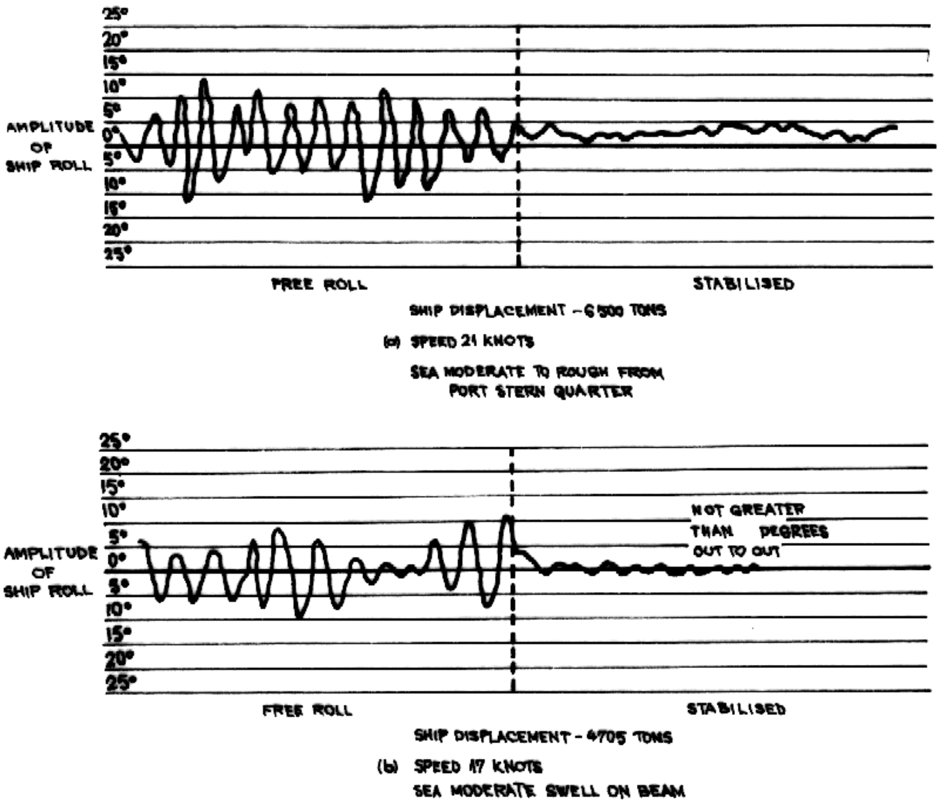

Figure 5: Roll and roll damping curves for two ships in various sea conditions, and obtained results with stabilizers

Source: Samoilescu G., Radu S., "Stabilisers and Stabilising Systems on Ships",2002.

The fins are most effective at higher speeds, since the force on the fin varies directly proportional to the speed of the ship. Below ten knots, the stabilizing moment available is not adequate to effectively counter the heel moment. In addition, the load on the fin or fin pivot may be such that the fin is unable to undergo full angular displacement at certain speeds. This could result in degraded performance at other additional speeds. Various parameters such as shapes, ship locations, and angles of attack can be varied to help obtain the maximum performance from them.

Active fin stabilizers have the ability to limit the angle of the stabilizer fins in relation to the speed of the ship. Stabilizer system in automatic mode is set in a way that limits and reduce the fin angle of attack when ship's speed is higher than 18 knots. Maximum allowable angle of attack is + / - 16.5 º, and restricted angle of attack is at ship's speed less than 10 knots and higher than 18 knots.

Figure 6: Photograph of Folding Fin Active Stabilizer of the cruise vessel in dry dock

Source: Author's archive from works in dry dock (Brisbane-Australia 2006)

As example, *Queen Mary 2* (length 345 m , tonnage 148528 GT), flagship of the Cunard Line, has four *'VM Series' folding fin stabilizers* built by Brown Brothers of Edinburgh. They are a one-piece, and when combined can reduce the ship's roll by 90 percent. The 70-ton stabilizers are 8.2 feet wide with a surface area of 168 square feet. They extend beyond the ship's side by 20.5 feet, provide 1070 kN lift and take about half a minute to extend or retract.

Non-folding fins are commonly used where space within the hull is limited. They are usually fitted at the round of the bilge and do not project beyond the vertical line from the

ship's side or the keel line, to minimize the risk of contact with a quay wall or the sea bottom. The fin shaft, to which the fin is rigidly attached, passes through a sea gland in a mounting plate welded or bolted to the hull and is supported by two substantial bearings. A doubleended lever keyed to the inner end of the fin shaft is actuated by two hydraulic rams supplied from an electrically driven pump.

Figure 7: Non-folding fin stabilizer

3.2 Passive Fin Stabilizers

Passive systems in which no separate source of power is required and no special control system. Such systems use the motion itself to create moments opposing or damping the motion. When fins are not retractable, they constitute fixed appendages to the hull, possibly extending the beam or draft envelope, requiring attention for additional hull clearances. This method of stabilization is considered as bilge keels. Bilge keels are the most widely used and simplest kind of roll stabilization in current use. They consist of a fin fixed to the hull at or near the bilge. The natural period of the roll of the ship is proportional to the radius of gyration of the ship.[4] By attaching this fin, the radius of gyration of the ship is effectively increased. This results in an increased mass of water to roll with the ship and therefore an increase in the period of the roll. Under forced rolling conditions, such as in a seaway, the increased natural period that results from the bilge keel results in a due to viscouseddy effects supplied by the bilge keels plays an even larger role in roll reduction. Energy is dissipated by viscous flow from around the ship and this energy dissipation is increased substantially by bilge keel use. The roll damping achieved is less than that by active fin stabilizers and on the vessels has been accompanied by an increase in fuel consumption of the order of 10–15%, and this option is not widely favored.

Figure 8: Photograph of passive fin stabilizers: a fixed fin stabilizer (front) and bilge keels.

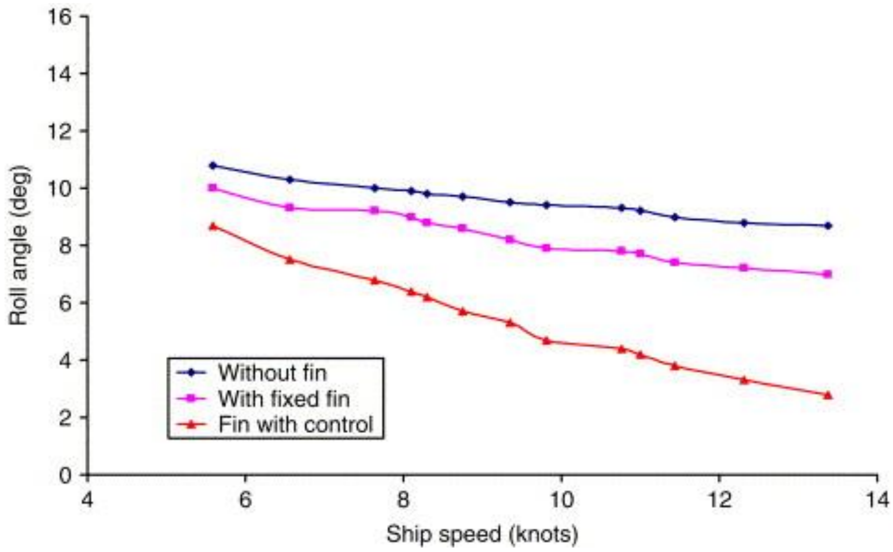

Figure 9: Roll reduction due to fin with active control

Source: Subramanian V.A., Asokumar G., Kumar V.J., "Active fin control for yacht using virtual instrumentation", 2007

4 THE ADVANTAGES AND DISADVANTAGES OF FIN STABILITY SYSTEMS

The advantages and disadvantages of **pasive fin (bilge keel)** systems are as follows:
Advantages:

1. Bilge keels are simple and easy to fit.
2. They remain effective at relatively low speeds.
3. Negligible reduction in ship's deadweight capacity, no reduction in initial static

stability, no auxiliary power requirements, and negligible space occupied by the hull.
4. Low initial cost.

Disadvantages:
1. Since they are external to the hull, there is added resistance to ahead motion that must be overcome by the main engines.
2. Comparatively to other methods, bilge keels offer smaller amounts of roll reduction.
3. Bilge keels, carefully aligned to flow around the hull in calm waters to reduce forward motion resistance, can lead to added resistance during roll motion.
4. Vulnerable to damage.

The following are advantages and disadvantages of **active fin stabilizers**:
Advantages:
1. They offer the highest possible roll reduction with no reduction in static stability characteristics. They are the most effective of all single stabilizing devices.
2. They are used in ships of different sizes.
3. They inflict very small increases in ship resistance and have small auxiliary power requirements.

Disadvantages:
1. They are not effective at low speeds.
2. They take up moderate machinery space, especially if they are retractable. This is desirable as they are less prone to damage.
3. High initial cost due to the controlling equipment and machinery required.

5 CONCLUSION

Today in the market there are a number of active fin stabilizers, which has almost identical working principle with the difference in performance and mechanical parts of the fins. Active fin stabilizers are offered in various shapes and sizes for different types and sizes of ships. Using years of experience, today's manufacturers of modern large active fin stabilizer monitor market demand and continue to work on improving the stabilizing system, so that today there are stabilizer fins resistant to cavitation despite being used on ships speed exceeding 25 knots.

Fin stabilizer with a folding fin is more costly to produce and maintain compared to fixed fin active stabilizer, but has better performance in stabilizing the ship is due to the greater length of fins, and the ability to retract the fin in the housing when the stabilizer is not used in navigation during calm sea, while reducing the impact on the speed of the ship.

Active fin stabilizers are used mostly in modern passenger ships, yachts, war ships due to their good performance in stabilization and can be mounted in combination with one or more other active or passive system stabilizers.

Active fin stabilizers are still not sufficiently present on cargo ships. Perhaps because of the lower effectiveness at cargo ships speed which is less than speed of the an cruise, war or pleasure vessel. Therefore, further development of active fin stabilizers should be focused on improving the efficiency of fin stabilizers at low speed, so that active fin stabilizers could be more applied on a slower merchant ships, what can result in less cargo damage and improved comfort onboard.

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THE QUALITY OF THE AIR TRANSPORT NETWORK IN THE SOUTH EAST EUROPE

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ABSTRACT

Air traffic between EU and South-East Europe has seen significant growth over the past few years and industry forecasts show positive trend in the future. Analysis of the European Air Transport Market published by European Commission shows that passenger flows within Europe count for remarkable 40% share in overall EU traffic, on average. This paper examines the quality of air service originating in the selected non-EU countries[1] of the South East European region (SEE). The connectivity and centrality index are crucial element of the network analysis. In this paper, network is defined by Ticketed Point Mileage (TPM)[2] and Maximum Permitted Mileage (MPM)[3] between city pairs flown in 2010 with origin or destination in SEE countries. In examples where sum of individual TPMs exceed MPM for more than 25%, connection is considered as non-reasonable and therefore not taken into consideration. Results of the air service quality analysis based on the basic connectivity index and air mobility for the selected countries are compared with EU-27 market.

Keywords: connectivity, air transport network, airport benchmarking, airport network, air mobility

1 INTRODUCTION

The air transport network consists of airline networks that are categorized by connected city-pairs. An air transport network is a broader term than just an airline network, as it includes overall network structure of a specific market or region, taking into account spatial and temporal perspective. In general, there are two types of networks in the airline industry, point-to-point and hub-and-spoke. While in the point-to-point all the cities in the network are connected with each other, in the hub-and-spoke system all city-pairs are connected via central point or hub. At a hub an airline concentrates its flights not only spatially, but also temporally. In the airline network, a hub is acting as a traffic node at which the airline operates a wave-system structure, using schedule coordination to maximize indirect connectivity and minimize the waiting time for passengers [1].

Size of the airport is not critical factor to the network quality, small airport may have high accessibility to the network if they have just a few flights to well-connected airports [2].

[1] Croatia, Serbia, Bosnia and Herzegovina, Macedonia, and Montenegro
[2] IATA Ticketed point mileage (TPM) – the distance of pairs of points published in the Ticketed Point Mileage Manual using non-stop sector mileages
[3] IATA Maximum permitted mileage (MPM) – the maximum mileage that can be travelled for a fare component.

Geographical location of the airport and economic power of the catchment area have direct impact on the hub airport development and integration in the global air transport network. The quality of network, of the hub-and-spoke system in general, depends on [3], [4], [5]:

- Number of destinations
- Frequency of connecting flights
- Additional travelling time due to the geographical location of the hub
- Additional travelling time due to transfer time at the hub airport
- Ticket price
- Air mobility.

Travelling via the hub instead of with a direct flight, results in a longer travelling time due to the transfer at the hub and to the detour that often has to be made (geographically). To be convenient as a transfer point and build strong network, hub airport should generate only a limited increase in terms of distance and travel times compared to direct travel [3]. On the other hand, the frequency with which the final destination is served is higher via the hub, therefore the network quality should be higher as well.

The air mobility is another indicator that can be used for the air transport network analysis and has a strategic role in the network development planning. It shows the intensity with which a given population uses air transport and country's capacity to attract air traffic (for business and tourism) and potentials for network development of global or regional basis. The air mobility for the European market has been analyzed and published for the last couple of years by International Center for Competitiveness Studies in the Aviation Industry (ICCSAI) and in this context it is defined as the average number of trips per capita, measuring a population's overall propensity to fly. It is given by the ratio between the number of passengers carried in a year and the country's population. To avoid double counting, the number of passengers arriving from and departing to domestic destinations is taken as a proxy for traveling nationals, and this total is then divided by 2 [5].

Distribution of demand, traffic flows and development of the air transport network varies amongst the regions. According to IATA, in 2011, RPK within Europe on the macro level had 8.6% share of the global realized RPK. On the micro level, more than 70% of European traffic was realized as international traffic within Europe. The top European city-pair traffic base on the origin and destination (O/D) of the passenger itineraries according to IATA are mainly located in Northern Europe (London-Dublin, Amsterdam-London, London-Milan, London-Madrid, Geneva-London) around hub airports that are categorized with strong intercontinental traffic but also those that have big share of low cost carrier flights.

Development of the air transport network is subject to many external factors, regulatory, economical as well as infrastructural (capacity). Despite the economic and financial downturns, demand for air transport is continuously growing. The official market analysis for 2012 are yet to come, but it is notable that 2011 was the second consecutive year of above-trend growth in airline passenger numbers worldwide. The growth of the past two years compares favorably with the 4-5% trend of the past 20-30 years. Worldwide international and domestic revenue passenger kilometers flown grew by 5.9% in 2011, compared with 7.5% in 2010 [6].

Even with a persistent economic uncertainty, tourist arrivals to Europe reached 503 million in 2011, accounting for 28 million of the 41 million additional international arrivals recorded worldwide. Central and Eastern Europe and Southern Mediterranean destinations (+8% each) experienced the best results. Although part of the growth in Southern

Mediterranean Europe resulted from a shift in traffic away from the Middle East and North Africa, destinations in the Mediterranean also profited from improved outbound flows from markets such as Scandinavia, Germany and the Russian Federation [6], [7].

UNWTO[4] forecasts continued growth in international tourist; arrivals are expected to increase by 3 to 4% [7]. IATA's annual survey of airline forecasts for traffic growth showed that passenger travel is expected to grow by 5.8% on average over the four year periods to 2015 (survey conducted third quarter of 2011). In long term forecast based on the 2012 data, IATA expects passenger demand (RPKs) growth to average 4.9% over next 20 years [6], [7].

Overview of other industry forecasts for the passenger demand growth is shown in Table 1, they all have in common growth of passenger travel demand.

Table 1: Passenger Forecast

Source	Market	Unit Measure	Period of forecast	Annual growth rate (%)
Airline survey	World	Passenger	2011-2015	5.80
IATA	World	Passenger	2011-2015	5.00
IATA	World	Revenue Passenger Kilometers	2011-2030	4.90
ICAO	World	Revenue Passenger Kilometers	2005-2025	4.60
ACI	World	Passenger	2010-2029	4.10
Airbus	World	Revenue Passenger Kilometers	2010-2030	4.80
Boeing	World	Revenue Passenger Kilometers	2010-2030	5.10
Embraer	World	Revenue Passenger Kilometers	2010-2030	5.20
US FAA	International (US Airlines)	Revenue Passenger Miles	2010-2032	4.30
Eurocontrol	Europe	IFR Movements	2012-2018	3.00
Eurocontrol	Europe	IFR Movements	2010-2030	3.90
UNWTO	Europe	Tourist arrivals	1995-2020	3.10

Source: adopted from [6] and [7]

2 NETWORK DEFINITION BASED ON THE IATA MILEAGE SYSTEM

Following liberalization in the air transport industry, the air transport network has undergone a major transformation, especially in Europe, where average flight distance between city-pairs is shorter than for example in USA where whole liberalization started [8]. There are number of researches done in the area of airline network and an airport hub development, weather the air transport network analysis is done from the airline perspective or airport perspective it is mainly measured from the aspect of airport connectivity and centrality [8], [9], [10], and some of them are taking into consideration the temporal coordination in view of the routing factor [10]. The routing factor is defined as the ratio between in-flight time and potential direct flight time and normally it is between 1.25 and 1.4. Based on this factor, in theory some of the connections can be excluded due to detour and longer total traveling time, however mileage restrictions and specified routings should be taken into consideration as well.

For the IATA airline members, that represent 84% of total air traffic [11], for any city-pair that has a direct service a Ticketed Point Mileage (TPM) is defined. TPM means the non-

[4] World Tourism Organization

stop or shortest constructed distance between any two ticketed points in the passenger journey, shown in the passenger ticket and it is subject to the specific routing provisions [12].

Published mileages are determined on the total airport to airport great circle distance of the route as scheduled to be operated. Where a particular city is served by more than one airport, mileages are based on the arithmetic mean of coordinates for such airports. In the case of scheduled surface transportation from/to points not having an airport, the mileages are determined on the off-line point to airport great circle distance.

The IATA Mileage system is one of the ticketing options that is used for international travel only, to calculate the fare for transportation as well as for charging amongst the airlines for an interline passenger travel based on the special prorate agreements.

For any direct travel between origin A and destination B only TPM will be taken into consideration for ticketing and passenger will usually experience higher cost of travel due to lower total travel time, as opposed to the passenger traveling between origin A and destination B via an intermediate point (H) that potentially will get lower priced journey as a consequence of detour and therefore longer traveling time. When O/D travel involves intermediate stops there is another important element in the mileage system, a Maximum Permitted Mileage (MPM). This states the maximum permitted mileage the passenger is allowed to travel between the O/D for travel in indirect routings. If passenger travel is on one direct flight (from Zagreb to Amsterdam), then there is no need to be concerned with the MPM. However, if travel between these cities is via an indirect routing with intermediate points (for example Zagreb-Athens-Amsterdam), then it is necessary to compare the actual mileage flown with the MPM.

In the mileage system an MPM has role of the routing factor, defining O/D network that can be priced in one ticket without incurring additional cost. Some of the connectivity measures use a routing factor or circuitry factor as the ratio between the actual time distance (Km/time) and the theoretical distance of a direct flight [8], [10], [13]. However, theoretical routing factor may not be applicable in practice.

A routing which exceeds the MPM will increase the fare or require a different fare breakpoint. If the MPM is higher than the sum of individual TPMs of flown sectors, then the total distance of the itinerary did not exceed the maximum distance between the fare component origin and the fare component destination. In ticketing terms, this situation is considered "within the mileage" and such a journey can be priced in one ticket.

Under the mileage system, the fare component is permitted at the direct fare if the MPM is greater than or equal to the total TPM of the individual journey components. In case the TPM is higher than the MPM, the next step is to check if any TPM deduction is available for specified routing or an Extra Mileage Allowance (EMA) is permitted. However, in case the EMA is not enough or is nil, the TPM is divided by the MPM to arrive at an Excess Mileage Surcharge (EMS). This surcharge ranges from 5 to 25%. If difference between sum of TPM and MPM for specific O/D is >25% journey has to be priced using multiple fare break points which will drastically increase total fare. IATA MPMs are established at 120% of the direct route mileage [14].

3 SOUTH EAST EUROPE AIR TRANSPORT NETWORK PERORMANCE

According to ICCSAI in 2010 there were a total of over 5,000 European routes of which majority (75%) were less than 1500 km and about 27% of them have length between 500 and 1000 km (Figure 1) [5]. As for the routes originating in SEE selected countries, almost all of them have a length less than a 1000 km.

Connectivity measures allow to identify how easy it is to reach the rest of the network starting from an airport of origin, or which are the opportunity for interconnections that the airport offers (centrality) with the latter typically employed in order to measure performance of airline hub [10], [13], [15], [16], [17], [18]. In this paper only basic connectivity index is described and computed for the selected countries. For detailed overview of connectivity measures and suggested methodology see [2].

In brief, this index represents the average minimum number of flights required for a passenger to reach any other airport in the network. A connectivity index exactly equal to one would mean that an airport is connected by non-stop flights to all other European airports. For example, if there is a direct link between airport A and airport B, the shortest path length (SPL) between A and B is 1. On the other hand, if A and B are both connected to an intermediate point but not directly linked, their shortest path length is 2.

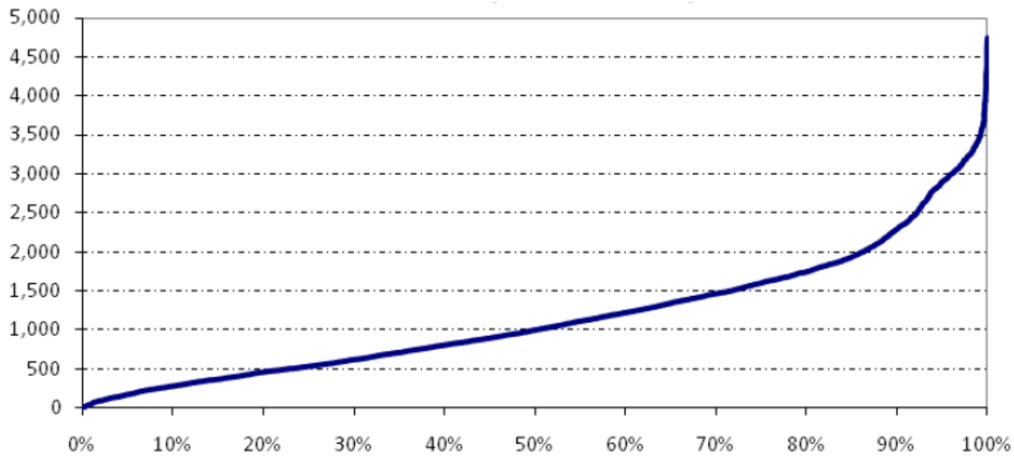

Figure 1: Distribution of 2010 European routes by distance (y-axis in km)

Source: adopted from [5]

The connectivity index of a specific airport (CI) is defined as the average of its Shortest Path Length (SPL) between airport *i* and all other airports *j* in the network of *n* accessible airports [5], [9]:

$$CI_i = \frac{1}{n-1} \sum_{j=1}^{n} SPL_{ij} \qquad (1)$$

Based on the SPL, the average simple connectivity index for the entire European airport network is 2.74 [5]. To calculate worldwide airport connectivity for SEE countries more than 24000 flown itineraries that meet MPM rules were taken into consideration. On average connectivity index for SEE countries shows better connectivity than one computed for EU-27. However, comparing individual connectivity indexes for the airports in SEE with the top connected European airports it is noticeable that high proportion of travel for top EU airports is realized with 1 or 2 connections, on the other hand for the airports in SEE journeys with 3 steps have relatively high proportion of overall travel (Table 2).

Table 2: Basic connectivity index

Airport	Connectivity Index	Step 1	Step 2	Step 3	Step 4	Step 5
Zagreb	2.42	2.00%	56.00%	41.00%	1.00%	0.00%
Belgrade	2.41	2.03%	56.98%	38.25%	2.66%	0.08%
Sarajevo	2.57	2.11%	45.79%	44.74%	7.26%	0.11%
Podgorica	2.23	3.31%	71.32%	24.08%	1.10%	0.18%
Skopje	1.84	20.00%	76.00%	4.00%	0.00%	0.00%
London Gatwick	1.83	26.40%	64.60%	8.50%	0.40%	0.00%
Amsterdam	1.84	27.80%	61.20%	10.60%	0.40%	0.00%
Dublin	1.86	27.40%	60.00%	11.80%	0.80%	0.00%
Paris Charles De Gaulle	1.89	25.00%	61.60%	12.60%	0.80%	0.00%
Barcelona	1.90	24.20%	63.00%	12.00%	0.60%	0.20%
Copenhagen	1.90	22.40%	66.70%	10.20%	0.60%	0.20%
Dusseldorf	1.90	23.00%	65.00%	10.80%	1.00%	0.20%
EU-27	2.74	4.50%	35.80%	43.80%	13.90%	1.80%

Source: SEE airports computed based on data available from AirportIS. Top 5 EU connected airport and EU-27 connectivity index for 2010 adopted from [5].

Malighetti et al. (2008) [8] show that more than 2-step connections account for less than 7% of all availbe connections in Europe, weighted by the offered seat of the linked airports.

The connectivity of an airport is an indicator of its relative position in the network it serves. A higher connectivity translates into a more favorable position, and therefore a higher competitive value with respect to other airports in the network [5]. Due to the fact that relativly high proportion of travel in SEE includes 3 and more steps, it is fair to assume that passengers starting trevel in one of the SEE countires has less opportunities to reach final destination with minimum number of steps, yet it is exposed to a network that has better connectivit for the market served than averagy EU-27 netwok. One of the reason is higher number of frequencies towards main europen hubs with well established network. Minimum number of steps for selected airports is shown in the Figure 2.

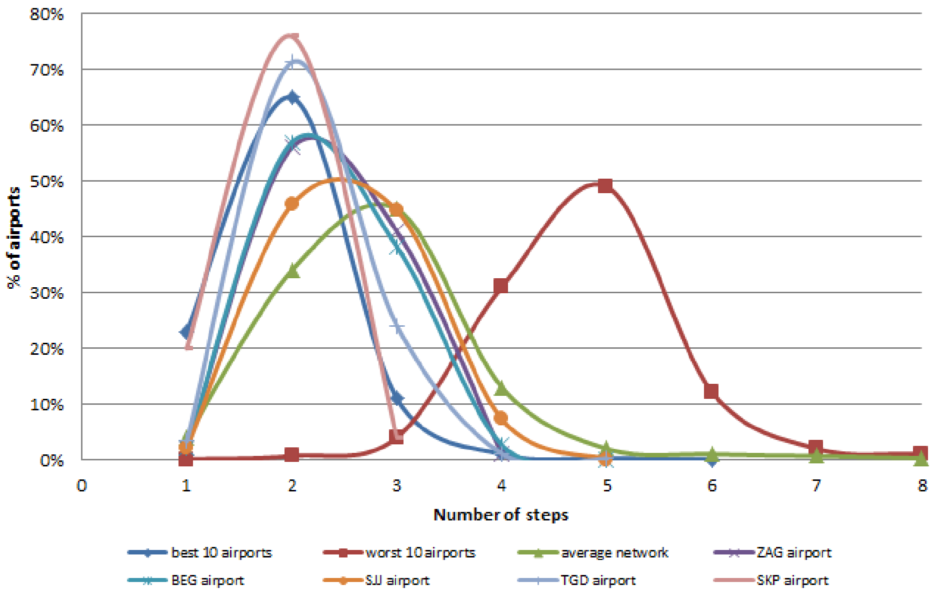

Figure 2: Minimum number of steps to reach the rest of the world

Source: ICCSAI, AirportIS and [6]

According to Eurostat, distribution of EU-27 air passenger transport in 2010 was; national 21%; extra-EU 38%; intra-EU 41% [19]. For the selected SEE countries majority of routes are intra-European, with exception of Croatia that also has some national routes (see Table 3).

Table 3: Summary of the scheduled flights offered by SEE countries

Country	No. of airports	Total routes (A)	European routes (B)	National Routes (C)	B/A	C/A
EU-27	496	13313	10575	2873	79%	22%
Croatia	8	205	203	20	99%	10%
Bosnia and Herzegovina	3	24	22	0	92%	0%
Macedonia	2	7	7	0	100%	0%
Montenegro	2	25	25	0	100%	0%
Serbia	2	49	49	0	100%	0%

Source: All data refer to 2010. EU-27 data computed based on [6], SEE data adopted from IATA AirportIS

Selection of routes and network development is subject to many factors, including but not limited to tourism activity, trade and Gross Domestic Product (GDP). In the UK businesses trade 20 times as much with Emerging Market countries that have a direct daily flight to the UK as they do with those countries that do not [20]. Same is applicable for the countries of SEE, majority of direct flights and passengers flown in 2010 are between SEE and their main trade countries (Germany, France, Austria, Russia, etc.).

Economic power and passenger mobility are directly related. While the relationship between passenger welfare and propensity to fly varies amongst the countries, according to UNTWO [21] in years when world economic growth exceeds 4 per cent, the growth of tourism volume tends to be higher. On contrary, when GDP growth falls below 2 per cent, tourism growth tends to be even lower. Income obviously has strong impact on economic power and therefore on propensity to fly [5]. For the SEE countries air mobility index is lower than the average EU-27 index, which means fewer flights per capita, due to lower welfare per capita. The only exception amongst the selected countries is Montenegro, with air mobility index of 1.72 flights per capita (Figure 3). For the last few years Montenegro has incremental growth in tourism arrivals, in 2012 travel and tourism direct contribution to GDP was 16.8% in terms of real growth [22]. For the next 10 years travel and tourism direct contribution to Montenegro's GDP is forecasted to 11.8% annual growth.

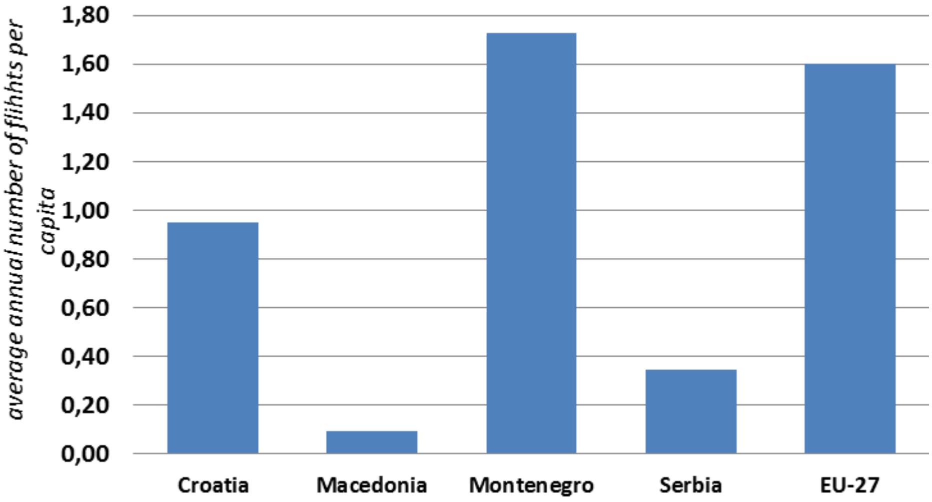

Figure 3: 2010 air mobility for SEE countries

Source: Eurostat, World Bank, IATA AirportIS

4 CONCLUSION

Liberalization of the air transport industry had positive impact on the development of the air transport network especially in terms of a hub-and-spoke system. Development of the network is usually measured through the connectivity index (basic that counts only number of steps passenger has to take to reach final destination, or more complex that is taking into consideration also temporal coordination as well as routing factor). IATA MPM is critical element for the routing factor and network definition as it limits absolute network to relative network taking into consideration maximum permitted mileage passenger can fly within a fare component.

Research on network analysis helps to understand diversity of air transport networks, airport competitive position and country or regional propensity to fly. Comparing with the EU-27 market, the selected countries of SEE have relatively small air transport market with limited number of direct flights, and high proportion of journeys that require at least 3 steps to reach final destination. Overall air mobility is lower than EU-27 market due to the lower economic power. However, as shown on Montenegro example, investments in travel and tourism sector even with low number of direct flight can improve air mobility and have positive and direct impact on the GDP.

The paper identifies key elements for the network analysis and determines current quality of network in the SEE region, based on the basic indicators.

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IMPACT OF LOW EMISSION ZONES ON AIR QUALITY – CASE MARIBOR

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ABSTRACT

Air quality, especially pollution by particulate matter (PM) is a serious problem in cities. Road traffic is its significant source. There are several approaches to cope with this issue. The most effective are access restriction schemes, but they cause a lot of resistance by residents and local economy. Low emission zones (LEZ) are well known measure, yet they have never been realized in Slovenia. In the year 2012 LEZ was implemented in the city of Maribor, causing some resistance, but also gaining support on the other hand. There are three major weaknesses of this approach: i) access restrictions affect only certain group of travellers and might be therefore recognized as discriminatory ii) relatively small impact on the general air quality, iii) impact on the city economy in the initial phases. The article shows some model calculations of needed measures to reach set goals.

Keywords: Access restriction, Low Emission Zone, Air Quality, Maribor

1 INTRODUCTION

1.1 Air quality and road traffic

Air quality, especially pollution by particulate matter (PM) is a serious problem in cities all over the world. Road traffic is its significant source. Slovenian cities are faced with the same problem. Official reports published by ARSO show that the air quality limit for PM daily values is exceeded in almost all Slovenian cities. General awareness of health risks caused by this problem, supported by fines foreseen by the legislation, triggered some activities in the city of Maribor. Therefore, the goal to improve the air quality by the reduction of emissions caused by road traffic by at least 30 % was set.

The contribution of different sources to PM concentrations in the ambient air was discussed a lot. A wide range of results can be found in published scientific papers and also professional publications. The main anthropogenic sources are always reported to be burning of fuels for heating purposes, road traffic, industry and construction. Their shares vary from year to year (according to local and regional anthropogenic activities) and from season to season (heating in winter). The current investigations of the PMinter project indicate that the average part of the airborne PM from road traffic in Maribor is at least 30%. Road traffic produces:

- exhaust PM emissions as a product of burning of fuel,
- non-exhaust PM emissions, produced by brake wear, road surface wear, tyre wears and

- resuspensions - the renewed suspension of precipitated PM due to vehicle speed, vehicle weight and aerodynamics.

The share of certain contributor is not always clear and can vary a lot. The preliminary results of the PMinter project, obtained by different research methods, indicate that the range of the exhaust PM emissions is between 10% and 30%.

1.2 Measures and its feasibility

Emissions from road traffic depend on vehicle speed, engine revs and load, driving mode, wear materials, fuel and lubricants, vehicle weight and aerodynamics, and road surface silt loading. To achieve some significant results, the measures should address all sources of pollution. Generally, the overall amount of road traffic must be decreased, the speed must be reduced and vehicles should improve their emission characteristics.

There are several approaches to cope with this problem. Access restriction schemes are the most effective, but they are causing a lot of resistance by residents and local economy. Restrictions can be implemented directly as hard (or physical) restriction or indirectly as charging scheme.

Low emission zones (LEZ) are well known measure for reduction of exhaust PM emissions, but have been never implemented in Slovenia, so there is no local or national practice available. There are three major weaknesses of this approach:

- Access restrictions are affecting only certain group of travellers and might be therefore recognized as discriminatory.
- Relatively small impact on the general air quality if the measures are implemented in a soft way with a lot of exceptions, limited area covered etc.
- Impacts on the city economy in the initial phases, requiring alternative supports.

Article is focused on the implementation of the low emission zones in Maribor, particularly on its impact on PM concentrations in the ambient air. Furthermore, it shows some model calculation of needed measures to reach significant impacts on air quality.

2 LOW EMISSION ZONE, PILOT PROJECT IN MARIBOR

In the year 2012, LEZ was implemented in the city of Maribor (MOM), causing some resistance but also gaining support on the other hand. All the vehicles not meeting the EURO 2 standard are not allowed to enter the LEZ on the working days (from Monday to Friday). There is a long list of exceptions like residents of LEZ, buses, all kinds of emergency and other important services. There is also a time block when all vehicles can deliver goods.

Figure 1 shows the area limited to old city centre on the left bank of Drava River, where the pilot LEZ was implemented in October 2012 (depicted as POC), and the planed enlargement of LEZ (described as “extended zone”).

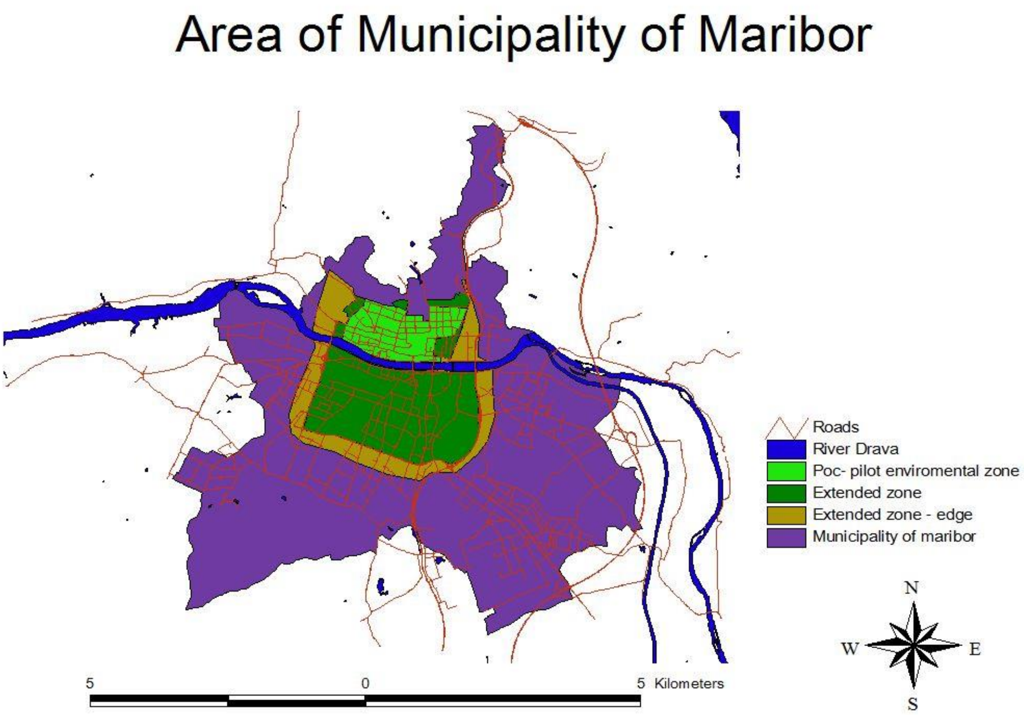

Figure 4: Low emission zone (LEZ) in Maribor; area of pilot implementation and planed enlargement

Source: (PMinter, 2012, [2])

As the base for all calculations, the base-year 2011 (the fleet structure from 31 December 2010) was taken into account. The structure of vehicle fleet is presented in the Table 1. Approximately 14% of all personal cars (PC) did not meet the threshold, but after exemptions were implemented, less than 10% of all private cars (PC) were affected by the measure. Among light and heavy duty vehicles (LDV and HDV) less than 5% of vehicles were affected. Buses and motorcycles were completely left out of restrictions.

Table 3: Structure of motorized fleet by EURO standards in the city of Maribor (Dec. 2010)

	Euro 0	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5+
Personal car	5,12%	9,06%	24,81%	32,37%	18,96%	9,68%
LDV	3,35%	3,98%	12,07%	32,27%	31,13%	17,21%
HDV	7,40%	5,74%	30,78%	22,21%	27,95%	5,91%
Bus	5,4%	4,9%	21,4%	27,2%	29,5%	11,6%

Source: (PMinter, 2012, [2])

Measured in vehicle-kilometres per year, the amount of affected traffic in the low emission zone (POC area) was around 10%. In the whole municipality of Maribor around 450 million vehicle kilometres are travelled per year, less than 10% of this amount is travelled inside of POC (and 10% of this were restricted) (Table 2).

Table 2: Vehicles-km per year by vehicle category in certain area (Maribor, 2011)

Area/type of vehicle	PC	LDV	HDV	BUS
POC	21.830.708	912.771	253.650	239.403
Extended cone	89.073.500	3.724.656	1.050.996	991.172
Extended cone + edge	106.763.032	5.683.360	5.885.585	676.680
Sum: MOM	411.760.648	21.228.830	17.831.115	3.740.419

Source: (PMinter, 2012, [2])

The implementation of LEZ described above has been a pilot project in a small area in order to:

- study the measures and their socio-economic impact and to
- raise the awareness for environmental problems caused by road traffic.

The goal to achieve significant impact on air quality was not really targeted. The prediction of impact according to HBEFA model was presented prior to implementation to stakeholders (Figure 2) [1]. The overall reduction of emitted particles caused by road traffic was predicted to be less than 10%.

Vehicle category	Restriction		Affected residents	Results (Extended zone)
Diesel	POC	Euro 0 Euro 1	2,5 % vehicles (84)	- 1 % of PM_{10}
	Extended zone	Euro 0 Euro 1	2 % vehicles (202)	- 3,5 % of PM_{10}
do 3,5 t	POC	Euro 0 Euro 1 Euro 2	20 % vehicles (223)	- 0,5 % of PM_{10}
	Extended zone	Euro 0 Euro 1 Euro 2	25 % vehicles (414)	- 2 % of PM_{10}
Nad 3,5 t	POC	Euro 0 Euro I Euro II	20 % vehicles (79)	- 0,2 % of PM_{10}
	Extended zone	Euro 0 Euro I Euro II	25 % vehicles (129)	- 3 % of PM_{10}
Bus	Extended zone		City public transport Maribor 10 buses euro II ⇩ 10 buses euro V	- 0,7 % of PM_{10} (reduction also outside of extended zone)

Figure 2: Impact of planed measures, the information for stakeholders

Source: (PMinter, 2012, [2])

3 IMPACT OF VARIOUS FUTURE SCENARIOS ON AIR QUALITY

Faced with the fact that restriction measures (like LEZ) should not have only demonstrative effect but must also reach the primarily set goal, several scenarios were developed. The purpose of these model calculations is to show the transport-policy decision makers the volume and list of measures needed to reach at least some significant impacts. The three scenarios were named as:

- Conservative
- Active
- Optimistic

Scenarios are named by the amount and effectiveness of accompanying measures, like improvement of public transport supply, closing of some streets in the city centre for private cars and transit, and similar.

3.1 Conservative scenario

The main characteristics of so-called “conservative” scenario are:

- LEZ characteristics:
  - The area is extended to the right bank of Drava River (“extended zone” according to Figure 1)
  - The threshold to enter LEZ is raised to EURO 3
  - The list of exemptions is slightly shorter
- Accompanying measures:
  - Extension of public transport by 15%

These measures are likely to be implemented in the year 2013. Several assumptions were taken into account, like:

- implementing assessment of expected impact on modal shift (5% of vehicle-km are shifted to public transport),
- implementing not appreciated, but realistic, re-routing (5% of all vehicle-km were shiftet around the LEZ in the so-called “extended zone – edge” zone),
- implementing the impact of renewing the fleet by 5% of new vehicles replacing the old ones each year.

The following results are expected:

Table 3: Conservative scenario, measures and impact, prognosis (Maribor, 2014)

Area	Restriction	Vehicle/km change	PM10 emissions change (HBEFA methodology)
Pilot environmental zone (POC)	Euro 0,1,2	-15 % (PC, LDV) + 15 % (Public transport)	-23,91%
Extended zone	Euro 0,1,2	-15 % (PC, LDV) + 15 % (Public transport)	-23,91%
Extended zone – edge	None	+2 % (PC, LDV) + 15 % (Public transport)	-4,52%
Other parts of Municipality of Maribor	None	+ 15 % (Public transport)	-6,25%
Municipality of Maribor		-3 % (PC) -2,2 % (LDV) +15% (Public transport)	-9,78%

Source: ([PMinter, 2012, [2])

The measures would cause the reduction of PM emissions by 24% in the city (POC and „extended cone“) and approximately 10% in the whole MOM.

3.2 Active scenario

The active scenario anticipates the same measures regarding the LEZ (geographical extension) but some extensive accompanying measures, like substantial improvement in public transport and restrictive measures for private cars in the city centre as well. The main characteristics of so-called “active” scenario are:

- LEZ characteristics:

- The area is extended to cover the right bank of Drava River
- The threshold to enter LEZ is raised to EURO 3
- The list of exemptions is much shorter

• Accompanying measures:
  - Extension of public transport by 30%
  - Extension of pedestrian zone, closing of several streets in the city centre
  - Raising the average price for parking and slight reduction of available parking spaces in the city centre
  - Introduction of P&R on the major three (to four) arterial roads

These measures are likely to be implemented in the year 2014. Several assumptions were taken into account, like:

• implementing assessment of expected impact on modal shift (15% - 50% of PC vehicle-km are shifted to public transport or other modes of travel),
• implementing the 15% of reduction of LDV vehicle-km,
• implementing the increase of 30% of vehicle-km by busses,
• implementing the impact of renewing the fleet by 5% of new vehicles replacing the old ones each year.

The following results are expected:

Table 4: Active scenario, measures and impact, prognosis (Maribor, 2015)

Area	**Restriction**	**Vehicle/km change**	**PM10 emissions change (HBEFA methodology)**
Pilot environmental zone (POC)	Euro 0,1,2	-50 % (PC) -15 % (LDV) + 30 % (Public transport)	-59,71%
Extended zone	Euro 0,1,2	-30 % (PC) -15 % (LDV) + 30 % (Public transport)	-48,81%
Extended zone – edge	None	-7 % (PC, LDV) + 30 % (Public transport)	-15,13%
Other parts of Municipality of Maribor	None	30 % (PC) + 30 % (Public transport)	-25,33%
Municipality of Maribor		-17,4 % (PC) -2,7 % (LDV) +30% (Public transport)	-28,55%

Source: (PMinter, 2012)

The measures would cause the reduction of PM emissions by 60% in the city centre (POC) and approximately 30% in the whole MOM.

3.3 Optimistic scenario

The optimistic scenario anticipates the extensive measures regarding the LEZ (geographical extension) and accompanying measures, like substantial improvement in public transport and restrictive measures for private cars in the city centre as well. The main characteristics of so-called “optimistic” scenario are:

• LEZ characteristics:

  - The area is extended to the right bank of Drava River
  - The threshold to enter LEZ is raised to EURO 4
  - The list of exemptions is reduced to emergency vehicles
- Accompanying measures:
  - Extension of public transport by 50%
  - Extension of pedestrian zone, closing of several streets in the city centre
  - Raising the average price for parking and slight reduction of available parking spaces in the city centre
  - Introduction of P&R on the major three (to four) arterial roads

These measures are likely to be implemented in the year 2015 if social acceptance is achieved. The following results are expected:

Table 5: Optimistic scenario, measures and impact, prognosis (Maribor, 2016)

Area	**Restriction**	**Vehicle/km change**	**PM10 emission change (HBEFA methodology)**
Pilot environmental zone (POC)	Euro 0,1,2,3	-80 % (PC) -40 % (LDV) +50 % (public transport)	-82,03%
Extended zone	Euro 0,1,2,3	-50 % (PC) -25 % (LDV) + 50 % (public transport)	-66,83%
Extended zone – edge	None	-15 % (PC, LDV) +50% (public transport)	-42,32%
Other parts of Municipality of Maribor	None	- 30 % (PC) - 15 % (LDV) + 50 % (Public transport)	-57,11%
Municipality of Maribor		-32,1 % (PC) -17,5 % (LDV) +50% (public transport)	-56,34%

Source: (PMinter, 2012)

The measures would cause the reduction of PM emissions by 82% in the city centre (POC) and approximately 56% in the whole MOM.

4 CONCLUSIONS

The city of Maribor implemented the measure “low emission zone” to reach at least three goals: to improve the quality of air, to raise the awareness for sustainable mobility and to reach the requirements set by European legislation. The intensity of implemented measures was too low to reach these three goals completely, but some evidences and experience were gathered.

It is obvious that significant improvements in the quality of air could be reached in short term only if the measure is implemented on bigger area, when thresholds are much higher than today and when the list of exceptions is much shorter than expected by the citizens. These might cause severe social and economic problems and resistance, therefore implementation of LEZ is acceptable only with accompanying measures (e.g. extension of public transport supply).

The results presented in this paper should serve primarily as support for the decision makers.

ACKNOWLEDGEMENT

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ASSESSMENT OF SOCIO - ECONOMIC LOSSES RESULTING FROM TRAFFIC ACCIDENTS IN THE FEDERATION OF BOSNIA & HERZEGOVINA

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ABSTRACT

The socioeconomic losses resulting from road accidents in FBiH have been calculated using the Gross output or Human Capital Method – a well recognized methodology used in many countries. This estimates the cost of administration, medical treatment of victims, property damage and the lost productivity of those killed and injured and includes an allowance for pain, grief and suffering. The purpose is to prepare an initial approximation of the costs of different types of road accidents and to use that to estimate the scale of annual economic losses being borne by the Federation of Bosnia and Herzegovina Given the current GDP of Federation Bosnia and Herzegovina, 14,161,972,692 KM in 2010), the total cost of accidents in the FB&H (823,8million KM (Euro 421 million)) represents approximately 5.8% of GDP in 2010.

Keywords: Traffic accident, economic losses, methodology, costs, casualty

1 INTRODUCTION

Cost analysis of road traffic accidents in the Federation of Bosnia and Herzegovina showed that the costs of deaths in traffic are very considerable. Socio - economic losses resulting from traffic accidents in the Federation were calculated using the gross output method or methods of human capital - a recognized methodology that is used in many countries. These are the estimated costs of administration, medical expenses, property damage and lost output/productivity of killed or injured, and includes compensation for pain, grief and suffering. Costs of material damage caused in a traffic accident are well understood, while the other losses (deaths and injuries) are much harder to assess and analyze.

It is often difficult to obtain the necessary data. However, comparison of the methods used in different countries show some similarities. For example, it is usually accepted as "sufficient" for estimating the costs of road traffic accidents, to use the average unit prices for different levels of road traffic accident /severity of injuries, e.g. death, serious physical injuries and minor physical injuries and / or fatal road traffic accidents, road traffic accidents with serious injuries, road traffic accident with minor severe injuries and traffic accidents with only material damage.

Analysis of road accidents costs in the Federation B&H shows that the costs of traffic deaths and injury are considerable. Table A shows the casualty costs for one fatal, one serious and one slightly injured person in traffic. Table B shows the costs of traffic accidents by type of accident, eg. the cost of each fatal, serious, slight and property damage only accidents.

Table A: Losses incurred for each traffic casualty[1] by severity

TYPE OF CASUALTY	COSTS
Death	BAM 273.416,00 (Euro 139.798,00)[2]
Serious injury	BAM 100.757,00 (Euro 51.517,00)
Slight injury	BAM 25.780,00 (Euro 13.181,00)

Source: (Costs of traffic accidents in FB&H)

Table B: Losses incurred for each Traffic accident by severity[3]

TYPE OF ACCIDENT	COSTS
Fatal Accident	BAM 371.913,00 (Euro 190.159,00)
Serious injury Accident	BAM 84.157,00 (Euro 90.180,00)
Slight injury Accident	BAM 32.225,00 (Euro 12.550,00)
Property damage only Accident	BAM 1.592,00 (Euro 814,00)

Source: (Costs of traffic accidents in FB&H)

Given the current GDP of Federation Bosnia and Herzegovina, 14.161.972.692 BAM in 2010), the total cost of accidents in the FB&H (823,8 million BAM (Euro 421 million)) represents approximately 5.8% of GDP in 2010.

2 PROGRAM OF THE STUDY

The valuation of accidents is controversial because life is too important to be valued in simple monetary terms. When given the choice of trading their lives for a sum of money, incurring added expenses to acquire safety devices or some other inconvenience to ensure an acceptable level of personal safety on roads, most people would choose to spend money or be inconvenienced.

The cost of accidents may consist of two components, often regarded as the coldblooded material cost and the warm-blooded willingness-to-pay component. Material costs may include damage to property, charges related to administration, fees for medical services, charges for hospitalization, and loss of productive work. The problem with determining accident costs is obtaining accurate relevant data for computation. The desire and the resulting willingness to pay the economic cost of reducing the risk are likely to be much higher than the material cost resulting from accidents. That explains why some developed countries adopt an ex ante method of estimation[4]. However, considerable difficulties are involved in estimating the willingness-to-pay component in developing countries, since extensive attitudinal surveys are required. Estimating the cost of traffic accidents involves two important steps:

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[1] Values presented here included a small allowance to reflect the admin costs plus property damage costs incurred in the accident that the victim was involved in. These values per casualty can be used in cost benefit analysis of proposed safety interventions which may deliver savings of casualties.
[2] 1 EURO = 1,9558 BAM
[3] The costs per accidents include the costs of the several casualties that may occur in an accident plus the additional accident related costs of property damage, administrative costs etc. associated with each severity of accident
[4] European Commission, *APAS - Methodologies for transport impact assesment*, Office for Official Publications of the European Communities, Luxembourg, 1996.

- identifying the cost components and
- placing a monetary value on each of these components.

To estimate the cost of road accidents in FB&H, the more conservative gross output method was adopted. This method is used in many countries and was recommended by the SweRoad team. The methodology was provided in the *Guidelines for Estimating the Cost of Road Crashes in Developing Countries*[5] supplied by the SweRoad project team.

3 COSTS COMPONENTS

The human capital method involves determining five cost components: property damage, administration costs, costs of medical treatment, lost output, and human costs. For most purposes, computing these from aggregate values obtained from summarized reports is sufficient.

3.1 Administrative costs in FB&H

Administrative costs include data on the average times spent in dealing with road accidents and their consequences, the cost of staff etc are contained within: Court and Prosecutor's Office (Preliminary charges and criminal proceedings), MIA (the cost of Police coming to the site, securing the site and inspections, the cost of the toxicological findings, etc.), Road administration (the cost of removal and storage of vehicles and staff) and Fire services (costs of vehicles and staff).

These costs are usually low compared to other cost components, such as damage to the vehicle. Within organizations that contribute to the administrative costs, it is necessary to explain and calculate how much money these organizations spend in dealing with the road traffic accidents. Appendix B outlines the detailed calculations and data used in estimating administration costs.

Table 1: Total administrative costs for FB&H by severity

INSTITUTION	FBiH TOTAL COSTS (BAM)
Police (MIA)	7.695.357,00
Fire Service	758.388,00
Courts and Prosecution	5.895.691,00
Directorate for roads	943.250,00
ADMINISTRATIVE COSTS	**15.292.686,00**

Source: (Costs of traffic accidents in FB&H)

Table 2: Administrative average traffic accidents costs by severity FB&H[6]

	FATAL	SERIOUS	SLIGHT	DAMAGE ONLY
ADMINISTRATIVE COSTS	13.500,00	2.160,00	1.350,00	270,00
Ratios	50	8	5	1

Source: (Costs of traffic accidents in FB&H)

[5] Babtie Ross Silcock, TRL *Guidelines for Estimating the Cost of Road Crashes in Developing Countries*, Department for International Development Project R7780, May 2003

[6] Babtie Ross Silcock, TRL *Guidelines for Estimating the Cost of Road Crashes in Developing Countries*, Department for International Development Project R7780, May 2003.

3.2 Damage to property in FB&H

For the purpose of appropriate and acceptable analysis for the needs of damage to the infrastructure assets of the categorized roads in FB&H, or determining the amount of damage costs of the road infrastructure in creating road traffic accidents, the data were collected from five cantonal authorities and six insurance companies, while data for other authorities and insurance companies are estimated.

Costs of damage to the infrastructure: The percentage of road traffic accidents in which damage to the road infrastructure occurred is 9.5%[7]. The average cost of one road traffic accident with damage to road infrastructure is about 880,80(BAM). In the Federation during the 2010, 2.720 road traffic accidents occurred with damage to road infrastructure. The costs of damage to road infrastructure are shown in Table 3.

Table 3: Cost of damage to road infrastructure

	Total traffic accidents	Traffic accidents with damage to infrastructure	Average damage costs (BAM)[8]	Total costs of damage to infrastructure (BAM)
TOTAL FB&H	28.506	2.720	880,00	2.395.776,00

Source: (Costs of traffic accidents in FB&H)

Table 4: The average costs of damage to infrastructure by accident severity

	FATAL	SERIOUS	SLIGHT	DAMAGE ONLY
DAMAGE TO PROPERTY 1	560	280	120	50

Source: (Costs of traffic accidents in FB&H)

Costs of property damage - data from insurance companies: Data on the total number of damaged vehicles, by type and category is made using a case study on a sample of 2.844 road traffic accidents occurred in FB&H in 2009.

Tables for calculating the average damage cost per vehicle for a road traffic accidents with serious and slight bodily injuries, as well as traffic accidents with material damage are given in Appendix C – *Costs of Traffic Accidents in FB&H*, (Tables C3, C4 and C5). Below is a table with the final calculation of the average costs of damage to the vehicle by severity of accident.

Table 5: Average damage costs per vehicle depending on the severity

	FATAL	SERIOUS	SLIGHT	DAMAGE ONLY
DAMAGE TO PROPERTY 2	10.548	9.187	2.108	790
Ratios	13,9	11,62	2,66	1

Source: (Costs of traffic accidents in FB&H)

Damage to property 2– data from car repair services: Based on the data collected, it is determined that where vehicles are not included in damages paid by insurance companies then the damage repairs were paid for by the owners themselves. This is not insignificant, and according to the indicators about 16.335 car owners repaired the damage to their vehicles in car repair services with an average value of about 1.000 (BAM). Damage costs of vehicles that are repaired by the owners themselves are shown in Table 6.

[7] Lindov O.; Omerhodžić A., Olovčić J., *Troškovi saobraćajnih nezgoda u FBiH*, *Apendix B*, Sarajevo, 2011.
[8] Lindov O.; Omerhodžić A., Olovčić J., *Troškovi saobraćajnih nezgoda u FBiH*, *Apendix C*,Sarajevo, 2011.

Table 6: Damage costs per vehicle repaired by the owners

	Traffic accidents	Number of vehicles repaired in auto services stations	Average damage cost (BAM)	Damage costs repaired in auto service stations (BAM)
TOTAL FB&H	28.506	16.535	1.000,00	16.535.000,00

Source: (Costs of traffic accidents in FB&H)

Table 7: Average damage costs per vehicles repaired by the owners

	FATAL	SERIOUS	SLIGHT	DAMAGE ONLY
DAMAGE TO PROPERTY 3	3.266	1.633	816	482
Ratios	6,28	3,39	1,69	1

Source: (Costs of traffic accidents in FB&H)

Table 8: Costs damage to property by severity of accident

	FATAL	SERIOUS	SLIGHT	DAMAGE ONLY
DAMAGE TO PROPERTY 1 (Infrastructure)	560	280	120	50
DAMAGE TO PROPERTY 2 (Vehicles, insurance paid)	10.548	9.187	2.108	790
DAMAGE TO PROPERTY 3 (Vehicle, owner paid)	3.266	1.633	816	482
TOTAL COSTS:	**14.374,00**	**11.125,00**	**3.044,00**	**1.322,00**

Source: (Costs of traffic accidents in FB&H)

3.3 Medical costs in FB&H

Medical costs of casualties in traffic accidents involve costs that range from those on the spot to recovery or death, and they include the first aid and emergency services (ambulance), hospital costs (food and bed, surgery, radiology, costs of doctors and medical staff) and rehabilitation costs (treatment and Prosthetics). These costs are direct medical costs; some of the costs are public while some of costs are private costs, and may be long-term costs depending on the type of injury. Increases of medical funds that become free after the reduction in the number of traffic accidents are very important. The main source for the assessment of medical costs include:

- Average daily hospital costs,
- Department of Public Health and
- General Hospitals.

The average hospital costs, with the average cost of beds are representatives of medical costs and they can often vary depending on the institution, i.e. whether it is the center of the state or local health center. Insurance companies may allow assessment of medical costs of traffic accidents based on their database. Private hospitals can provide information on costs, but this can be very indicative depending on the type of hospital and can vary widely. Private hospitals in developing countries may have better information on costs, but these data are not representative because the majority of casualties of traffic accidents are located in public hospitals.

Medical costs for one death= costs of coming to the site, transportation[9], hospital costs and funeral costs = 144,00 + 3.352,58 + 1.500,00 = 4.996,58 (BAM).

Medical costs for one seriously injured person in FB&H = costs of coming to the site + transportation + hospital costs (number of days is multiplied by the average daily cost) + outpatient cost + cost of rehabilitation and prosthetics (the number of days x average daily

[9] Lindov O.; Omerhodžić A., Olovčić J., *Troškovi saobraćajnih nezgoda u FBiH, Apendix D*, Sarajevo, 2011.

costs + average costs of prosthetic devices) = 144,00+3.440,80+1.500,00+1.314,33 = 6.399,13 (BAM).

Medical costs for one slightly injured person in FB&H = costs of coming to the site + transportation + medical treatment costs (number of days x average daily cost) = 1.144,00 (BAM).

Table 9: Medical costs of casualties by severity

	DEATH	SERIOUS INJURY	SLIGHT INJURY
(MEDICAL COSTS)	4.997,00	6.399,00	1.144,00

Source: (Costs of traffic accidents in FB&H)

3.4 Lost output

Lost output refers to the loss of productive capacity of the economy from those who are injured or killed in a traffic accident. These costs can range from one day for someone slightly injured to several decades of lost productivity for one killed or seriously injured. Appendix E presents details of data and calculations on lost output. The average age of death in traffic is 40 years. The average number of days of hospitalization for serious injuries is 11 days. The number of days spent in recovery at home for serious injuries is 30 days. An average number of hospitalization days for slightly injuries is 4 days. About 20% of the total number of slightly injured that are hospitalized remained at home recovering. Value of care compensation is 85.17 BAM per month. The number of days that the caregiver spent with the seriously injured person was 15 days. The average monthly gross wage per employee in B&H in 2010 amounted to 1.217 BAM per month, while the average net salary for that period amounts to 798 BAM per month. The average value of compensation for physical disability is 85,14 BAM per month. The average annual gross salary is 14.604 (BAM). (The average monthly gross salary in FB&H in 2010. is 1.217 BAM). Discount rate is 6,65%. The minimum retirement age is 65.

Table 10: Number of persons killed, serious injured and slights injured in traffic accidents

YEAR	DEATHS	SERIOUS INJURED	SLIGHT INJURED
2008	245	1.462	6.439
2009	209	1.246	6.108
2010	208	936	5.885
2010	251[10]	3.765[11]	15.060

Source: (Costs of traffic accidents in FB&H)

Lost output for one death= $$\sum_0^n \frac{w}{(1+r)^n} = \sum_0^n \frac{14,604}{(1+0.065)^n} = 192.741,79(KM) \qquad (1)$$

Lost output for one serious injury= [(11+4+30) x 1.217+(15 x 85,17)] = 56.042,50 BAM (2)

Lost output for one slight injury = (4+2+10) x 1.217= 19.472,00 BAM (3)

[10] Federalni zavod za statistiku FBiH, Statistički godišnjak/ljetopis FBiH, Sarajevo,2010.
[11] Babtie Ross Silcock, TRL Guidelines for Estimating the Cost of Road Crashes in Developing Countries, Department for International Development Project R7780, May 2003.

Table 11: Lost output per traffic casualty per severity (BAM)

	DEATH	SERIOUS INJURY	SLIGHT INJURY
LOST OUTPUT	192.742,00	56.043,00	19.472,00

Source: (Costs of traffic accidents in FB&H)

3.5 Human costs

The human costs[12] are not exact and are difficult to define precisely and are related to the pain, grief and suffering due to loss of human life in the traffic and all those associated with the persons who were killed or injured in traffic. The values of the human costs given in the international guidance[13] provided are as follows:

28 % total human costs for death,
50 % total human costs for serious bodily injuries and
8 % total human costs for slight bodily injuries.

Table 12: Human Costs traffic accidents per casualty[14]

	DEATH	SERIOUS INJURY	SLIGHT INJURY
HUMAN COSTS (BAM)	55.367,00	31.221,00	1.649,00

Source: (Costs of traffic accidents in FB&H)

4 TOTAL COST OF ROAD TRAFFIC ACCIDENTS IN FB&H

The overall objective of the project is to estimate the total annual costs of road traffic accidents. The costs of road traffic accidents involve incidents or costs that are related to accidents, property damage and administrative costs, and expenses related to the victims such as lost outputs and medical costs of the victims injured in road traffic accidents.

4.1 Component costs for casualties and accidents by severity

These are calculated from individual costs outlined in earlier chapters and the appendices – *Costs of Traffic accidents in FB&H.*

Table 13: Average cost per traffic accident by severity (Administrative costs and Property damage costs)

Costs components	Fatal	Serious Injury	Slight Injury	Property Damage Only
1. ADMINISTRATIVE COSTS	13.500,00	2.160,00	1.350,00	270,00
2. PROPERTY DAMAGE	14.374,00	11.125,00	3.044,00	1.322,00
TOTAL	**27.874,00**	**13.285,00**	**4.394,00**	**1.592,00**

Source: (Costs of traffic accidents in FB&H)

[12] Regional Road Safety Program: Singapore, *Accident Costing Report*, ADB 2002.
[13] Road Safety Guidelines, *ADB*, 1999.
[14] Babtie Ross Silcock, TRL *Guidelines for Estimating the Cost of Road Crashes in Developing Countries*, Department for International Development Project R7780, May 2003.

Table 14: Average costs per casualty by severity (Medical costs, Lost output costs and Human costs)

Costs components	Death	Serious injury	Slight injury	Property Damage Only
1.MEDICAL COSTS	4.997,00	6.399,00	1.144,00	--
2.LOST OUTPUT	192.742,00	56.042,00	19.472,00	--
3.HUMAN COSTS	55.367,00	31.221,00	1.649,00	--
TOTAL	**253.106,00**	**93.662,00**	**22.265,00**	

Source: (Costs of traffic accidents in FB&H)

Table 15: Average Casualties involved in different severities of traffic accident (2010)

Casualties / Accident category	DEATH	SERIOUS INJURY	SLIGHT INJURY	Total casualty
Fatal accident	1,24	0,27	0,22	1,73
Accident with serious injury	-	1,62	0,51	2,13
Accident with slight injury	-	-	1,25	1,25

Source: (Costs of traffic accidents in FB&H)

Table 16: Average medical costs per different severities of casualties and accidents

Per casualty cost		Accident severity					
		Fatal		Serious		Slight	
		Number of casualties per accident	Total cost	Number of casualties per accident	Total cost	Number of casualties per accident	Total cost
Death	4.997,00	1,24	6.196,00	-	-	-	-
Serious	6.399,00	0,27	1.728,00	1,62	10.366,00	-	-
Slight	1.144,00	0,22	252,00	0,51	583,00	1,25	1.430,00
Total costs			**8.176,00**		**10.949,00**		**1.430,00**

Source: (Costs of traffic accidents in FB&H)

Table 17: Summary of Average component by severity of accident

Accident severity	Accident related costs		Casualty related costs			Average costs per accident
	Property damage	Administration	Lost output	Medical cost	Human costs	
Fatal accident	14.374,00	13.500,00	258.415,00	8.176,00	77.448,00	371.913,00
Serious accident	11.125,00	2.160,00	100.721,00	10.949,00	51.419,00	176.374,00
Slight accident	3.044,00	1.350,00	24.340,00	1.430,00	2.061,00	32.225,00
Property damage only	1.322,00	270,00	-	-	-	1.592,00

Source: (Costs of traffic accidents in FB&H)

Table 18: Damage costs incurred by Severity of accident

Accident severity	Number of accidents	Cost per accident	Total Cost
Fatal	167	14.374,00	2.400.458,00
Serious	1,051	11.125,00	11.692.375,00
Slight	3,600	3.044,00	10.958.400,00
Damage only	23,688	1.322,00	31.315.536,00
TOTAL			56.366.769,00

Source: (Costs of traffic accidents in FB&H)

Table 19: Summary average component costs by severity of casualty

	Accident related costs[15]		Casualty related costs			Average costs per casualty including accident related costs	Average costs per casualty excluding accident related costs
	Property damage	Administration	Lost output	Medical cost	Human costs		
Fatal	9.831,00	10.479,00	192.742,00	4.997,00	55.367,00	273.416,00	253.106,00
Serious	6.101,00	993,00	56.043,00	6,399,00	31.221,00	100.757,00	93.663,00
Slight	2.435,00	1.080,00	19.472,00	1.144,00	1.649,00	25.780,00	22.265,00

Source: (Costs of traffic accidents in FB&H)

4.2 Calculating national losses to the economy

In 2010, FB&H Police reported 208 deaths and further 43 were reported by hospitals giving a total of 251 road deaths. In addition, police reported 936 serious injuries and 5,885 slight injuries. It is recognized worldwide that police can only ever record the accidents that are reported to them and many motorists choose not to report accidents and even injuries to police authorities. Consequently under reporting of road accidents and casualties occurs in most countries and research has been often done in countries to estimate the level of under reporting so that adjustments can be made when the losses to the National economies are calculated.[16] No research has been undertaken on such issues in FB&H so there is no way to establish the true level of under reporting in FB&H. In the interim, until more reliable research can be taken of such issues, international experience can be used to estimate the likely true numbers of injuries in FB&H. The guidelines on accident costing indicate that internationally it has been found that for every 1 person killed, there are typically 15 people who will be seriously injured and around 60 or more persons who will be slightly injured. For the purposes of this costing exercise, these ratios will be used in estimating the socio economic losses resulting from road accidents in FB&H. The average costs of each casualty are multiplied by the estimated numbers (allowing for under reporting) of casualties and to those costs are added the losses incurred from the accident related costs (administration and property damage). We know that the real damage cost will actually be higher since unreported accidents will also have resulted in some damage. This provides a conservative assessment of overall annual losses due to road accidents. Although there also have been many damage only accidents that were not reported to Police, at least some of the losses related to those have been included in the data collected from insurances and repair services. Table 20 below shows the estimated losses in FB&H.

Table 20: Estimated total Cost of Road accidents in FB&H (2010)

Severity	Estimated number[17]	Average cost (BAM)	Total costs (BAM)
CASUALTY RELATED COSTS			
Death	251	253.106,00	63.529.606,00
Serious injury	3.765	93.663,00	352.641.195,00
Slight injury	15.060	22.265,00	335.310.900,00
Total Casualty Costs			751.481.701,00

[15] European Commission, A Set of Guidelines for socio-economic cost-benefit analysis of transport infrastructure project appraisal, New York and Geneva, 2003
[16] Lindov, O.; Sigurnost u cestovnom saobraćaju, Fakultet za saobraćaj i komunikacije, Univerzietat u Sarajevu, 2008.
[17] Federalni zavod za statistiku FBiH, Statistički godišnjak/ljetopis FBiH, Sarajevo,2010.

ACCIDENT RELATED COSTS: (1) Administrative Costs			
Fatal	167	13.500,00	2.254.500,00
Serious	1.051	2.160,00	2.270.160,00
Slight	3.600	1.390,00	5.004.000,00
Damage only	23.688	270,00	6.395.760,00
Subtotal 1: Administrative Cost			15.924.420,00
(2) Property Damage Costs			
Fatal	167	14.374,00	2.400.458,00
Serious	1.051	11.125,00	11.692.375,00
Slight	3.600	3.044,00	10.958.400,00
Damage only	23.688	1.322,00	31.315.536,00
Subtotal 2: Property Cost			56.366.769,00
Total Accident Costs			72.291.189,00
TOTAL ESTIMATED LOSSES			823.772.890,00 (Euro 421 million)

Source: (Costs of traffic accidents in FB&H)

Table 21: Socio-economic Losses as percentage of GDP

GDP in 2010	BAM 14.200,00 million
Estimated Losses	BAM 823,8 million (Euro 421 million)
% of GDP	5,8%

Source: (Costs of traffic accidents in FB&H)

5 CONCLUSION

This study shows that the national economic losses resulting from road accidents in Federation of Bosnia and Herzegovina are very high, even if the conservative human capital method is employed in estimating the losses. As presented, in 2010, the total national economic loss resulting from road accidents is estimated at 823,8 million (Euro 421 million), or approximately 5.8% of the gross domestic product in 2010.

Based on this estimated annual road accident cost, it can be said that road accidents are now, one of the most severe health problems in FB&H, these accidents do not cause only losses in lives of productive members of the population and a substantial number of disabilities and injuries but also generate a huge annual losses to the country’s economy.

Reducing such economic losses requires all government institutions to participate in reducing casualties and to invest in improvement of road safety.

The losses resulting from traffic accidents should motivate all the relevant institutions and political leaders to begin more serious implementation of traffic safety on the roads for the benefit of society as a whole.

We strongly urge all parties concerned to use these estimates to persuade the Government to be more proactive in promoting road safety and the allocation of resources, especially financial resources, in order to alleviate this serious problem of deaths and injury to persons.

The calculated costs for individual casualties and accidents can be used for cost benefit assessments of proposed safety schemes and interventions.

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[4] European Commission, *APAS - Methodologies for transport impact assesment*, Office for Official Publications of the European Communities, Luxembourg, 1996.

[5] Federalni zavod za statistiku FBiH, *Statistički godišnjak/ljetopis FBiH*, Sarajevo,2010.

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AUTOMATIC GENERATION OF RAIL TIMETABLES USING A DETAILED INFRASTRUCTURE MODEL

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ABSTRACT

The timetable represents a key element for the competitiveness of railways, since it allows exploiting the existing networks at their maximum. To support timetable planners in meeting the variety of requirements given by operators and customers, since the early 90s a rich literature has appeared, which deals with the automatic or semi-automatic definition of optimal timetables. Despite of the wide literature, few models have been tested and used under real conditions.

This work presents a model for the automatic generation of optimal timetables, which is based on a mesoscopic infrastructure, which allows a significantly higher accuracy compared to the macroscopic models used in most scientific work. The model considers all signals in lines and stations, while the layout of stations is simplified in the switch areas.

The running times for all train routes are estimated by solving the motion equation; therefore running times and time-losses are calculated with the same detail enabled by simulation models and the headway times and the conflicts on lines and stations are automatically derived from the blocking times.

The timetable is generated using a heuristic solution to solve a multicommodity flow model. In order to maximize the accuracy in the definition of the timetable, various parameters can be defined for each train, including the buffer times, the priority and the allowances.

The model is applied to the rail network of the North-East of Italy, with over 600 km of lines and 60 stations, among which the large junction stations in Venice and Verona.

Keywords: railway, timetable, multicommodity flow model, mesoscopic infrastructure

1 INTRODUCTION

This work presents a heuristic solution approach to the Train Timetabling Problem (TTP) for large-scale railway networks when they are described at mesoscopic level.

The TTP is an NP-hard problem that aims at determining, for a given set of trains, the arrival and departure time at each of the stations the train visits along its route (see, e.g., [1]). The timetable represents a key element for the competitiveness of railways, since it allows exploiting the existing infrastructures at their maximum. In the recent years, the importance of an optimal usage of these infrastructures is, if possible, even increased due to the progressive deregulation of the market. Different operators are now competing for the access to the same generally scarce resources and many conflicts may arise [2] and must be solved through a sensible timetabling.

This work presents a large-scale application of the heuristic solution approach to a multicommodity flow model.

The key for high-quality timetabling is a precise estimation of blocking times based on realistic running, dwell and headway times taking into account the signal spacing and train processing at critical route nodes and platform tracks [3]. For these reasons we provide to our timetabling procedure a mesoscopic description of the infrastructures of the railway network of interest. Such a description allows a significantly higher accuracy compared to the macroscopic models used in most scientific work. Specifically, a mesoscopic description allows a realistic estimation of the headway times and of the conflicts on lines and stations as well as a calculation of running times and time-losses performed with the same detail enabled by simulation models. In order to maximize the accuracy in the definition of the timetable, various parameters can be defined for each train, including the buffer times, the priority and the allowances.

The model is applied to the rail network of the North-East of Italy. It is tested under different realistic demand conditions, for example considering an increase of the demand for freight slots or a different structure of regional services. Moreover, it is used to obtain a rough estimate of the maximum capacity for freight trains combined to fixed passenger services and the effects of infrastructure improvements.

In addition, the limits of the mathematical modeling of a complex system and the consequent difficulties of introducing decision support system in the real word operations are discussed.

The first section describes the infrastructure model used by the timetabling algorithm, which is presented in the following one. Third, the first results of a large-scale application in the North-East of Italy are discussed. A final paragraph draws some conclusions and possible improvements to the algorithm.

2 INFRASTRUCTURE MODEL AND IMPLEMENTATION

Choosing the right detail to represent the infrastructure and train dynamics is a key factor in train timetabling. In fact, macroscopic models may lead to a by far simpler network structure while, on the other hand, the microscopic ones may be require too much computation time, although they lead to a more precise estimation of the behaviour of trains on lines and therefore to a more precise allocation of the existing capacity.

Compared to a macroscopic model, in which stations are represented in a simplified way and fixed running times are used, a microscopic model appears significantly more accurate in the estimation of some key parameters used in timetable planning:

a) Running times take into account the speed profile of the train, also including low-speed alternative routings within stations
b) Within the stations, the blocking time of each switch is estimated, enabling a reliable representation of traffic conflicts.
c) On the lines, the blocking times are considered instead of the more simplified headway times.

Most algorithms that solve the TTP problem are based on a macroscopic model, while some others, such as [4] and timetabling tool DONS [5], already mentioned in the previous section, introduce a two-level approach. They use a macroscopic model to create draft timetable that will subsequently be checked for feasibility on a microscopic level for the principal station areas of the country. In any case, none of the two works consider the blocking times.

In order to combine the advantages of micro and macroscopic models some authors proposed algorithms for an automatic generation of a macroscopic model based on the corresponding microscopic one [6].

In the same framework, a microscopic model less detailed than the conventional ones was used Caimi [7] to represent the station areas.

In this work a mesoscopic model is introduced. It includes most of the accuracy of a microscopic model, but it also maintains a reasonable complexity. Its aim is to allow the generation a network-wide timetable in a reasonable time without the necessity of resorting to two-level approaches -level approach. Similarly to the macroscopic models, the network is rigidly separated into stations and line sections.

The station features of our mesoscopic model are the following:

- the station tracks, which include their real length, speed the stop position for different train lengths as well as the presence of a platform for passenger service.
- The line tracks of the lines converging to the station, the distant and home signals at their distance from the station building; they include their aspects. The home signals belong to the station, while the distant ones are used to estimate the route occupation times.
- A switch region at each side of the tracks (except, of course, the dead-end stations): each line is connected to all tracks; a set of matrices contains the possible and impossible routes and their compatibility. Figure 1 compares a mesoscopic model of a station vs. a microscopic one.

The line features of our mesoscopic model include all signals, the speed limits, the gradients and the curve radii.

The running time of each train is calculated by solving the motion eqation, considering the exact train routing and signaling system as well as the characteristics of the rolling stock. Together with the running time on the default track, also the running times within each station of all possible routings are calculated.

The running times on each line section and within each station are stored separately for each train: therefore, when the software tool changes the track assigned to a train, or inserts an additional stop, the corresponding time-loss is added to the running time of the train.

Within the stations the blocking times estimated on the mesoscopic model are also used as input for the timetabling algorithm. Differently, on the line sections blocking times are represented in a simplified way by means of two parameters: a headway time before each train and a headway time after each train. The former represents the mean blocking time before the train, while the latter includes the time a train physically occupies a section.

The result is model in which the running times are estimated with the same accuracy of the microscopic ones, while the blocking times and the definition of conflicts appears slightly simplified.

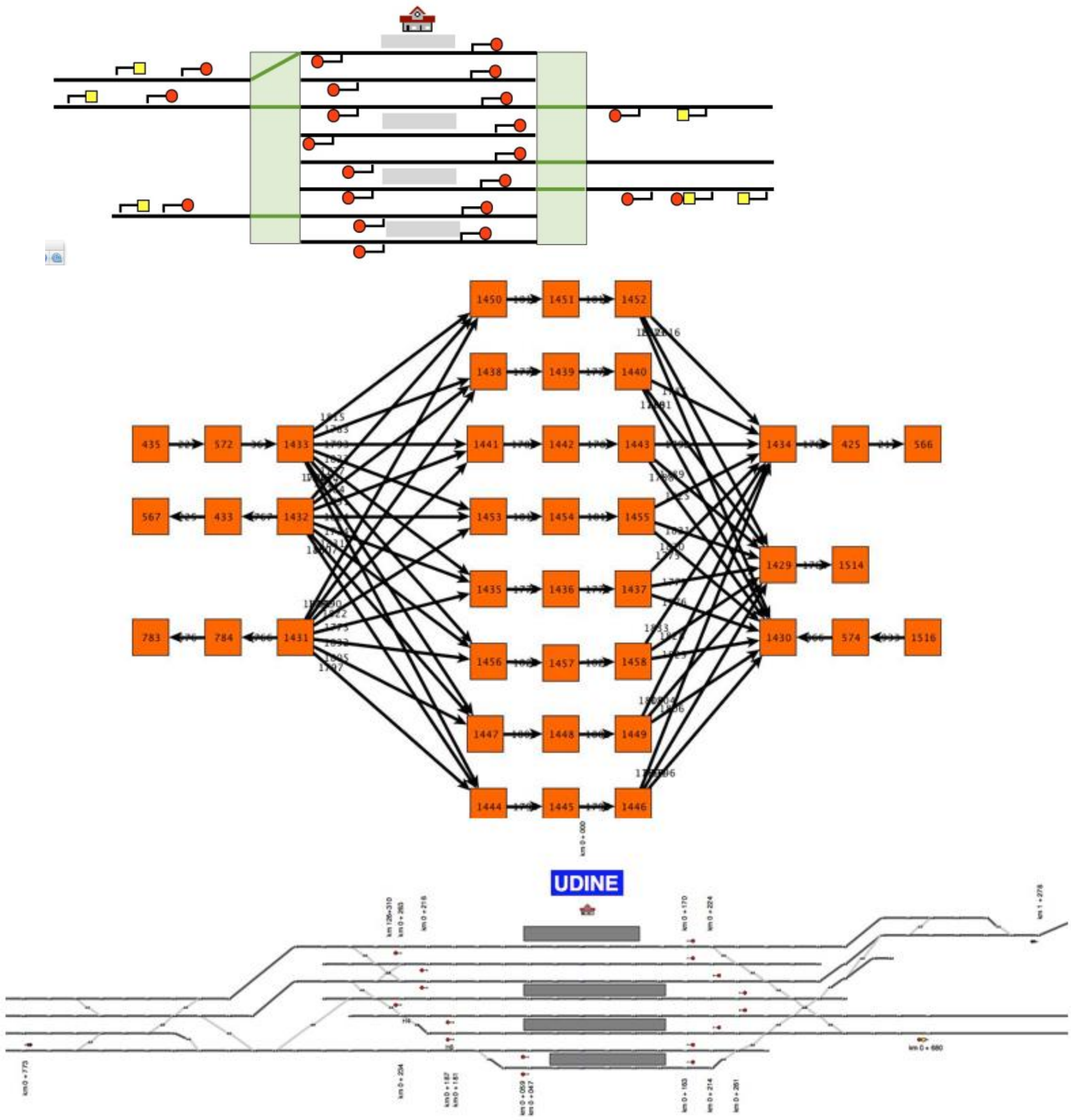

Figure 1: Drawing and corresponding mesoscopic graph (above) and microscopic model of a station

Key factors for the acceptance of a software tool such the Timetable Planning Software (TTPSW) are its perceived usefulness and the perceived ease of use. Within this framework, the final user, i.e., the timetable planner should not feel losing the control of the planning operations in a domain where he assumes to have some critical informal knowledge that cannot be easily transferred to an information system. In addition, as in a real environment the criteria defining the optimality of a timetable are often quite fuzzy, the final user should also be able to influence the structure of the timetable that the TTPSW picks up among the feasible ones.

Given the above considerations, we opted for the development of a software tool which, on one side, is able to deal with all the information that a mesoscopic model can provide, on the other side, provides its solutions quickly and whose working mechanisms are easily understood by the final user.

The aim of TTPSW is to allow the planner to iteratively generate different timetables in a reasonable time in order to assess them also in the light of the of its informal knowledge and to provide new (or different) constraints and objectives to the TTPSW for the generation of a new round of timetables. The algorithm is described in detail in [8].

The output of the TTPSW is a complete timetable for each train of the families in *C* that TTPSW has been able to schedule. Specifically, the software reports the arrival time, the departure time, the platform and the route of the train in each station, junction or halt that the train visits along its line.

3 CASE STUDY: NORTH-EAST ITALY

The first large-scale tests of the tool were performed on the railway network of the North-Eastern part of Italy. This network includes a total of 10 lines, both single and double-track, with over 120 stations, junctions and stops. The largest station included is the main station of Venice. The main station of Venice is a terminal one with 20 platforms and up to 44 train movements/hour excluding the shuntings. Venezia Santa Lucia is connected by two double track lines to Venezia Mestre, where five double-track and a single-track line diverge.

The hourly services on the network are represented on the map in Figure 2.

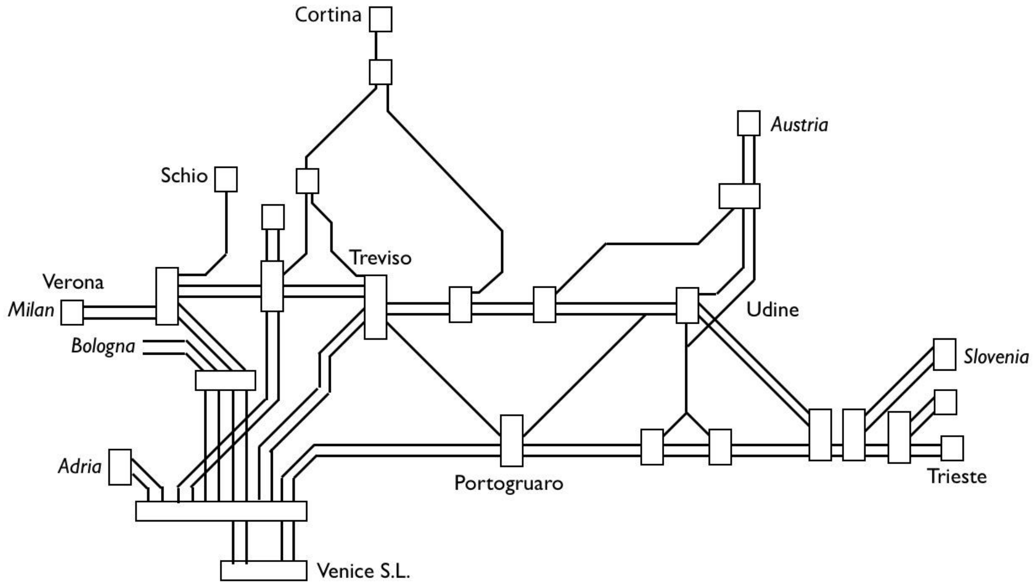

Figure 2a: Rail network of North-Eastern Italy

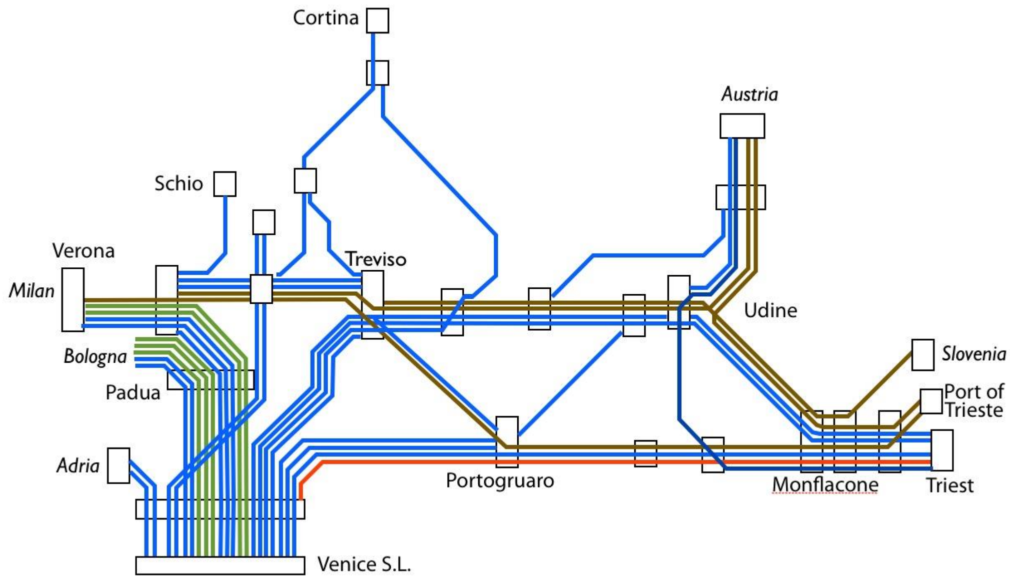

Figure 2b: Hourly schedules services on the study area

The tests were carried out in accordance with the main aim of the tool, which was not primarily to create the optimal timetable, but to obtain a realistic draft to be used as input for operational studies.

Therefore the tests aimed both at benchmarking the performances of the algorithm in a realistic context and at evaluating the quality of its outputs, especially in terms of applicability of the timetable structure (such as the sequence of trains and the connections).

In order to test the feasibility and the quality of the timetables created by TTPSW, they were first analysed qualitatively. Specifically, it was assessed whether the distribution of service in the period appears realistic in terms of:

a) Sequence of fast and slower services;
b) Headway times between similar services (As an example it was chcked ., if when there are two similar services each hour, they are separated by 30');
c) Position of the freight slots;
d) Location of overtaking between passenger and freight trains.

Table 1 shows the time performance of the TTPSW, it reports the time required on a standard PC featuring a 2.5 GHz Quad-Core Intel i7 to create some test timetables. They are described by their key characteristics: the number of train groups and the number of lines.

The computation times appeared very low in all test cases (under 6'). However, multiple testes were required to estimate a set of parameters – in both absolute and relative terms - that lead to a realistic timetable structure and infrastructure utilization. Coherently with the operating principle of the algorithm, an inappropriate set of parameters results in a timetable with too long running time margins at some trains or with some missing trains and not in long computational times.

After this initial parameter tuning session., tests were carried out starting with the eastern part of the case study area, between Venice and the border with Slovenia. The passenger services on these 7 lines are scheduled in about 2', inserting all trains and defining a realistic timetable structure and platform assignment. With a low increase in the computational time, but a more careful estimation of the parameters also the freight services are scheduled, thus leading to the saturation of the Monfalcone – Triest line section.

In a third test the frequency of some services was lowered to two hours, hence doubling the number of freight slots in these hours. A fourth test was also performed. It is slightly but significantly different form the third one. It included freight services in one direction only. The aim of this test was to reproduce a frequent condition for freight services, which show non-symmetric flows in the different parts of the day.

A fifth, test was performed on the western part of the network, gradually inserting multiple respective constraints between trains to model connections in Verona and Padua. Figure 4 shows the results on the Venice – Verona line. The results of the tests were visualized in a graphic interface based on the mesoscopic model and therefore representing the blocking times on the timetable graph. This scenario was improved inserting the (real) constraint that fixes the departure and arrival of most high-speed services, whose timetable in Venice is defined starting from the arrival/departure slots in Milan and Rome and therefore can't be modified. The algorithm modelled correctly also this scenario with an increase of a few seconds in the computation time.

In the last tests the second and fourth scenarios were combined, obtaining a timetable draft of the entire network in about 5', including the platform assignment of all services in Venezia S.Lucia, the critical point of the entire network. The computation time for the last scenario, which included all constraints and mono-directional services of tests 4 and 6 was lower that 6'.

In seventh and eighth the second and fourth scenarios were combined, obtaining a timetable draft of the entire network in about 5', including the platform assignment of all services in Venezia S.Lucia, the critical point of the entire network. The computation time for the last scenario, which included all constraints and mono-directional services of tests 4 and 6 was lower that 6'.

Finally, the algorithm as network saturation tool was tested, inserting the maximum number of freight trains on fixed passenger services. The tool was able to insert the same number of freight services considered as maximum capacity by the Infrastructure Manager, confirming the its potentials for quick timetable – related capacity estimations.

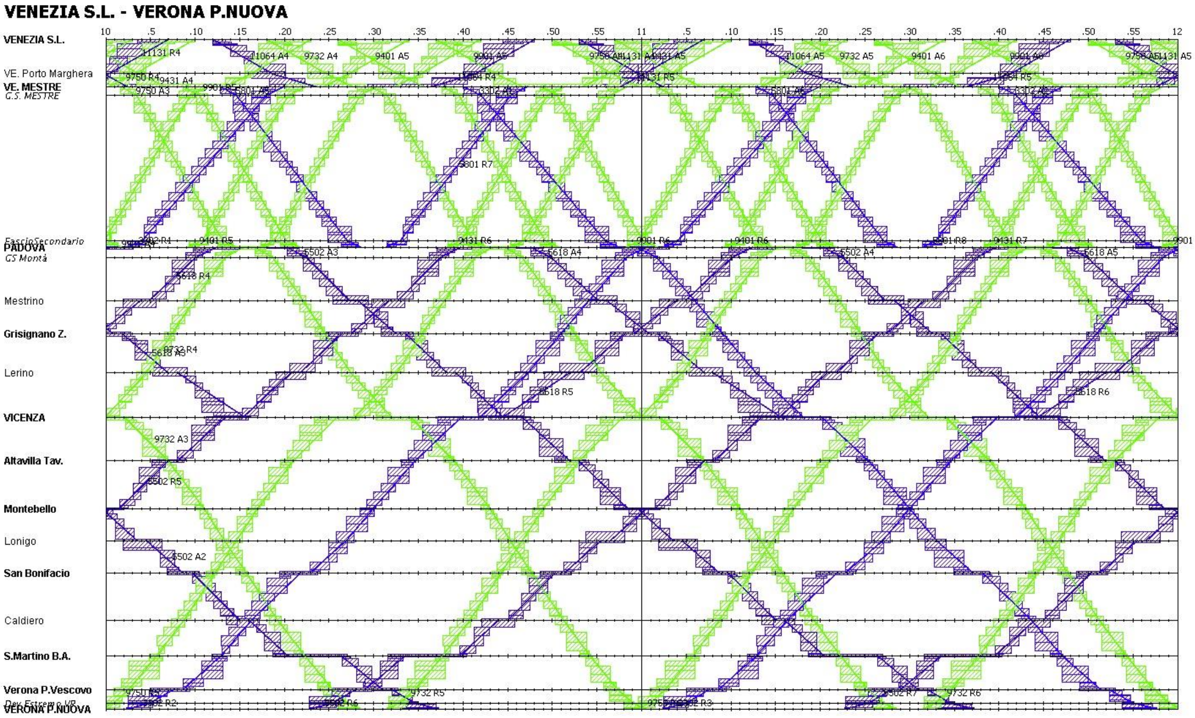

Figure 3: Graphic timetable of the Venezia – Trieste line, created by the TTPSW and simulated.

Table 1: Key characteristics of the tests

	Test	N of Train Groups (each direction)	Computation Time [s]	Differences from manual scheduling
1	All passenger services on the eastern part	14	127	No
2	All services on the eastern part (all hourly)	18	143	No, relatively sensitive to parameters
3	All services on the eastern part (freight services at alternate hours)	22	157	No, but quite sensitive to parameters
4	All services on the eastern part (different freight services east- and westbound)	22	154	No, but quite sensitive to parameters
5	All services in the western part	20	196	position of two stopping services
6	All services in the western part, including fixed departure to some High Speed services	20	217	No
7	All services on the network (Test 2+5)	39	298	No
8	All services on the network (Test 4+6)	43	354	No
9	All passenger services on the eastern part (fixed), saturation with freight services	27	163	No

4 CONCLUSIONS

The importance of precise timetabling is increasing, since it allows an optimal use of the existing infrastructures. This work presents a heuristic solution approach to the Train Timetabling Problem (TTP) for large-scale railway networks when they are described at mesoscopic level.

This intermediate detail level compared to most models proposed in literature allows a favorable balance between the computational effort required to solve the problem and the accuracy of the results.

The algorithm that solves the TTP and the others used for estimating the running- and blocking times were implemented in a tool, which was successfully applied to the rail network of the North-Eastern part of Italy, in order to estimate it applicability under real conditions.

The tests showed that the model is able to compute realistic solutions for the entire network in a few minutes: the position of the slots on the timetable graph appears similar to that used in the timetable created by practitioners.

The promising results obtained in the first large-scale tests foster further improvements to the algorithm and the whole approach, in order to make it more reliable and understandable for practitioners, especially concerning the selection of the constraints and parameters.

The method used to estimate mean blocking times on line sections will be improved, while its effective accuracy will be estimated, especially considering longer distances between stations.

Results obtained in the most used part of the network will be compared to micro-simulation in order to estimate the difference between micro- and mesoscopic models in terms of blocking times and conflicts effectively considered.

Tests will be carried out also on larger networks, in order to extend the benchmarks, estimating the maximum network size that can be considered in a single step and in a reasonable time. While all mentioned improvements appear relevant in order to benchmark the quality of the results their applicability to very large networks, the most extensive tests will be carried out in order to find some general rules that allow defining the parameters and constraints that lead to a realistic timetable structure.

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THE PROBLEMATICS OF INTERCONTINENTAL PASSENGER TRANSPORT BY AIR

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ABSTRACT

In a globalized world and with the increased urge to travel across continents, intercontinental flights have become more and more common with a high yearly increase. A quick look back in time show us several technological steps. At the beginning, transcontinental flights with hydroplanes sold very expensive fares. The first technological step was the economy of scale as flying became a product of mass consumption. In the 60's the Boeing 747 revolutionized intercontinental fares. At the same time the Concord covered the Paris – New York liaison in less than 3h45.
The last technological revolution comes as s social revolution. The late 90's and early 2000's saw the appearance of low cost airlines. Their philosophy was to cut costs as to reduce fares to a minimum.
With the development of the Airbus 380, intercontinental low cost concept seem to have reached feasibility but only extremely few intercontinental low cost exist, and none of them have the A380. Is this model possible at all? What would be the future of intercontinental aircraft tendencies? The author will analyzes and compare the "mammoth" vs smaller and more numerous aircraft fleet concepts in this globalized world where the situation changes rapidly if not daily.

Keywords: Intercontinental flights, long-range, wide body, low cost concept.

1 INTRODUCTION: INTERCONTINENTAL FLIGHTS THROUGH HISTORY

Throughout the history of aviation, flying has always symbolized modernized fast and luxurious transportation. The goals were always set to fly farther and faster. From a small jump to an 18h around the world flight technology has evolved.

As to define intercontinental flights the author shall first define this concept. In modern aviation transoceanic or long-range transcontinental flights, as a Europe-Asia flight would be, are considered as intercontinental. A South Europe to North Africa flight would not be taken into account as an intercontinental flight in this study, even though it would connect two separate continents. Usually a separation is made past the 4h to 6h benchmark.

First transatlantic scheduled passenger flights were performed with airships for the simple reason they did not require any or very little engine power in order to stay in the air and could therefore float in case of mechanical failure or lack of fuel, carried by the winds. Followed the routes opened and operated by Pan Am with aircraft of type Boeing 314 and named "Clipper". These flights would take over 12h to cross the Atlantic. After the Second World War the first land based aircrafts like the DC-4 and Super Constellations, started to replace flying boats for transatlantic flights. The journey would be shortened and would last no more than 6h to 9h.

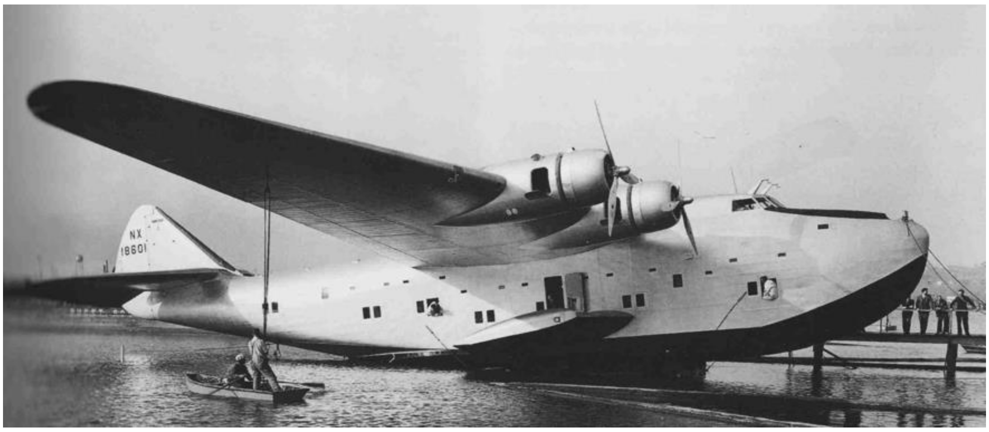

Figure 1: picture of a Boeing 314, Pan Am operated "Clipper"

Source: http://rbogash.com/B314.html

The first jet to operate a transatlantic flight was the DH-106 Comet. It would reduce the flight from New York to Paris to some 7h20.

Figure 2: picture of a Comet, SAS operated

Source: http://cdn-www.airliners.net/aviation-photos/photos/3/1/1/1332113.jpg

Finally, in the end of the 60's, two aircrafts revolutionized intercontinental flights: the Boeing 747 became the first aircraft to offer the possibility of a huge economy of scale. On the other hand the Concorde allowed extremely fast connections, though at a quite high price. The Boeing 747 turned out to be a commercial success, whereas the Concorde was more a prestigious object that France and Great Britain maintained well beyond it's supposed lifespan. The Concorde by itself was a technological success and even a moneymaker for the Airlines, but as a development program, turned out to be too much fuel consuming for a wider use. After several oil crises and the world globalization with the changes that it included, the path most airlines chose was a cost reduction and mass transportation system.

2 TODAY: THE LOW COST CONCEPT WITH THE AIRBUS A380 AGE?

Today, as we know it, the organization used by those airlines called “no frill”, “low budget” or “low cost”, is based on a point-to-point system. Several attempt were made to try to introduce a low cost hub-and-spoke system. Unless subsided by region or states, these airlines failed or were unable to compete with such low fares than their competition.

2.1 Point-to-point concept

The success of low cost airlines lays in several cost cutting factors:

- Single fleet:
  - Ground and air personnel optimization
  - Maintenance system cost reduction
  - Spare parts cost reduction
  - Acquisition of aircraft and price negotiation power
  - “Negative depreciation” as in Ryanair’s case where used airplanes are sold without depreciation or sometimes at a higher price than bought new
- Labor cost reduced:
  - Crew training cost paid by the crews themselves
  - Crew efficiency nearing the legal limits (900h block time for pilots yearly compared to 700-800h for legacy carrier)
  - Multiple tasks for labor crew (check-in and cleaning duties for cabin crew…)
  - Lowering the salaries in the branch
- Aircraft efficiency (nearly 80% higher than legacy carrier)
- Catering, additional services on board, priority boarding etc. at additional costs
- Flying routes from and to low cost airports or even benefiting of subsidies from region and airports (no landing fees etc.)
- Aircraft choice – economy of scale
- Online booking system saving on agencies fees
- Limited advertising or advertising paying for itself

As we can see, no frill airlines use several cost cutting methods as to reduce their cost per available seat. Furthermore their load factor is much higher then legacy carriers. These are more bound to their schedule and routes for reasons other than economics, such as political pressure (connecting to Europe’s capital Brussels for example), prestige or simply due to their schedule of feeder connections.

2.2 Hub-and-spoke system

Most so-called legacy carriers, regional, national or international, work on the hub-and-spoke concept. They have one or several main bases where they hold ground personal, stations, maintenance, aircraft stations and management. These hubs are used as a gateway. Passengers, unless flying to or from a hub, always have to use connecting flights through a hub. The advantage of this system is a much higher connectivity than a point-to-point connection. For example, all passengers flying out of a secondary airport are on the same flight to the hub where they split to various destinations. On the same principle all passengers flying to this secondary airport are grouped in the hub and therefore the load factor to this destination is higher. Point-to-point concept would not permit this type of operation, as there would be not enough passengers for a bigger airplane. Smaller secondary airports often have very few passengers and the lines connecting them to the hub are called “feeder” lines, as their main aim is to “feed”, or to fill the bigger airplanes for the further flights.

Let us take the example of Lufthansa and Air France, two main legacy carriers on the European scale. For Lufthansa the hubs are Frankfurt and Munich, for Air France it is Paris CDG and Paris ORY. Both companies have similar sized regional jets and turboprop aircrafts ranging 35-100 seats. They also have a continental fleet of jets between 120 and 210 seats flying from secondary airports into the hubs. These lines “feed” each other on the European scale. But if we further analyze the schedule of the lines we can recognize some typical patterns: most frequent flights are early morning flights from secondary airports into the hub. These flights coincide with arrivals and departures of intercontinental fleets of aircrafts. In this case we can also consider the 120-210 seats fleets to be feeder lines, as they tend to bring enough passengers to the same hub in order to fill the intercontinental flights.

2.3 Intercontinental flights – technology, organization and economics

2.3.1 Technology of intercontinental flights

Intercontinental aircrafts, as the author has previously described, are nowadays mostly aircrafts with a capacity of several hundred passengers, ranging from 290 to 550. Even more would be achievable with the A380. To achieve such a high number of passengers, the aircraft has to be wide enough to accommodate a minimum of 6 or 7 seats per row. This would in turn require a so-called “wide body” aircraft and 2 aisles. Due to a limited width because of the drag it creates, as well as a limited length, the only way to further increase the number of passengers is to create a double decker aircraft. Boeing achieved this in the 747 series and Airbus recently with the A380. This one is a continuous double decker as opposed to the 747 that has only the front section in a two levels configuration.

ICAO and national regulations define the minimum number of emergency equipment and flight attendants usually per block of 50 seats. The emergency equipment also includes the number of doors for evacuation along with slide, inflatable life rafts etc. With this number of emergency doors, there is also a practical reason to use several ones for normal operations. For practical purposes of boarding and disembarking the aircraft, the use of a minimum of two “fingers” on the terminal is essential in order to keep the turnaround time reasonable.

The Airbus A380 has a capacity of a maximum 853 seats although no aircraft in this single class configuration has been ordered yet. Disembarking over 800 passengers, cleaning the cabin and boarding another load of 800 passengers would, with two accesses (finger or ground stairs) take a very long time, reducing the productivity. As the study “A Practical Approach to Board/Deboard an A380” suggested, a 3 fingers access to the plane shall speed up the process.

Furthermore, with flights lasting 8h to 13h and more, there is a strong need for catering and sanitary water with waste as product. The aircraft has to be replenished before each flight. Catering for 350 or 450 passengers already takes a huge impact on the payload and time to load. Catering for 550 passengers or hypothetically 850 would take much longer.

On the other side passenger transportation, especially on intercontinental flights where passengers usually spend longer periods of time at the destination, always implies transportation of luggage. Depending on which regulation or system we look at, it is either considered as part of passenger transportation or cargo transportation. The technology used is in both cases the same. On intercontinental flights check-in luggage is packed into pallets or containers on the ground. These are specially designed, standardized to fit one or several airliners. These containers are then loaded in the lower part of the aircraft and do not necessitate a lot of time to load. The problem arises from connecting flights, where luggage has to be unloaded from several feeder aircrafts, sorted out, and loaded on the appropriate container for the appropriate destination. The time for these changes can dramatically affect turnaround time.

2.3.2 Organization and economics of intercontinental flights

The longer the flight the lower has to be the cost per available seat kilometer or ASK. The total cost of a flight is the sum of the fixed costs (use of terminal, landing fees, booking fees etc.) and variable costs (fuel used, maintenance costs in hourly base, labor costs etc.) The longer the flight the more expensive the total costs. It is hence critical to improve the cost per ASK with economy of scale. As we can see in the figure 3, most legacy carriers have a rule of third: 1/3 of passengers come from the neighboring area of the departure airport, 1/3 come with their own means of transportation (this includes all ground transportation) and 1/3 come with feeder aircrafts of the same carrier as the intercontinental flight or on a code sharing flight.

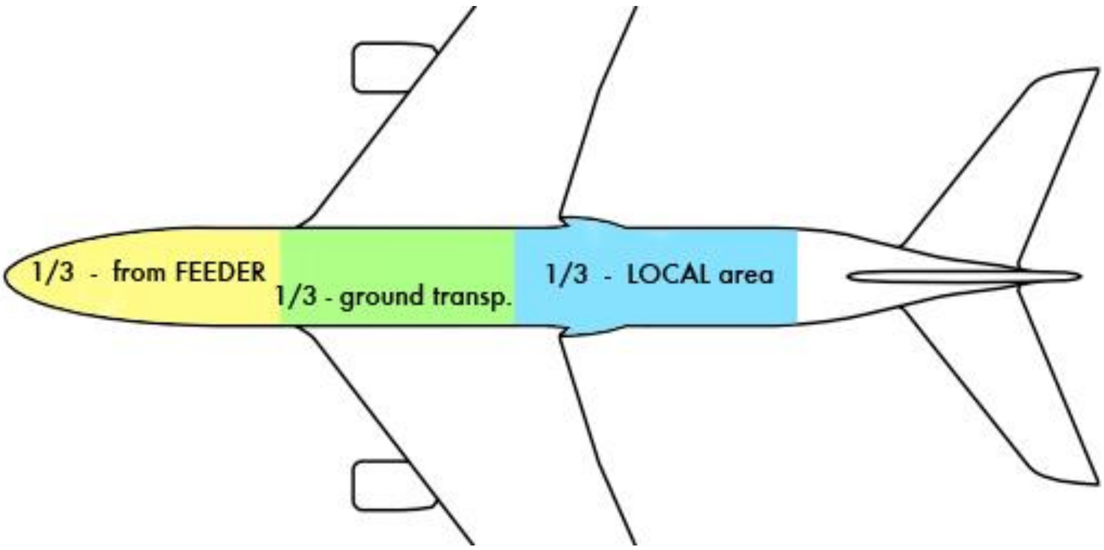

Figure 3: Schema of "the Rule of Third"

Source: author

Let us now take an example of an airline operating an Airbus A340 with a 3-class seating totaling 380 seats available for passengers. Let us assume the operating costs of the A340 to be 14,000 € per flight hour. These are approximate and average costs the author is using for the purpose of this article. Specific airlines may have slightly higher or lower operating cost depending on numerous other factors that are not the subject of this study.

For a flight Paris-New York with a total flight distance of 5900 km this would represent for the A340 about 6h30 and the cost would be:

14,000 x 6.5 = 91,000 € (1)

That would be 239 € per available seat. Let us assume a load factor of 0.80 or an 80% full aircraft. With only 304 revenue passengers (paying customers) we have the cost per passenger rising to:

91,000 / (380 x 0.80) = 299 € (2)

Considering the rule of third we have approximately 101 passengers coming from the neighboring area (that would be Paris), 101 passengers coming from a closer area with ground transportation (that would be the region around Paris, eventually up to a radius of several hundreds of kilometers, therefore France and part of the Benelux) and 101 passengers coming with feeder flights up to several hours (that would cover Western Europe).

Table 1: cost per seat at different load factors for a CDG-JFK flight, total cost 89,680 €, 380 seats configuration and one way only with Airbus A340

Load factor	Flight	100%	90%	80%	70%	60%	50%
Cost (per seat)	91,000 € (entire flight)	239 €	266 €	299 €	341 €	398 €	478 €

Source: author

From Table 1 it is clear that the cost per seat is lower with increasing number of passengers and hence the higher the profit, provided the tickets are sold at a certain fixed price. Let us analyze the same flight, flown with an A380, with a 3-class configuration and 550 seats.

Assuming an economy of scale and therefore similarly assuming the hourly cost of the A380 to be around 17,500 € we calculate the following costs of the flight:

6.5 x 17,500 = 113,750 € (3)

On the same basis we can calculate the cost at different load factors. If we calculate the cost per available seat kilometer or ASK we see that the A340 costs 0.041 €/ASK and the A380 costs 0.035 €/ASK to operate (see formula 4 and 5.)

91,000 / 5,900 / 380 = 0.041 € (4)

113,750 / 5,900 / 550 = 0.035 € (5)

Table 2: cost per seat at different load factors for a CDG-JFK flight, total cost 89,680 €, 550 seats configuration and one way only with Airbus A380

Load factor	Flight	100%	90%	80%	70%	60%	50%
Cost (per seat)	113,750 € (entire flight)	207 €	230 €	259 €	296 €	345 €	414 €

Source: author

Many analyses do the mistake of comparing two aircrafts at the same load factor. If the capacity of both planes, their age and operating environment are different, it is completely impossible to compare that way. If there are 200 passengers to transport and there are two aircrafts available, one with 201 seats and the other with 380 seats we have one aircraft at 99,5% full and the other barely over half full (52.6%). On charter flights an operator rarely buys a certain percentage of whatever number of seats is available. It is usually agreed to buy the entire aircraft, or a certain number of seats. If we compare now both planes at an equal number of passengers we come to following conclusions:

- Bigger aircrafts have a higher cost for a certain flight but the global cost per ASK is lower, therefore at equal load factor the cost per revenue passenger is lower hence a higher margin and profit.
- At the same number of passengers, smaller aircrafts have a higher load factor, and hence the highest margin.

So bigger airplanes are justified only when the demand for seats is high enough to support more passengers per flight than a smaller aircraft would be able to transport. In this case it is important either to have a high demand of passengers that are not willing to pay more or a strong concurrence, otherwise it may be preferable to increase prices as to regulate demand.

Table 3: comparison of costs per passenger at different total number of passengers for a CDG-JFK flight, one way only with Airbus A340 and A380

Number of passengers	200	250	300	350	380*	450	500	550
A340 Loadfactor Cost per seat	54% 455 €	66% 364 €	79% 303 €	92% 260 €	100% 239 €	X	X	X
A380 Loadfactor Cost per seat	36% 569 €	45% 455 €	55% 379 €	64% 325 €	69% 299 €	82% 253 €	91% 228 €	100% 207 €

* Comparison is done at 380 seats, which is the maximum capacity of the A340, instead of 400.

Source: author

To summarize, a bigger airplane costs less per available seat but represents a bigger risk in case of deficiency of passengers. Smaller airplanes represent a smaller risk if there are fewer passengers, as they operate at a higher load factor. But even if full, their operating costs per seat are higher than those of bigger airplane at equal load factor.

The author would like to point out that technology today has reached such a high level that the two main producers Boeing and Airbus offer aircrafts with very similar direct operating costs. The main differences come in form of regional preferences (higher airbus pilots and spare parts availability in Europe and similar situation for Boeing in the North American area), political influences to rather buy a European or an American airplane etc.

The author will now try to apply those calculations to the low-cost model.

3 FEASIBILITY AND ECONOMICS OF POINT TO POINT INTERCONTINENTAL SCHEDULED FLIGHTS

First we need to find out if point-to-point intercontinental flights are possible. Referring to the rule of third described in the previous part of this article we have the following:

- 1/3 of the plane from local area
- 1/3 of the plane from ground transportation

- 1/3 of the plan from feeder services

If we wish to operate a point-to-point service, we automatically renounce to the 33% of passengers we have from a feeder service. If we compare the costs of both small and big aircraft we can see that in this case, with a lower number of passengers, our interest is to have the smaller one. This aircraft should still be large enough to be able to have an economy of scale. But even then, a full A340 would cost 239 € one-way or 478 € for a return flight from Paris to New York. Furthermore, a flight can never be operated at 100% load factor all the time. Therefore the calculation would have to be done on a lower load factor. Some flights are operated on such a point-to-point basis, but they are sold to charter operators for a global fee or have 3 classes and cannot be considered as low cost. The charter or tour operator carries the economical risk or burden of not filling the plane. Charters are sold in packages and very rarely flown like a regular line. Tour operators have higher margins in their packages, and therefore also higher flexibilities to give discounts and special offers to attract more clients shall there be seats left vacant.

One cannot really consider an airplane ticket costing around 500 € to be in the low cost category. This is especially so when legacy carriers like Lufthansa, Emirates and British Airways sometimes offer even cheaper tickets. They practice such low fares to attract clients that would otherwise not chose to fly, in order to fill the empty seats and compensate on the other side with extremely high first class fares. They use a classic legacy price policy.

True low cost airlines based on a point-to-point system can hardly be operated, as there are almost never enough passengers from a departure and to a destination to set up a scheduled airline.

4 CONCLUSION: POSSIBLE FUTURE EVOLUTIONS FOR INTERCONTINENTAL FLIGHTS

As the author tried to demonstrate, point-to-point intercontinental flights are possible only on a charter basis, which cannot be considered as a true low cost operation. On a scheduled basis, only hub-and-spoke system is economically viable. An airline, to be a true low-cost, as we know it on a European or North American scale, cannot operate with hubs. This raises costs and the operation concept moves toward the classical or legacy system. Most legacy airlines practice discount flights, closing by their fares to low cost prices.

Future evolution could tend toward lower fares on intercontinental flights by cutting costs by all means. An even higher seat density, more classes (introduction of a 4th class) or fewer classes (only a business and a low-cost 2nd class) could help achieve this lowering of costs.

Many airlines in the world have ordered the A380, in order to increase the seating compared to a Boeing 747, hence reducing the cost per seat. None has ordered an A380 with higher seating configuration that 550 even though the airplane has a capacity of 850. Those airlines carry the risk of operating a very expensive airplane at a low load factor in case of economical downturn. On the other side, there are airlines that only operate two-engine intercontinental aircrafts with seating 300 to 400. They deliberately operate smaller aircrafts with the ability change the frequency if the demand drops, which is not possible with a bigger aircraft.

The region in the world that is the closest to have an intercontinental low-cost airline would be Asia. With a high population density and high economical growth, several airlines, such as Air Asia, Tiger Airways or Kingfisher Airlines have made attempts to offer a low-costs service and are evolving towards this model.

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THE MOTORWAYS OF THE SEA: A STUDY ON THE DEVELOPMENT OF THE RO-RO NETWORK TO/FROM ITALIAN PORTS IN THE YEARS 2008-2012

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ABSTRACT

In this paper, the development of the ro-ro Short Sea Shipping (SSS) services offered at Italian ports in the last five years is analyzed. In particular, a detailed research on all the ro-ro SSS routes departing from and arriving to Italian ports, in the years 2008, 2010 and 2012, is performed. All routes regarding these three years are extensively reported. The study highlights two main aspects. The first aspect is that domestic ro-ro routes cannot constitute, by now, an alternative to domestic road freight transport: as no routes connect together two ports in the mainland, but they only connect the Italian mainland with the Italian islands. The second aspect is a general modification of the routes in recent years, particularly between 2010 and 2012: they tend to increase in number, decrease their frequency but increase their length, in particular with reference to the number of ports involved. This fact is a result of the economic crisis: on one hand the transport demand is decreased, and therefore the routes' frequencies; on the other hand, the shipping companies look for new markets in order to face the reduction in traffic.

Keywords: Motorways of the Sea routes; comparison years 2008 2010 2012; alternative to "all road" transport

1 INTRODUCTION

Motorways Of the Sea can be defined, according to the European Commission [2], as follows: The trans-European network of Motorways Of the Sea is intended to concentrate flows of freight on sea-based logistical routes in such a way as to improve existing maritime links or to establish new viable, regular and frequent maritime links for the transport of goods between Member States so as to reduce road congestion and/or improve access to peripheral and island regions and States. Motorways Of the Sea should not exclude the combined transport of persons and goods, provided that freight is predominant.

According to the definition proposed by the European Commission [1], Short Sea Shipping (SSS) is the movement of cargo and passengers by sea between ports situated in geographical Europe or between those ports and ports situated in non-European countries having a coastline on the enclosed seas bordering Europe. Short Sea Shipping includes domestic and international maritime transport, including feeder services, along the coast and to and from the islands, rivers and lakes. The concept of Short Sea Shipping also extends to maritime transport between the Member States of the Union and Norway and Iceland and other States on the Baltic Sea, the Black Sea and the Mediterranean.

Five categories of ships have been identified to operate within the SSS network [5]: container feeder vessels; ferries; bulk cargo carriers and tankers; general cargo and multipurpose ships; sea-river ships. Ferries are almost an extension of road and in some cases of rail transport too. These ships are capable of carrying both passengers and a whole range of cargoes that embraces: trucks, trailer, semi-trailers, accompanied and unaccompanied, swap-bodies, railway wagons, palletised cargo and machinery. Motorways of the Sea services are operated by this kind of ships.

The EU has a coastline of 67,000 km and has between 60% and 70% of its industrial and production centres located within 150-200 km of the coast [5]. These conditions provide MOS with a geographic advantage in order to be competitive with “all-road” transport.

On the other hand, MOS still have to overcome several shortcomings. Due to their nature, this mode can hardly offer a door-to-door transport service. This disadvantage arises from ro-ro Short Sea Shipping services being part of a broken chain. As a result, to complete a door-to-door service, MOS require the collaboration of rail or road modes for collection and delivery, and a network of well-located inland terminals. The approach adopted by the European Commission in developing the policy of Trans-European Networks (TEN-T) is an important step towards the integration of MOS in intermodal transport systems. But other three aspects are fundamental: firstly, proper rail links and road accessibility; secondly, the implementation of an organisational culture by shipping companies and port authorities, in order to reduce the overall transit time of cargoes, especially regarding port operations; thirdly, the performances of MOS in terms of punctuality, flexibility, availability and frequency of services.

In this article, firstly the Italian MOS routes, both domestic and international, in year 2012 are shown. Data collected refer to November 2012. The performed survey shows that existing domestic routes mainly connect the Italian mainland with the Italian islands, while routes connecting together ports of the Italian mainland are just a few and parts of international routes. After, a comparison of MOS routes, in 2008 (February 2008), 2010 (March 2010) and 2012, is carried out. This comparison shows the effects of the economic crisis: from 2010 to 2012 a strong decrease in ship departures per week can be observed, as well as an increase in the routes’ length. Conclusions follow.

2 THE MOTORWAYS OF SEA ROUTES IN YEAR 2012

The MOS routes, to/from Italian ports, in November 2012 are reported in tables 1 and 2, concerning respectively domestic and international routes. For each route, the following is reported: operator, weekly frequency, average travel time in hours and length of the route in kilometres.

35 domestic routes are operated by 14 shipping companies. The longest domestic route is Catania–Ravenna, 1179 km long, while the shortest is Civitavecchia – Olbia, 223 km long.

Considering the number of connections per week between each couple of Italian ports, the most frequent is the one between Civitavecchia and Olbia, with 15 weekly connections. Other important domestic connections are: Napoli – Palermo with 14 connections per week, Livorno – Olbia and Messina – Salerno with both 13 weekly connections.

We can compare these results with those reported in Danesi et al. [4]. In 2010 the most frequent connection resulted Livorno – Olbia, with 19 weekly services; other important connections were: Civitavecchia – Olbia, Napoli – Palermo and Civitavecchia – Palermo, with 14, 14 and 12 connections by week respectively.

Regarding international routes, in year 2012, 56 routes are operated by 37 shipping companies.

The longest international routes are: Trieste – Mersin (2545.9 km), Livorno – Barcelona – Tangier (2384.6 km), Trieste – Pendik (2214.9 km), Trieste – Ambarli (2192.6 km). The shortest international routes are: Pozzallo – Malta (95.7 km), Livorno – Bastia (113.6 km).

The most important international routes are those which connect the western and eastern coast of the Adriatic Sea. In particular we should mention: Bari – Durres, with 31 departures per week; Ancona – Igoumenitsa – Patras, with 19 departures per week; Brindisi – Vlore, with 17 departures per week.

The number of domestic routes registered in 2012 is equal to 35, with 166 ship departures per week from/to the 26 Italian ports considered. The number of international routes is 56, with 241 ship departures from the 26 Italian ports considered towards 24 non Italian destinations. The total number of routes registered in November 2012 is 91, with 407 departures per week and 50 destinations.

Table 1: Domestic routes to/from Italian ports. Data refer to November 2012

Route	Operator	Weekly frequency	Average travel time (h)	Distance (km)
Arbatax-Cagliari-Civitavecchia	Tirrenia navigazione	2	11.5	597
Arbatax-Genova	Tirrenia navigazione	2	19	516
Arbatax-Olbia-Genova	Tirrenia navigazione	3	18	535
Cagliari-Civitavecchia	Tirrenia navigazione	5	13	445
Cagliari-Livorno	Tirrenia, Armamento Sardo	7	18.5	572.6
Cagliari-Napoli	Tirrenia navigazione	2	16	502.9
Cagliari-Palermo	Tirrenia navigazione	1	14	416.2
Cagliari-Salerno	Grimaldi Lines	1	18	328.5
Cagliari-Trapani	Tirrenia navigazione	1	10	327
Cagliari-Vado Ligure	Gruppo Grendi	3	24	685.9
Catania-Civitavecchia	Grimaldi Lines	2	19	644.8
Catania-Genova	Grimaldi Lines	4	29	997.4
Catania-Livorno	Grimaldi Lines, Italtrag	3	25	882.2
Catania-Napoli	TTT Lines	7	10.5	440.2
Catania-Ravenna	Tirrenia Divisione Adriatica	3	12.5	1179.3
Catania-Salerno	Grimaldi Lines	3	14	393.2
Civitavecchia-Olbia	Tirrenia navigazione, SNAV	15	15	222.8
Civitavecchia-Palermo	Grandi Navi Veloci, SNAV	6	14.5	472
Civitavecchia-Porto Torres	Grimaldi Lines	2	7	318.5
Civitavecchia-Trapani	Grimaldi Lines	1	14.5	458.7
Genova-Olbia	Tirrenia Navigazione	3	11.5	418.7
Genova-Palermo	GNV, Grimaldi	8	20	796
Genova-Porto Torres	Tirrenia Navigazione	7	11.5	399.5
Golfo Aranci Livorno	Sardinia Ferries	4	10	391.6
Livorno-Olbia	Armamento Sardo, Moby L.	13	8.5	313.5
Livorno-Palermo	Grimaldi Lines, Italtrag	5	19	696.9
Livorno-Termini Imerese	Grandi Navi Veloci	3	18.5	721
Livorno-Trapani	Italtrag	3	22	686.9
Marina di Carrara-Olbia	Armamento Sardo	6	12	359.7
Messina-Salerno	Caronte & Tourist	13	8	296.5
Milazzo-Napoli	Siremar	2	23	325.1
Napoli-Palermo	SNAV, Tirrenia navigazione	14	10.5	320.5
Palermo-Salerno	Grimaldi Lines	2	9.5	316
Salerno-Termini Imerese	Caronte & Tourist	6	9	311.7
T.ni Imerese -Vado Ligure	Strade Blu	4	24	846

Source: Italian Motorways of the Sea website [6],shipping companies websites [7].

Only a few routes exist which connect ports in the mainland, and these connections are always part of a long international route. These connections are:

- Genova – Livorno and Salerno – Genova (both one way), which are part of the route Genova–Livorno–Catania–Patras–Bar–Catania–Salerno–Genova (1 connection per week);
- Genova – Napoli (two ways), which is part of the route Genova – Napoli – Tunis (1 connection per week);
- Livorno – Savona (two ways), part of the routes Livorno – Savona – Barcelona and Livorno – Savona – Barcelona – Valencia (5 connections per week);
- Trieste – Ancona (two ways), part of the route Trieste – Ancona – Igoumenitsa – Patras and return (3 connections per week).

Table 2: International routes to/from Italian ports. Data refer to November 2012

Route	Operator	weekly freq.	av. travel time (h)	Distance (km)
Ancona-Durres	Adria Ferries	3	19	575
Ancona-Igoumenitsa-Patras	Adria Ferries, Anek Lines, Minoan	19	22	953
Ancona-Split	Blu Line, Jadrolinija	9	10	260
Ancona-Zadar	Jadrolinija	3	6	180.9
Bari-Bar	Montenegro Lines	2	9	215
Bari-Corfu-Igoumenitsa	Nel Lines, Ventouris	9	11	363
Bari-Corfu-Igoumenitsa-Patras	Superfast	7	9.5	574
Bari-Dubrovnik	Jadrolinija	6	9	201
Bari-Durres	Adria, Albanian, European Seaways, Adriatica Traghetti, Ventouris	31	8	221.8
Brindisi-Corfu-Igoumenitsa	Agoudimos, Grimaldi Lines	9	9	259
Brindisi-Corfu-Igoumenitsa-Patras	Grimaldi Lines, Endeavor	12	16	499
Brindisi-Vlore	Agoudimos, European Ferries, Star Ferries	17	7.5	133.8
Cagliari-Valencia	Grimaldi Lines	3	23	867.9
Catania-Civitavecchia-Barcelona-Civitavecchia-Catania-Malta	Grimaldi Lines	2	40	1699.7
Catania-Corinth	Grimaldi Lines	1	25	710.1
Catania-Malta	Grimaldi Lines	3	7	208
Civitavecchia-Barcelona	Grimaldi Lines	6	19	826.9
Civitavecchia-Palermo-Tunis	SNAV,Grandi Navi Veloci	2	24	779.2
Civitavecchia-Trapani-Tunis	Grimaldi Lines	1	22.5	699.9
Genova-Alger	Messina	1	240	965
Genova-Barcelona	Grandi Navi Veloci	1	18	666.5
Genova-Barcelona-Tangier	Grimaldi Lines	2	49	1706.6
Genova-Catania-Malta	Grimaldi Lines	3	38	1205.4
Genova-Catania-Malta-Tripoli	Grimaldi Lines	1	68	1565.5
Genova-Livorno-Catania-Patras-Bar-Catania-Salerno-Genova	Grimaldi Lines	1	39	3305.1
Genova-Malta	Messina	1	39	1067.2
Genova-Napoli-Tunis	Messina	1	24	1212.5
Genova-Palermo-Tunis	Grimaldi Lines	2	35	1150.7
Genova-Tunis	CTN, Grandi Navi Veloci	5	24	867.3
Livorno-Barcelona	Flota suardiaz	4	27	712.2
Livorno-Bastia	Corsica ferries	10	4	113.6
Livorno-Barcelona-Tangier	Grimaldi Lines	1	62	2384.6
Livorno-Catania-Malta	Grimaldi Lines	3	28	1094.2
Livorno-Catania-Patras	Grimaldi Lines	1	52	1477.6
Livorno-Palermo-Tunis	Grimaldi Lines	2	36	1044.9
Livorno-Savona-Barcelona	Grimaldi Lines	1	23	800.8
Livorno-Savona-Barcelona-Valencia	Grimaldi Lines	4	47	1107.7

Livorno-Tripoli	Grimaldi Lines	1	120	1214
Palermo-Salerno-Cagliari-Valencia	Grimaldi Lines	2	60	1502.8
Porto Torres-Marseille	SNCM	3	17	407.3
Porto Torres-Propriano	SNMC	2	3.5	169
Pozzallo-Malta	Virtù Ferries	8	1.5	95.7
Salerno-Malta	Grimaldi Lines	1	25	571.9
Salerno-Tripoli	Grimaldi Lines	1	57	925.3
Salerno-Tunis	Grimaldi Lines	2	24	581.5
Salerno-Valencia	Grimaldi Lines	1	42	1319.7
Savona-Bastia	Corsica ferries	5	10.5	200.6
Trapani-Civitavecchia-Barcelona	Grimaldi	1	42	1285.6
Trieste-Ambarli	UN Ro.Ro	1	48	2192.6
Trieste-Ancona-Igoumenitsa-Patras	Grimaldi Lines	3	72	1234
Trieste-Cesme	Ulusoy Gemi Isletmeleri	3	58	1931.1
Trieste-Durres	Agemar	2	24	735.2
Trieste-Mersin	UN Ro.Ro	2	60	2545.9
Trieste-Pendik	UN Ro.Ro	7	60	2214.9
Venezia-Igoumenitsa-Corfu-Patras	Minoan Lines	2	36	1205.9
Venezia-Igoumenitsa-Patras	Anek Lines	5	35	1150.5

Source: Italian Motorways of the Sea website [6],shipping companies websites [7]

However, we have no information whether cargo is accepted also for the domestic part of the route, e.g. in the last route, cargo having origin Trieste and destination Ancona.

In Table 3, the 26 Italian ports which offer a Motorways of the Sea service are listed. Regarding the number of destinations served, the most important port is Livorno, which is connected with 10 other Italian ports and 9 non Italian ports. The second port for number of destinations served is Genova, with 16 total destinations.

Table 3: Number of destinations and weekly departures from Italian ports (November 2012)

Ports	Number of national destinations	Number of international destinations	Total number of destinations	n° domestic departures per week	n°international departures per week	Total n° of weekly departures
Ancona	0	5	5	0	34	34
Arbatax	3	0	3	7	0	7
Bari	0	6	6	0	55	55
Brindisi	0	4	4	0	38	38
Cagliari	8	1	9	24	5	29
Catania	6	6	12	22	15	37
Civitavecchia	7	3	10	33	12	45
Genova	8	8	16	27	18	45
Golfo Aranci	1	0	1	4	0	4
Livorno	10	9	19	38	28	66
Marina di Carrara	1	0	1	6	0	6
Messina	1	0	1	13	0	13
Milazzo	1	0	1	2	0	2
Napoli	5	8	13	25	5	30
Olbia	5	0	5	40	0	40
Palermo	6	2	8	36	8	44
Porto Torres	2	2	4	9	5	14
Pozzallo	0	1	1	0	8	8
Ravenna	1	1	1	3	0	3
Salerno	7	6	13	25	8	33
Savona	1	3	4	0	10	10
Termini Imerese	3	0	3	13	0	13
Trapani	3	2	5	5	2	7

Trieste	1	7	8	0	18	18
Vado Ligure	2	0	2	7	0	7
Venezia	0	3	3	0	7	7

Regarding the total (national + international) ship departures per week, Livorno results the most important port, with 66 departures, followed by Bari, with 55 departures, and by Civitavecchia and Genova, with 45 weekly departures. Palermo and Olbia are also important, and they register 44 and 40 departures per week respectively. Olbia is also the first Italian port for domestic departures per week, with 40 departures (it has only domestic routes).

In November 2012 the MOS routes were operated by 37 shipping companies. The most important operator is Grimaldi Lines, which offers 37 routes, considering both domestic and international ones. The second operator is Tirrenia and the third Grandi Navi Veloci, with respectively 13 and 6 routes. All other operators offer less than 5 routes: in particular, 20 operators offer only 1 route and 12 operators offer 2 or 3 routes; moreover 4 operators offer only 2 departures per week. Regarding the weekly ship departures, again Grimaldi is by far the greatest Italian operator, with more than 80 departures per week, followed by Tirrenia, with 48 departures per week. SNAV, Sardinia and Corsica Ferries, and Caronte & Tourist register respectively a weekly frequency of 20, 19 and 19 departures.

3 THE TREND IN ITALIAN MOS TRAFFIC. COMPARISON OF ITALIAN RO-RO SHORT SEA SHIPPING ROUTES IN THE YEARS 2008, 2010 AND 2012

As shown in figure 1, in the last four years, i.e. from 2008 to 2012, a general reduction in maritime traffic to/from Italian ports can be observed. The general trend is: decrease of maritime traffic from 2008 to 2009, increase from 2009 to 2010, and decrease again from 2010 to 2012. As far as the the traffic between Italy and Mediterranean countries is concerned, the values of year 2012 are even lower than those in 2009. Ro-Ro short sea shipping routes change according to this trend, and, as will be shown below, they have become less frequent and longer, in order to adapt to the decrease of the demand on one hand, and to search for new markets on the other.

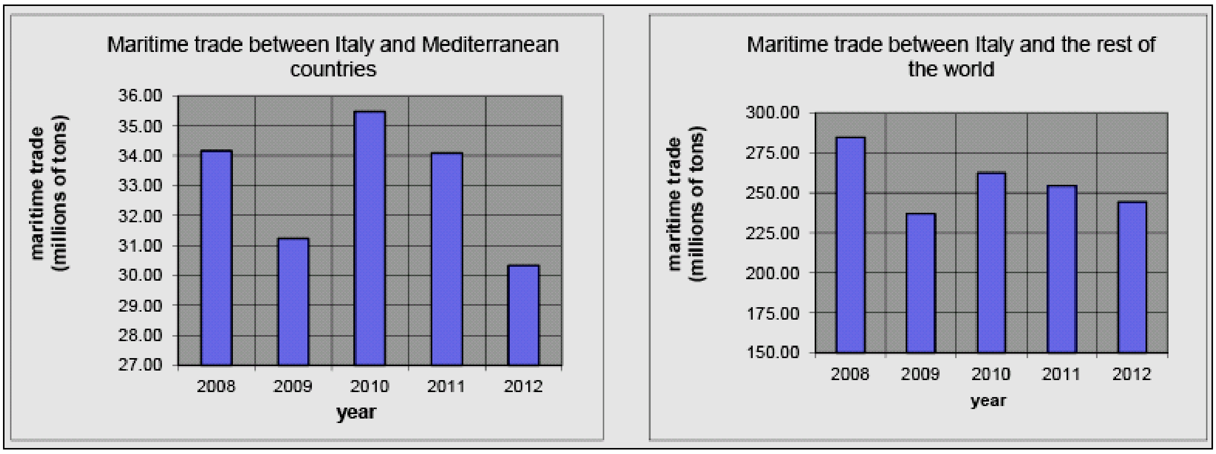

Figure 1: The development of maritime trade to/from Italian ports with Mediterranean area (left) and with the rest of world (right) (comprised Mediterranean) in the years 2008–2012

Source: ISTAT

In tables 4 and 5 a comparison of respectively domestic and international ro-ro SSS routes in 2008, 2010 and 2012 is reported. Data refer to February 2008, March 2010 and

November 2012. If a space for a given route, in a given year, is left empty, it means that the route does not exist in that year.

New domestic routes have been settled between 2010 and 2012: Arbatax – Cagliari – Civitavecchia, operated by Tirrenia; Arbatax – Olbia – Genova (Tirrenia), Cagliari – Salerno (Grimaldi), Cagliari – Vado Ligure (Grendi), Catania – Salerno (Grimaldi), Livorno – Termini Imerese (Grandi Navi Veloci). Instead, in 2012, some routes previously existing, are no longer operated: Arbatax – Civitavecchia (Tirrenia), Cagliari – Genova (Grendi), Olbia – Piombino (Moby Lines). Some routes were operated only in 2010: Cagliari – Olbia – Livorno – Cagliari (Strade Blu) and Catania – Corigliano Calabro (Ustica Lines).

Regarding international routes, 23 new routes have become operational in 2012, with respect to 2010, among which 19 are operated by Grimaldi Lines. Moreover, 9 of these 23 new routes cross more than 3 ports (for example, Malta - Catania – Civitavecchia – Barcelona and return), 10 cross three ports (for example Civitavecchia – Trapani – Tunis), and only 4 cross two ports (for example Cagliari – Valencia). Moreover, 15 routes were present until 2010 and are no longer operated. They are usually point-to-point routes, such as Ancona - Cesme, operated by Marmara Lines, and only 4 of them passed through 3 ports.

Comparing the MOS routes operated in 2008, 2010 and 2012 (see table 6), we can see that the number of routes has grown, from 77 in 2008 and 2010 to 91 in 2012. Regarding domestic routes, the total number of routes has increased from 27 in 2008 to 35 in 2012, while the total number of international routes has decreased from 50 in 2008 to 45 in 2010 and after has increased again to 56 in 2012.

Table 4: The development of domestic MOS routes in 2008, 2010 and 2012 (February 2008, March 2010 and November 2012)

Route	Weekly frequency			Average travel time (h)			Distance (km)		
	2008	2010	2012	2008	2010	2012	2008	2010	2012
Arbatax-Cagliari-Civitavecchia			2			11.5			597
Arbatax-Civitavecchia	2	2		10.5	10.5		299	299	
Arbatax-Genova	2	2	2	20	19	19	516	516	516
Arbatax-Olbia-Genova			3			18			535
Cagliari-Civitavecchia	7	7	5	15	16	13	445	445	445
Cagliari - Genova	3	5		32	31		663	663	
Cagliari-Livorno		7	7		18.5	18.5		572	572
Cagliari-Napoli	3	2	2	17	16	16	502	502	502
Cagliari-Olbia-Livorno-Cagliari		1			14.5			575	
Cagliari-Palermo	1	1	1	14.5	14.5	14	416	416	416
Cagliari-Salerno			1			18			328
Cagliari-Trapani	1	1	1	11	10	10	327	327	327
Cagliari-Vado Ligure			3			24			685
Catania-Civitavecchia	2	3	2	21	19	19	644	644	644
Catania-Corigliano Calabro		3			13			447	
Catania-Genova	2	2	4	25	25	25	997	997	997
Catania-Livorno	2		3	30		25	882		882
Catania-Napoli	7	7	7	10.5	10.5	10.5	440	440	440
Catania-Ravenna	4	3	3	36	36.5	36	1179	1179	1179
Catania-Salerno			3			14			393
Civitavecchia-Olbia	25	14	15	7.5	8	8	222	222	222
Civitavecchia-Palermo	3	10	6	12	12	14	472	472	472
Civitavecchia-Porto Torres		2	2		7	7		317	317
Civitavecchia-Trapani		1	1		14.5	14.5		458	458
Genova-Olbia	10	3	3	10.5	13.5	11.5	418	418	418
Genova-Palermo	6	6	8	20	20	20	798	789	798
Genova-Porto Torres	14	10	7	10	11.5	11.5	399	399	399

Genova-Termini Imerese	4			30			819		
Golfo Aranci-Livorno	7	10	4	8	6.5	6.5	291	291	291
Livorno-Olbia	7	18	13	9	8.5	8.5	313	313	313
Livorno-Palermo	5	3	5	20.5	19	19	696	696	696
Livorno-Termini Imerese			3			18.5			721
Livorno-Trapani	3	4	3	22	23.5	22	686	686	686
Marina di Carrara-Olbia		6	6		12	12		359	359
Messina-Salerno	16	12	13	7.5	8	8	296	296	296
Milazzo-Napoli	2	2	2	19.5	23	23	325	325	325
Napoli-Olbia	1			14.5			415		
Napoli-Palermo	14	14	14	10.5	10.5	10.5	320	320	320
Olbia-Piombino	14	7		6.5	4.5		248	248	
Palermo-Salerno	2	2	2	10	9.5	9.5	316	316	316
Salerno-Termini Imerese			6			9			311
Termini Imerese-Vado ligure		4	4		30	24		846	846

Source: Danesi et al. [3, 4], Italian MOS website [6],shipping companies websites [7]

Table 5: The development of international MOS routes in 2008, 2010 and 2012 (February 2008, March 2010 and November 2012)

Route	Weekly frequency			Average travel time (h)			Distance (km)		
	2008	2010	2012	2008	2010	2012	2008	2010	2012
Ancona-Cesme	1	1		56	56		1582	1582	
Ancona-Durres	3	3	3	18	19	19	575	575	575
Ancona-Igoumenitsa-Patras	23	20	19	21	22	22	953	953	953
Ancona-Split	13	10	9	7	10	10	260	260	260
Ancona-Zadar	3		3	6		6	180		180
Bari-Bar	6	4	2	9	8	9	215	215	215
Bari-Corfù-Igoumenitsa		9	9		12.5	11		363	363
Bari-Corfù-Igoumenitsa-Patras			7			9.5			574
Bari-Dubrovnik	2		6	9		9	201		201
Bari-Durres	21	25	31	9	9	8	221	221	221
Bari-Igoumenitsa	13	9		10	10		363	363	
Bari-Igoumenitsa-Patras	7			16			560		
Bari-Patras		10			17			560	
Bari-Rijeka	2			32			520		
Bari-Split	2			26			287		
Brindisi-Cesme	3			35			1085		
Brindisi-Corfù-Igoumenitsa		15	9		9	9		259	259
Brindisi-Corfù-Igoumenitsa-Patras			12			16			499
Brindisi – Igoumenitsa – Patras	14			7			259		
Brindisi - Patras		14		16	16		455	455	
Brindisi-Vlore	13	13	17	7	7	7.5	133	133	133
Cagliari-Valencia			3			23			867
Catania-Civitavecchia-Barcelona-Civitavecchia-Catania-Malta			2			40			1699
Catania-Corinth			1			25			710
Catania-Malta	4	3	3	8	7	7	208	208	208
Catania-Toulon	2			75			1105.8		
Catania-Tripoli	1			80			585		
Civitavecchia-Alicante		1			48			1179	
Civitavecchia-Barcelona	6	6	6	20	20	19	826	826	826
Civitavecchia-Catania-Malta		1			20			776	
Civitavecchia-Malta	2			31			776		
Civitavecchia-Palermo-Tunis		2	2		24	24		779	779
Civitavecchia-Porto Vecchio	1			8			220		

Civitavecchia-Tarragona	1			30			908		
Civitavecchia-Toulon	3			15			536		
Civitavecchia-Trapani-Tunis			1			22.5			699
Civitavecchia-Tripoli	1			114			1033		
Civitavecchia-Tunis	2			25			616		
Genova- Algier			1			24			965
Genova-Barcelona	6	4	1	18	18	18	666	666	666
Genova-Barcelona-Tangier			2			49			1706
Genova-Bastia	7	7		5	5		206	206	
Genova-Catania-Malta			3			38			1205
Genova-La Spezia-Algier		1			24			1112	
Genova-Malta	3	2	1	39	39	39	1067	1067	1067
Genova-Malta-Tripoli		1			22			1500	
Genova-Livorno-Catania-Patras-Bar-Catania-Salerno-Genova			1			39			3305
Genova-Napoli-Tunis			1			24			1212
Genova-Palermo-Tunis			2			35			1150
Genova-Catania-Malta-Tripoli			1			68			1565
Genova-Tangier	1	7		49	49		1620	1620	
Genova-Tripoli	1	1		100	100		1333	1333	
Genova-Tunis	5	7	5	23	24	24	867	867	867
Livorno-Barcelona	3	3	4	20	21.5	27	712	712	712
Livorno-Savona-Barcelona			1			23			800
Livorno-Savona-Barcelona-Valencia			4			47			1107
Livorno-Bastia	11	16	10	4	4	4	113	113	113
Livorno-Catania-Malta			3			28			1094
Livorno-Catania-Patras			1			52			1477
Livorno-Barcelona-Tangier			1			62			2384
Livorno-Palermo-Malta		1			56			1131	
Livorno-Tarragona	5			30			806		
Livorno-Tripoli			1			120			1214
Livorno-Palermo-Tunis			2			36			1044
Livorno-Toulon		2			16			376	
Livorno-Tunis	2			25			775		
Palermo-Salerno-Cagliari-Valencia			2			60			1502
Palermo-Tripoli	1			131			706		
Palermo-Tunis	3	3		11	10		374	374	
Palermo-Valencia	2			92			1229		
Porto Torres-Barcelona		7			12			569	
Porto Torres-Marseille		3	3		17	17		407	407
Porto Torres-Propiano		2	2		3.5	3.5		169	169
Pozzallo-Malta		8	8		1.5	1.5		95	95
Salerno-Malta	1	1	1	24	24	25	571	571	571
Salerno-Tarragona	1			32			1161		
Salerno-Tripoli	1	1	1	57	57	57	925	925	925
Salerno-Tunis	2	2	2	25	22	24	581	581	581
Salerno-Valencia	3	1	1	47	47	42	1319	1319	1319
Savona-Bastia	2		5	8		10.5	200		200
Trapani-Civitavecchia-Barcelona			1			42			1285
Trapani-Tunis	2	1		9	7.5		262	262	
Trieste-Ambarlì		2	1		48	48		2192	2192
Trieste-Ancona-Igoumenitsa-Patras			3			72			1234
Trieste-Cesme		3	3		58	58		1931	1931
Trieste-Durres	3	1	2	24	24	24	735	735	735
Trieste-Istanbul		7			48			2223	
Trieste-Mersin		2	2		60	60		2524	2545

Trieste-Pendik	7		7	54		60	2214		2214
Venezia-Igoumenitsa-Corfù-Patras			2			36			1205
Venezia-Igoumenitsa-Patras	7	8	5	23	35	35	1150	1150	1150
Venezia-Patras	3			35			1149		

Source: Danesi et al. [3, 4], Italian MOS website [6],shipping companies websites [7]

The number of lines crossing more than two ports has increased relevantly. The number of routes crossing 3 ports increased from 4 in 2008 (all international) to 10 in 2010 (9 international) and to 19 in 2012 (17 international). The number of routes crossing more than 3 ports were absent until 2010 and increased to 9 (all international) in 2012.

The average length of the routes has varied:

- regarding domestic routes, from 489 km in 2008 to 478 in 2010 and to 518 in 2012;
- regarding international routes, from 706.4 km in 2008 to 795.4 km in 2010 and to 967 km in 2012;
- regarding both domestic and international routes, from 618 km in 2008 to 646 km in 2010 and to 794.4 km in 2012.

Table 6: Number of routes crossing a different number of ports in years 2008, 2010, 2012. Data refer to both domestic and international routes (February 2008, March 2010, November 2012)

Typology of routes	2008	2010	2012
Routes point to point	73	67	63
Routes crossing 3 ports	4	10	19
Routes crossing more than 3 ports	0	0	9

Table 7: Number of destinations and of departures per week from Italian ports. Comparison among the years 2008, 2010 and 2012. (February 2008, March 2010 and November 2012)

Ports	Number of destinations			Number of departures by week		
	2008	2010	2012	2008	2010	2012
Ancona	6	5	5	43	34	34
Arbatax	2	2	3	4	4	7
Bari	7	5	6	53	57	55
Brindisi	4	4	4	30	42	38
Cagliari	5	7	9	15	24	29
Catania	8	6	12	24	21	37
Civitavecchia	12	11	10	55	49	45
Corigliano Calabro	0	1	0	0	3	0
Genova	13	17	16	64	63	45
Livorno	9	17	19	45	68	66
Marina di Carrara	0	1	1	0	6	6
Messina	1	1	1	16	12	13
Milazzo	10	1	1	2	2	2
Napoli	5	7	13	25	26	30
Olbia + Golfo Aranci	6	6	6	64	59	44
Palermo	9	8	8	37	43	44
Piombino	1	1	0	14	7	0
Porto Torres	1	5	4	14	24	14
Pozzallo	0	1	1	0	8	8
Salerno	7	6	13	26	19	33
Savona + Vado Ligure	1	1	6	2	4	17
Termini Imerese	1	1	3	4	4	13
Trapani	3	4	5	6	7	7
Trieste	2	5	8	10	15	18
Venezia	2	3	3	10	8	7

Source: Danesi et al. [3, 4], Italian MOS website [6],shipping companies websites [7]

The average travel time regarding domestic routes has kept quite constant in the years 2008 – 2012 and equal to 15.5 – 16.5 hours. Regarding international routes, it variates from 25.2 hours in 2008 to 22.8 hours in 2010 and to 29.1 hours in 2012. Regarding both domestic and international routes, the average travel time has varied from 22.12 hours in 2008 to 19.8 hours in 2010 and to 24.0 hours in 2012.

The average speed is important to evaluate the efficiency of maritime routes. Regarding domestic routes, the average speed has kept almost constant, as it ranges from 31.15 km/h in 2008 to 31.9 km/h in 2010 and to 32.9 km/h in 2012. Regarding international routes, it ranges from 36.0 km/h in 2008 to 35.5 in 2010 and to 33.2 in 2012. Considering both domestic and international routes, the average speed variates from 34.3 km/h in 2008 to 34.0 in 2010 and to 33.1 in 2012. The general decrease of the average speed is due to the greater number of port calls per route, as the average speed is calculated by taking into account also the time in which the ship is stopped at the port for the loading / unloading operations.

In table 7, the total number of destinations served and the total number of departures per week, for each Italian port, regarding MOS routes, is reported. The ports with highest number of destinations are Livorno, Genova and Civitavecchia. In particular, Livorno is the first port concerning the number of destinations (19 destinations) in 2012, and it shows a constant increase in these years. Livorno and Genova were the first two ports in 2010 with 17 destinations. In 2008 the first port was Genova, with 13 destinations, and Civitavecchia followed, with 12 destinations (Civitavecchia reduces the number of destinations from 12 in 2008 to 10 in 2012), while Livorno registered in 2008 only 9 destinations.

Regarding the number of departures per week, the most important ports are: Livorno, Genova, Bari, Olbia and Civitavecchia. In 2012, the most important port is Livorno, with 66 departures per week, which has increased its traffic from 45 departures per week in 2008 to 68 in 2010. Livorno was also the first port in 2010 concerning the number of weekly departures. Genova and Olbia were the most important ports regarding departures per week in 2008, but their traffic of ro-ro ships reduces from 2008 to 2012: Olbia reduces heavily its traffic of ro-ro ships from 64 weekly departures in 2008 to 59 in 2010 and to 44 in 2012, while Genova decreases from 64 departures per week in 2008 to 63 in 2010 and to 45 in 2012. Civitavecchia, which was the third Italian port in 2008, also decreases its traffic from 55 departures by week in 2008 to 49 in 2010 and to 45 in 2012. Bari, which is the second Italian port for MOS departures per week in 2012, registers 53 weekly departures in 2008, 57 in 2010 and 55 in 2012.

In table 8, some synthetic remarks, for all Italian ports, have been reported. The total number of destinations has slightly increased from 46 (in 2008) to 50 (in 2010 and 2012). The number of weekly departures registers a slight increase, from 417 in year 2008 to 427 in year 2010: the number of departures in 2012 instead is lower than in 2008, and equal to 407 departures per week. The number of routes instead kept constant and equal to 77 from 2008 to 2010, and increased to 91 in 2012.

Table 8: Synthesis of the comparison among 2008, 2010 and 2012: number of destinations, number of departures, number of routes (February 2008, March 2010 and November 2012)

	Number of destinations			Number of departures per week			Number of routes		
	2008	2010	2012	2008	2010	2012	2008	2010	2012
Domestic	24	27	26	169	174	166	28	32	35
International	22	23	24	245	250	241	50	45	56
Total	46	50	50	414	424	407	77	77	91

4 CONCLUSIONS

In this article, a study on the Motorways of the Sea routes, to and from Italian ports, and a comparison among 2008, 2010 and 2012 routes has been performed. Italian economy is currently in strong crisis, and maritime traffic follows this trend. A strong decrease in the maritime Italian trade actually has been registered from 2010 to 2012.

This trend is clearly visible in ro-ro short sea shipping routes. Actually, weekly frequencies decreased (from 424 to 407) and routes increased relevantly their length. Indeed, in 2008, 74 point to point routes were registered, while in 2012 they decreased to 63. On the other hand, the number of routes crossing three ports increased constantly, from 3 in 2008 to 10 in 2010 and to 19 in 2012. Furthermore, in 2012, 9 routes crossing more than 3 ports are operational, this kind of route were not operated until 2010. This choice, to operate longer routes, is made by shipping companies in order to limit the trips performed with a low loading factor of the ship; this however decreases the speed of the service and therefore the competitiveness with "all-road" services decreases.

The number of routes registered a slight increase, from 77 in 2008 and 2010 to 91 in 2012, and the frequencies decreased from 424 in 2010 to 404 in 2012 (in 2008 the frequencies was 414). The increase in the number of routes is an attempt by shipping companies to enter new markets, which are under development, and therefore frequencies are kept low. Actually, the greatest majority of new routes are operated by Grimaldi Lines. This shows that greatest operators try to face the economic crisis by searching for new markets, while the smallest operators, whose resources are not enough to face the crisis, decrease their traffic.

With regard to the capability of MOS routes of being alternative to "all-road" transport, this study shows that the only existing connections between Italian mainland ports are actually part of international routes. Some of these connections are only one-way, such as Salerno – Genova, while others are two-way, like Trieste – Ancona. However, some of these routes have a frequency of only 1 connection per week; moreover, we have no information whether cargo having domestic both origin and destination is accepted.

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ENHANCING THE EUROPEAN PASSENGER RIGHTS WHEN TRAVELLING BY WATER

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ABSTRACT

New European rights of passengers travelling by sea and inland waterways constitute a significant step forward in achieving targeted consistent legal framework that is in the interest of passengers travelling in all modes. The paper focuses on the accomplishments of the Regulation (EU) No 1177/2010 of the European Parliament and of the Council of 24 November 2010 concerning the rights of passengers when travelling by sea and inland waterways and amending the Regulation (EC) No 2006/2004 applicable as from 18 December 2012. Among other things it provides for a guarantee of reimbursement or rerouting in situations of cancellation or of delay at departure of more than 90 minutes, adequate assistance, compensation in situation of delay in arrival or cancellation of journeys, non-discriminatory treatment and assistance for disabled persons or persons with reduced mobility, minimum rules of information, establishment of complaint handling mechanism and establishment of independent national bodies for the enforcement of regulation. The author is highlighting the need for adequate training of seafarers and employees to ensure a thorough understanding of the Regulation as a key element for its effective implementation.

Keywords: passenger right, traveling by water, training of seafarers, European Union

1 INTRODUCTION

In relation to the carrier, the passenger is the weak party because the carrier is often an actual monopolist in the sense that the passenger has no or very few alternatives. Thus, all passengers in maritime and inland waterway transport should be granted a minimum level of protection similar to those that air and rail passengers already have under European Union law. From just being somebody that should be transported from A to B the passenger is nowadays viewed as a customer.

The Regulation (EU) No 1177/2010 of the European Parliament and of the Council of 24 November 2010 concerning the rights of passengers when travelling by sea and inland waterways and amending the Regulation (EC) No 2006/2004 (hereinafter called: the Regulation)[1] establishes rules for sea and inland waterway transport as regards non-discrimination between passengers with regard to transport conditions offered by carriers, non-discrimination and assistance for disabled persons and persons with reduced mobility, the rights of passengers in cases of cancellation or delay, minimum information to be provided to passengers, the handling of complaints and general rules on enforcement. The regulation constitutes a significant improvement in enhancing passengers' rights on the basis of achievements of the majority of rules of the Athens Protocol incorporated into European law

[1] Regulation (EU) No 1177/2010 of the European Parliament and of the Council of 24 November 2010 concerning the rights of passengers when travelling by sea and inland waterways and amending the Regulation (EC) No 2006/2004, OJ L 334, 17.12.2010; Regulation (EC) No 2006/2004 of the European Parliament and of the Council of 27 October 2004 on cooperation between national authorities responsible for the enforcement of consumer protection law, OJ L 364, 9.12.2004

by Regulation (EU) No 392/2009 of the European Parliament and of the Council of 23 April 2009 on liability of carriers of passengers by the sea in the event of the accidents.[2]

2 APPLICATION OF THE REGULATION

The Regulation shall apply in respect of passengers travelling on passenger services where the port of embarkation is situated in the territory of a Member State and on passenger services where the port of embarkation is situated outside the territory of a Member State and the port of disembarkation is situated in the territory of a Member State, and on a cruise where the port of embarkation is situated in the territory of a Member State[3].

However, this Regulation shall not apply in respect of passengers travelling on board the ships certified to carry up to 12 passengers, on board the ships which have a crew responsible for the operation of the ship composed of not more than three persons or where the distance of the overall passenger service is less than 500 metres, one way, on excursion and sightseeing tours other than cruises, or on ships not propelled by mechanical means as well as original, and individual replicas of, historical passenger ships designed before 1965, built predominantly with the original materials, certified to carry up to 36 passengers.

Member States may, for a period of 2 years from 18 December 2012, exempt from the application of this Regulation seagoing ship of less than 300 gross tons operated in domestic transport, provided that the rights of passengers under this Regulation are adequately ensured under national law. Moreover, Member States may exempt from the application of this Regulation passenger services covered by public service obligations, public service contracts or integrated services provided that the rights of passengers under this Regulation are comparably guaranteed under national law.

3 PASSANGERS RIGHTS IN THE EVENT OF INTERRUPTED TRAVEL

In the case of a cancellation or a delay in departure of a passenger service or a cruise, passengers departing from port terminals or, if possible, passengers departing from ports shall be informed by the carrier or, where appropriate, by the terminal operator, of the situation as soon as possible and in any event no later than 30 minutes after the scheduled time of departure, and of the estimated departure time and estimated arrival time as soon as that information is available. If passengers miss a connecting transport service due to a cancellation or delay, the carrier and, where appropriate, the terminal operator shall make reasonable efforts to inform the passengers concerned of alternative connections.[4]

Right of assistance in the event of cancelled or delayed departures is of utmost importance. Therefore**,** where a carrier reasonably expects the departure of a passenger service or a cruise to be cancelled or delayed for more than 90 minutes beyond its scheduled time of departure, passengers departing from port terminals shall be offered free of charge snacks, meals or refreshments in reasonable relation to the waiting time, provided they are available or can reasonably be supplied. In the case of a cancellation or a delay in departure

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[2] Council decision of 12 December 2011 concerning the accession of the European Union to the Protocol of 2002 to the Athens Convention relating to the Carriage of Passengers and their Luggage by Sea, 1974, with the exception of Articles 10 and 11 thereof (2012/22/EU and 2012/2/23), OJ L 8, 12.1.2012

[3] Bulum, Božena, Prava putnika u pomorskom prijevozu prema Uredbi Europske unije br. 1177/2010, Zbornik Pravnog fakulteta u Zagrebu, 62, 4 (2012)

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where a stay of one or more nights or a stay additional to that intended by the passenger becomes necessary, where and when physically possible, the carrier shall offer passengers departing from port terminals, free of charge, adequate accommodation on board, or ashore, and transport to and from the port terminal and place of accommodation in addition to the snacks, meals or refreshments. For each passenger, the carrier may limit the total cost of accommodation ashore, not including transport to and from the port terminal and place of accommodation, to EUR 80 per night, for a maximum of three nights.

According to the obligations on re-routing and reimbursement in the event of cancelled or delayed departures where a carrier reasonably expects a passenger service to be cancelled or delayed in departure from a port terminal for more than 90 minutes, the passenger shall immediately be offered the choice between: re-routing to the final destination, under comparable conditions, as set out in the transport contract, at the earliest opportunity and at no additional cost, and reimbursement of the ticket price and, where relevant, a return service free of charge to the first point of departure, as set out in the transport contract, at the earliest opportunity.

Where a passenger service is cancelled or delayed in departure from a port for more than 90 minutes, passengers shall have the right to such re-routing or reimbursement of the ticket price from the carrier. The payment of the reimbursement provided shall be made within 7 days, in cash, by electronic bank transfer, bank order or bank cheque, of the full cost of the ticket at the price at which it was purchased, for the part or parts of the journey not made, and for the part or parts already made where the journey no longer serves any purpose in relation to the passenger's original travel plan. Where the passenger agrees, the full reimbursement may also be paid in the form of vouchers and/or other services in an amount equivalent to the price for which the ticket was purchased, provided that the conditions are flexible, particularly regarding the period of validity and the destination.

Compensation of the ticket price in the event of delay in arrival is strictly regulated**.** The minimum level of compensation shall be 25 % of the ticket price for a delay of at least 1 hour in the case of a scheduled journey of up to 4 hours, 2 hours in the case of a scheduled journey of more than 4 hours, but not exceeding 8 hours, 3 hours in the case of a scheduled journey of more than 8 hours, but not exceeding 24 hours, or 6 hours in the case of a scheduled journey of more than 24 hours. If the delay exceeds double the time the compensation shall be 50 % of the ticket price.

Passengers who hold a travel pass or a season ticket and who encounter recurrent delays in arrival during its period of validity may request adequate compensation in accordance with the carrier's compensation arrangements. These arrangements shall state the criteria for determining delay in arrival and for calculation of compensation. Compensation shall be calculated in relation to the price which the passenger actually paid for the delayed passenger service. Where the transport is for a return journey, compensation for delay in arrival on either the outward or the return leg shall be calculated in relation to half of the price paid for the transport by that passenger service.

The compensation shall be paid within 1 month after the submission of the request for compensation. The compensation may be paid in vouchers and/or other services, provided that the conditions are flexible, particularly regarding the period of validity and the destination. The compensation shall be paid in money at the request of the passenger. The compensation of the ticket price shall not be reduced by financial transaction costs such as fees, telephone costs or stamps. Carriers may introduce a minimum threshold under which payments for compensation will not be paid. This threshold shall not exceed EUR 6.

4 PASSANGERS RIGHTS ON INFORMATION AND COMPLAINTS

Carriers and terminal operators shall, within their respective areas of competence, provide passengers with adequate information throughout their travel in formats which are accessible to everybody and in the same languages as those in which information is generally made available to all passengers.[5] Particular attention shall be paid to the needs of disabled persons and persons with reduced mobility.

Information on passenger rights needs to be publicly available on board ships, in ports, if possible, and in port terminals[6]. The information shall be provided as far as possible in accessible formats and in the same languages as those in which information is generally made available to all passengers. When that information is provided particular attention shall be paid to the needs of disabled persons and persons with reduced mobility.

Carriers and terminal operators shall set up or have in place an accessible complaint-handling mechanism for rights and obligations. Where a passenger wants to make a complaint to the carrier or terminal operator, he shall submit it within 2 months from the date on which the service was performed or when a service should have been performed. Within 1 month of receiving the complaint, the carrier or terminal operator shall give notice to the passenger that his complaint has been substantiated, rejected or is still being considered. The time taken to provide the final reply shall not be longer than 2 months from the receipt of a complaint.

5 RIGHTS TO MOBILITY OF DISABLED PERSONS AND PERSONS WITH REDUCED MOBILITY

People with disabilities and those with reduced mobility have the right to make a reservation and to obtain a ticket in the same way as other passengers and at no extra cost. Reservations and tickets may, however, be refused in order to meet safety requirements and where the design of the passenger ship or port infrastructure and equipment makes the safe embarkation, disembarkation or carriage of a person with a disability impossible. In the case of such a refusal, all reasonable efforts must be made to find an alternative means of transport for the person concerned.

If the carrier, travel agent or tour operator requires that you be accompanied by a person capable of providing assistance to you, the accompanying person must be carried free of charge. Where you are being refused a reservation or a ticket, or you are required to bring an accompanying person, you should be immediately informed of the reasons why. On request, those reasons must be notified to you in writing, within 5 working days of your request. Where you hold a reservation or a ticket and you have complied with the notification requirements about your specific needs, but you are nonetheless denied embarkation under the Regulation, you should be offered the choice between reimbursement and re-routing.

Carriers and port operators must provide passengers with information on their rights and the accessibility of their facilities. The information is to be available in accessible formats.

Subject to the access conditions of their facilities, carriers and terminal operators must provide assistance free of charge to people with disabilities and people with reduced mobility in ports and on board ships, including embarkation and disembarkation. Carriers, travel agents and tour operators may refuse to accept a reservation from, to issue or otherwise provide a

[5] Communication from the Commission to the European Parliament and the Council, A European vision for Passengers: Communication on Passenger Rights in all transport modes, COM(2001)898, 19.12.2011
[6] Strengthening passengers rights within the European Union, COM (20005) 46 final of 16 February 2005

ticket to or to embark a disabled person or person with reduced mobility: in order to meet applicable safety requirements established by international, Union or national law or in order to meet safety requirements established by the competent authorities, or where the design of the passenger ship or port infrastructure and equipment, including port terminals, makes it impossible to carry out the embarkation, disembarkation or carriage of the said person in a safe or operationally feasible manner.

6 LEGAL FRAMEWORK FOR IMPLEMENTATION

Community legislation relating to passenger transport services is a part of the Common Transport Policy instituted by Articles 70 to 80 of the EC Treaty[7]. The adequate protection of passengers when travelling by water is a key concern of the European Union transport policy. New passengers' right have been established and carriers' obligation imposed[8].

The aim is to help carriers towards a more coherent and effective application of European law, national authorities towards a harmonised enforcement of passenger protection and passenger towards a better understanding of what they can legitimately expect as minimum quality services when travelling.

Carriers and terminal operators shall establish disability-related training procedures, including instructions, and ensure that their personnel, including those employed by any other performing party, providing direct assistance to disabled persons and persons with reduced mobility are trained or instructed and their personnel who are otherwise responsible for the reservation and selling of tickets or embarkation and disembarkation, including those employed by any other performing party, are trained or instructed.

On the other hand, passengers need to know and understand their rights. Passengers need to be confident that they will be applied and that authorities will effectively protect them if necessary. In author's opinion, we need even more public awareness of rights and how to claim them through easily accessible complaint handling procedures and effective means of redress.

Enforcing the rules is crucial and if this is not done effectively, transport operators have no economic incentive to comply. Not only do national differences in applying the rules confuse both passengers and transport operators alike, they also create damaging distortions in the market. Therefore, according to Regulation each Member State shall designate a new or existing body or bodies responsible for the enforcement of this Regulation as regards passenger services and cruises from ports situated on its territory and passenger services from a third country to such ports. A Member State may decide that the passenger as a first step shall submit the complaint covered by this Regulation to the carrier or terminal operator and/or that the national enforcement body or any other competent body designated by the Member State shall act as an appeal body for complaints not resolved.

By 1 June 2015 and every 2 years thereafter, the enforcement bodies shall publish a report on their activity in the previous two calendar years, containing in particular a description of actions taken in order to implement the provisions of this Regulation, details of sanctions applied and statistics on complaints and sanctions applied.

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[7] Consolidated versions of the Treaty on European Union and the Treaty on the Functioning of the European Union, OJ C 83, 30 March 2010

[8] Karsten, Jens, Passengers, consumers and travellers: The rise of passengers' rights in EC transport law and its repercussion for Community consumer law and policy, J Consum Policy (2007) 30:117-136

7 CONCLUSIONS

Since 18 December 2012 passengers travelling by sea or inland waterway within the European Union have rights similar to those available to airline and rail passengers if their service is cancelled or delayed. The Regulation is designed to protect passengers using waterborne transport by establishing certain rights and a guaranteed level of service, including passengers with disabilities which cannot be discriminated against and should be provided with assistance.

The Regulation gives passengers rights which are in addition to their existing statutory rights[9]. In most cases, it covers aspects of passenger travel that are outside the scope of other compensation regimes, but there are some points of overlap between regimes. Without prejudice to social tariffs, the contract conditions and tariffs applied by carriers or ticket vendors shall be offered to the general public without any direct or indirect discrimination based on the nationality of the final customer or on the place of establishment of carriers or ticket vendors within the Union.

In author’s opinion, passenger law is addicting to the edifice of consumer law. Passenger rights are based on non-discrimination, accurate, timely and accessible information and immediate and proportionate assistance. The trend of passenger transport law adopting the concepts of European Communities consumer law mirrors the general trend for the transport sector to move away from special regimes for this industry.

Moreover, the author is emphasizing the need for adequate training of seafarers and employees to ensure a thorough understanding of the Regulation particularly in information and assistance providing procedures in port, including embarkation and disembarkation, as a key element for its effective Regulation enforcement.

In setting quality standards, full account shall be taken of internationally recognised policies and codes of conduct concerning facilitation of the transport of disabled persons or persons with reduced mobility, notably the International Maritime Organization's Recommendation on the design and operation of passenger ships to respond to elderly and disabled persons’ needs.

[9] Regulation (EU) No 392/2009 of the European Parliament and of the Council of 23 April 2009 on liability of carriers of passengers by the sea in the event of the accident, OJ L 131/24, 28.05.2009; Regulation (EC) No 261/2004 of the European Parliament and of the Council of 11 February 2004 establishing common rules on compensation and assistance to passengers in the vent of denied boarding and of cancellation of long delays and flights, and repealing Regulation (EEC) 295/91, OJ L 46, 17.2.2004; Council Regulation (EEC) No 4055/86 of 22 December 1986 applying the principle of freedom to provide services to maritime transport between Member States and between Member States and third countries, OJ L 378, 31.12.1986; Council Directive 90/314/EEC of June 1990 on package travel, package holidays and package tours, OJ L 158, 23.6.1990

SHORTEST TRAIL PROBLEM WITH RESPECT TO PROHIBITED MANEUVERS

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ABSTRACT

There are several prohibited maneuvers in real transportation networks e. g. prohibited left turn, prohibited right turn, direct to be followed etc. A transportation network can be modeled as an arc weighted digraph. A prohibited maneuver can be modeled as a prohibited sequence of adjacent arcs. A feasible route in transportation network is modeled as a path or a walk in corresponding digraph such that this path or walk does not contain any prohibited sequence of arcs. The paper presents several attitudes to just formulated problem suitable for huge transportation networks (e.g. road network for Europe used in GPS navigators) and compares them from several points of view.

Keywords: Route planning, prohibited maneuver, digraph, shortest path

1 INTRODUCTION

The part of graph theory concerning shortest path problem seemed to be closed. Many types of shortest path algorithms were published, implemented and successfully applied in practice. However, GPS street navigation carries with its new challenges. European street network contains approximately 20 million vertices and 50 million arcs. These numbers have been rising since the street models contain more and more details – e. g. not only streets but also street lines, not only street crossings but also important points of street crossings, etc. Usable route planner should propose such instructions which obey traffic rules. Most of them are one way streets and prohibited left turn, prohibited right turn and prohibited U-turn.

On one hand, the users require results in real time, and on the other hand, available computational devices have to be cheap, mobile, and small and energy saving what implies limited CPU speed and limited RAM size. Effective implementation of all requirements and additional constraints expects development of new exact or suboptimal mathematical methods.

2 FUNDAMENTAL GRAPH THEORY DEFINITIONS

Graph theory terminology is considerably not uniform. That is why we introduce here several fundamental graph definitions.

Nowadays road and street network contains a lot of one way segments. If more detailed model is used where street segments are street lines then almost all of them are unidirectional. Therefore a directed graph will be the fundamental structure for our research.

Definition 1

A *digraph* (a directed graph) is an ordered pair $G = (V, A)$, where V is a nonempty finite set and A is a set of ordered pairs of the type (u, v) such that $\in V$, $v \in V$ and $u \neq v$. The elements of V are called vertices and the elements of A are called arcs of the digraph G.

Definition 2

A (v_1, v_k)-*walk* in digraph $G = (V, A)$ is an alternating sequence of vertices and arcs of the form $(v_1, v_k) = (v_1, (v_1, v_2), v_2, \dots, v_{k-1}, (v_{k-1}, v_k), v_k)$.

A (v_1, v_k)-*trail* in G is a (v_1, v_k)-walk in G with no repeated arcs.

A (v_1, v_k)-*path* in G is a (v_1, v_k)-walk in G with no repeated vertices.

Definition 3

Let μ be a walk. A *subwalk* of μ is arbitrary subsequence of μ starting and finishing with a vertex, i.e. $(v_i, (v_i, v_{i+1}), v_{i+1}, \dots, v_{j-1}, (v_{j-1}, v_j), v_j)$, where $1 \leq i \leq j \leq k$.

Definition 4

A *prohibited maneuver* is a walk declared as prohibited. A walk μ is *feasible with respect to prohibited maneuvers* (or only feasible), if no prohibited maneuver is a subwalk of μ.

Definition 5

A *simple prohibited maneuver* is a walk declared as prohibited containing only two arcs, i.e. $\omega = (i, (i, j), j, (j, k), k)$.

A simple prohibited left or right turn can be modeled as a prohibited pair of arcs as shown in Figure 1. Prohibited maneuver is $(u, (u, v), v, (v, w), w)$ or simply tuple $[(u, v), (v, w)]$.

Feasible $u - w$ trail with respect to this prohibited maneuver is $(u, (u, v), v, (v, x), x, (x, y), y, (y, v), v, (v, w), w)$.

In more detailed models prohibited left turn, prohibited right turn and prohibited U-turn can be formulated as a prohibited sequence of vertices and arcs which will be called a prohibited maneuver. Prohibited maneuver is a traffic engineering notion – it cannot be derived from graph theory properties of road network. Prohibited maneuvers belong to input data of shortest route problem. Some of the prohibited U-turns in Figure 2 from point a to point b are:

- $(a, (a, d), d, (d, i), i, (i, e), e, (e, b), b)$
- $(a, (a, d), d, (d, h), h, (h, e), e, (e, b), b)$
- $(a, (a, d), d, (d, h), h, (h, i), i, (i, e), e, (e, b), b)$

Some of the real prohibited maneuvers in the road network are shown in Figure 3.

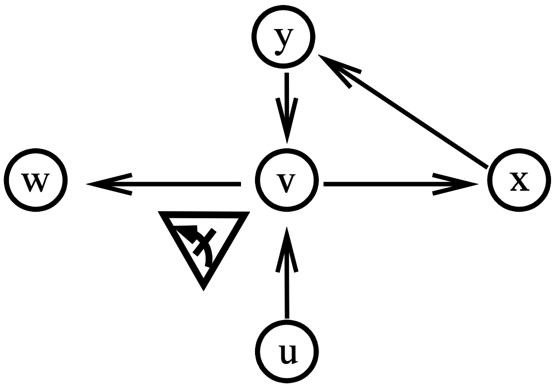

Figure 1: Prohibited left turn

Source: Palúch, S., Peško, Š.: Kvantitatívne metódy v logistike. Žilinská univerzita v Žiline, EDIS Žilina, 2006.

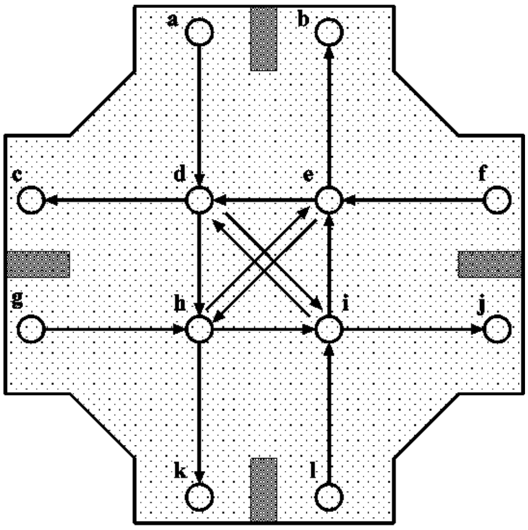

Figure 2: Model of junction

Definition 6

An arc weighted digraph $G = (V, A, c)$ is an ordered triple where $G = (V, A)$ is a digraph and $c: A \to R$ is a real function defined on the arc set A, the value $c(a)$ for $a \in A$ is called the weight of the arc a (or sometimes the arc-weight, the length or the cost of the arc a). In this paper we will assume that $c(a) \geq 0$. This condition is fulfilled in many practical applications.

Definition 7

The length of the $u - v$ walk μ in a digraph $G = (V, A, c)$ is the total sum of arc-weights of its arcs, whereas the arc weight is added to the total sum as many times as many times it appears in the walk.

Definition 8

Denote $V^+(v) = \{w | (v, w) \in A\}$, denote $A^+(v) = \{(v, w) | (v, w) \in A\}$. The forward star $F_{\text{star}}(v)$ of vertex v is a subgraph of $G = (V, A)$ with vertex set $V^+(v) \cup \{v\}$ and arc set $A^+(v)$, i.e. $F_{\text{star}}(v) = (V^+(v) \cup \{v\}, A^+(v))$.

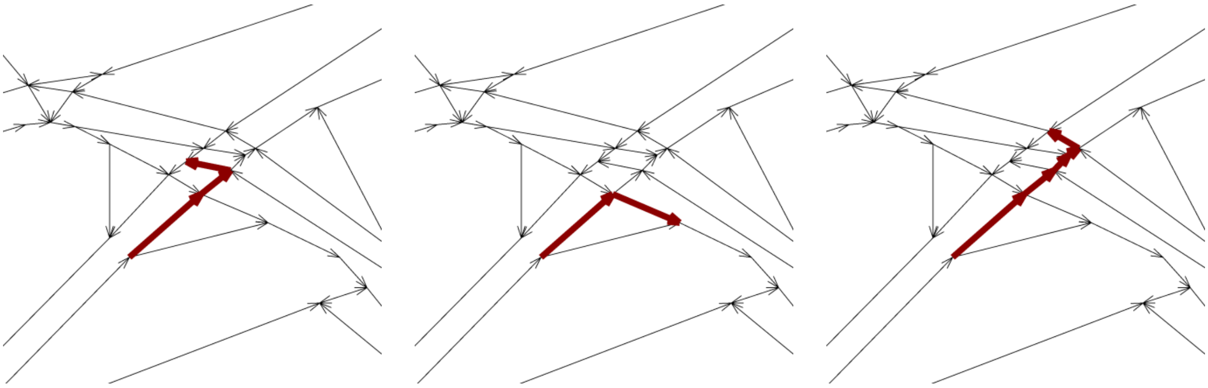

Figure 3: Real prohibited maneuvers in the road network

3 AN ALGORITHM TO SEARCH FEASIBLE SHORTEST TRAIL

3.1 An algorithm to search feasible shortest trail with respect to simple prohibited maneuvers

Palúch and Peško in [4] present a solution how to find shortest trail with respect to simple prohibited maneuvers (prohibited turns) in digraph $G = (V, A. c)$.

Let Z be a set of prohibited turns,

$Z = \{[(u,v),(v,w)] | [(u,v),(v,w)] \text{ is tuple of arcs of prohibited maneuver}\}$.

Let I_V be a set of loops $I_V = \{(v,v) | v \in V\}$.

Then they construct a special arc-based digraph $G_A = (V_A, A_A, c_A)$, where

- $V_A = A \cup I_V$,
- $A_A = \{[(x,y),(y,z)] | (x,y),(y,z) \in A\} \cup \{[(y,y),(y,z)] | (y,z) \in A\} \cup \{[(x,y),(y,y)] | (x,y) \in A\} - Z$.
- $c_A([(x,y),(y,z)]) = \begin{cases} 0 & \text{if } x = y \\ c(x,y) & \text{if } x \neq y \end{cases}$

Then the problem to find feasible shortest trail with respect to prohibited turns Z in digraph G is equivalent to find shortest path in arc-based digraph G_A.

3.2 A modified *k*–shortest path algorithm to search feasible shortest trail

Palúch in [5] presents a multi label algorithm for k shortest paths problem. Multiple labels for any vertex allow that this algorithm can be modified to find a trail, too. We find several shortest trails first and then we choose the shortest feasible trail among them.

For every vertex $i \in V$ we remember a set of definitive labels L_i. Every label is in the form (k, t, x, x_k), where

- k is the sequence number $u - i$ trail,
- t is the length of $u - i$ trail,
- x is the last but one vertex on $u - i$ trail,
- x_k is the sequence number of the trail into last but one vertex x.

An element of heap E is in the form (w, t, x, x_k), where

- w is the candidate to become pivot vertex,
- t is the length of $u\!-\!w$ trail, the priority of element of heap,
- x is the last but one vertex on $u\!-\!w$ trail,
- x_k is the sequence number of trail into last but one vertex x.

Then the algorithm to search feasible shortest $u-v$ trail in digraph $G=(V,A,c)$ with respect to prohibited maneuvers can be described as follows:

Step 1

Initialization
Let $L_u=\{(1,0,0,0)\}$. For every $i\in V, i\neq u$ let $L_i=\emptyset$.
Let $E=\emptyset$. For every $i\in V^+(u)$ let $E=E\cup\{(i,c(u,i),u,1)\}$.

Step 2

Get an element (w,t,x,x_k) from heap E with minimal component t.
Let $k=|L_w|+1$.
Let $L_w=L_w\cup\{(k,t,x,x_k\}$.
For every $i\in V^+(w)$: If arc (w,i) is not in $u\!-\!w$ trail and expanded $u\!-\!i$ trail does not contain prohibited maneuver then let $E=E\cup\{(i,t+c(w,i),w,k)\}$.

Step 3

If $L_v=\emptyset$ and $E\neq\emptyset$ then go to Step 2.

Step 4

Finish
The shortest $u-v$ trail with respect to prohibited maneuvers can be constructed from labels L_i:
Let $L_i[j]$ be a label of vertex i with $k=j$, so if $(k,t,x,x_k)\in L_i$, then $L_i[k]=(k,t,x,x_k)$. Let $L_i[k]^{()}$ be a component part of label, i.e. $L_i[k]^{(t)}=t$, $L_i[k]^{(x)}=x$ and so on.
Then

$$
\begin{array}{ll}
w_s=v, & k_s=1,\\
w_{s-1}=L_{w_s}[k_s]^{(x)}, & k_{s-1}=L_{w_s}[k_s]^{(k)},\\
w_{s-2}=L_{w_{s-1}}[k_{s-1}]^{(x)}, & k_{s-2}=L_{w_{s-1}}[k_{s-1}]^{(k)},\\
\vdots & \vdots\\
w_1=L_{w_2}[k_2]^{(x)}. & k_1=L_{w_2}[k_2]^{(k)}.
\end{array}
$$

And finally feasible shortest $u-v$ trail is
$(u=w_1,(w_1,w_2),w_2,\dots,w_{s-1},(w_{s-1},w_s),w_s)$.

Described algorithm was implemented using programming language C# in Microsoft Visual Studio 2010 using target framework .NET 4.0. The most time consuming routine is determining if arc (w,i) is or is not in $u\!-\!w$ trail. This routine can be optimized using minimal length of $u\!-\!w$ trail in label $L_w[1]^{(t)}$.
Number of 100 feasible shortest trails with randomly chosen vertices u,v is computed on digraph of road network of Slovakia. This digraph contains 237,417 vertices, 516,463 arcs

and 12,360 prohibited maneuvers. Feasible shortest trail contains in average 628 arcs and its length is in average 196.5 km.

The average running time and number of created and analyzed labels of basic and optimized algorithm is shown in Table 1. Program was run on HP ProBook 6550 with AMD Phenom(tm) II N830 Tripple-Core 2.1 GHz Procesor and 4 GB of main RAM.

Table 1: Comparison of running time of basic and optimized algorithm

Algorithm	Running time [s]	Created labels	Analyzed labels
Basic	65.80	517,413	238,968,199
Optimized	2.27	517,413	522,149

4 CONCLUSION

Feasible shortest trail is a common problem in navigation systems. A shortest feasible trail algorithm has to be suitable for application in mobile devices with limited computation power and limited memory space.

The open problem is how many labels are needed for a vertex to find a feasible shortest trail. It is possible that this number is different for vertices in prohibited maneuvers and vertices not contained in any of the prohibited maneuver. Reduction of the number of labels for a vertex decreases the total number of created labels and makes our algorithm faster.

Hart, Nilsson, Raphael, Goldberg, Harrelson, Gutman in their works [1], [2], [3] show that some information about transportation network (e.g. GPS or pre-computed shortest paths) can be used to speed up solving the shortest path problem. We intend to make use of this information to speed up our algorithm to find feasible shortest trail in our next work.

ACKNOWLEDGEMENTS

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CONTAINER TERMINAL SIMULATION: A CASE STUDY

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ABSTRACT

In the movement of freight across the container transport chain, container terminals play a key role. They represent points of transfer between different modes, and the transit time of container through them represents one of the most relevant bottlenecks in transport chain. Inland container terminals are smaller one, but very important in feeding port container terminals with freight. Also, they act as base container terminals in landlocked countries. Establishing inland container terminals as efficient transfer points requires appropriate capacity planning and operations optimisation. For this purpose, the use of models has been very often. Simulation models, as one kind of models are particularly well applicable due to stochastic and dynamic nature of container terminal processes. In order to reproduce the activities carried out inside an inland container terminal and to calculate the total container transit time as one of two major bottlenecks of the intermodal transport chain, this paper approach discrete event simulation modeling. For modeling the academic version of software Arena was used. For the application of the model an inland container terminal in Serbia was chosen: the road-rail container terminal ZIT. Different scenarios were simulated with various number of handling equipment and terminal working days.

Keywords: Container terminal, Simulation, Arena

1 INTRODUCTION

The development of international merchandise trade progressed at an exceedingly dynamic rate during the postwar period. Between 1950 and 2000, trade volume increased an average of 6% annually. This development has been driven by progressive globalisation and the intensification of the international division of labor [3]. On the other hand, one of the key globalisation drivers was the onset of containerization. Use of container as "hardware" have revolutionized global trade, but in allowing for a box to be transferred from one mode of transport to another, containerization also became the "software" allowing for true intermodalism - the coordinated flow of goods over long distances using different modes [7]. In the movement of freight across the container transport chain, container terminals play a key role. They represent points of transfer between different modes, and the transit time of container through them represents one of the most relevant bottlenecks in transport chain. The major challenge for container terminals is how to successfully handle the escalation in container traffic demand? Hence, container terminals are in constant searching for solutions to manage additional demand, otherways, they risk losing business to their competitors.

Inland container terminals are smaller one, but very important in feeding port container terminals with freight. Also, they act as base container terminals in landlocked countries. Establishing inland container terminals as efficient transfer points requires appropriate capacity planning and operational optimisation. When we talk about capacity problem, the main question is 'does the terminal have the capacity to manage the additional containers'?

Common solution assumes adding extra capacity through physical expansion: new storage yards, new handling equipment, etc. On other hand, the issues of operational considerations are connected with efficiency checking of different types of operational changes such as technologies of container storage, moving and handling. For this purpose, the use of models has been very often. Simulation models, as one kind of models are particularly well applicable due to stochastic and dynamic nature of container terminal processes. In the last several years discrete event simulation models in the object oriented approach have been proposed as decision support systems, with reference to container terminals. The object oriented approach has been particularly useful to describe logistic operation of the main system terminal modules [1]. In this paper discrete event simulation modeling is used in order to reproduce the activities carried out inside an inland container terminal and to calculate the total container transit times as one of two major bottlenecks of the container transport chain. The remainder of the paper is organized as follows. The next section provides the basics of container terminals and containerization. The third section reports the description of inland container terminal modelling. Section four illustrates the case study and simulation model design process. The model is described in terms of required inputs, algorithms used and outputs provided. In the final section, conclusions are drawn and research limitations are identified.

2 CONTAINER TERMINALS

2.1 Intermodal transport and containerization

Intermodal transport represents transportation technology in which goods movement is performed by means of intermodal loading units (e.g. containers, swap bodies, trailers) that are not subject to deconsolidation during the entire transport chain. Intermodal transport may be viewed as an alternative to unimodal transport in the case of long travel distances and high volumes. Intermodal transport efficiency and competitiveness with respect to full-road transportation lie essentially in the lower transport costs that can be achieved in the central part of the trip (i.e. by rail or sea), but also highly depend on the efficiency and effectiveness of the activities performed within the network 'nodes' (i.e. ports or intermodal terminals) [6].

Containerization can be considered as the industrial revolution of the general cargo transportation and handling methods and as an activator of full intermodalism. The main rationale behind the setting of container transportation chain was to improve the efficiency of transhipments from a cost, time and reliability standpoint. Container transportation is nowadays the major component of the freight intermodality. Containerization and intermodality revolutionized and redefined the modern shipping, ports and, at a later stage, inland transportation. From the initial spreading of the containerization up to no now, modern ports and container terminals have been built to efficiently and efficaciously accommodate modern liner vessels and perform container transfer operations through the employment of specialized equipments. New nodes on hinterland routes of seaports have also been built to function as regional inland satellite terminals with frequent connections to the main container terminals [5]. On that way containerization's impact has been significant not only on global trade and the maritime transport chain, but also with major impact to inland transport chain.

2.2 Port and inland container terminals

The principle of the modern container transport chains is a network of container terminals that are interlinked by high capacity transport routes and that serve as a points of transfer between different transport modes. There are two major types of container terminals: port and inland container terminals.

Port container terminals are key hubs of global supply chain networks and they role, as a seamless intermodal interface between marine and overland transportation, is to stevedore and store containers [4]. The port container terminals is generally found in one or both of two types of ports - a transhipment hub designed to optimize the transfer of containers between network long-haul trunk lines and/or between trunk and feeder lines; or a gateway port designed to serve the needs of local, regional, and sometimes large inland populations [2]. These concepts are illustrated in Figure 1.

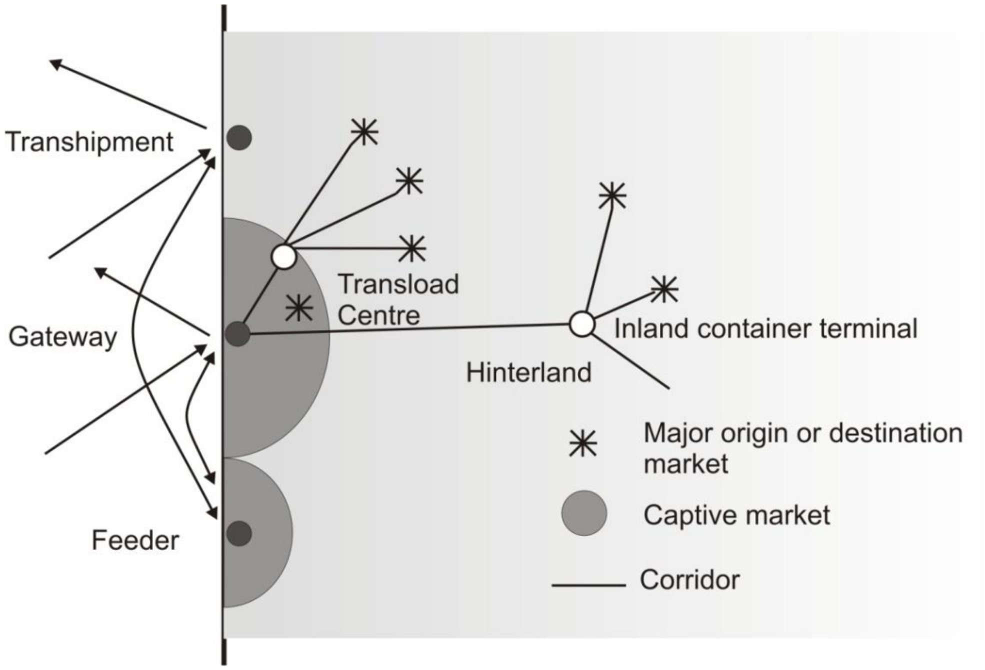

Figure 1: Basic port container concepts

Source: adapted from [2]

The productivity of the modern port container terminal is highly dependent on its equipment, yard configuration, processes organization and strength of hinterland connectivity. Even more, connection with hinterland could be one of the major bottleneck, because of congestion and reliability problems. Hence, there is a necessity for searching a new container chain organization and solutions through the development of modern inland container terminal facilities to relieve arising congestion in port areas, rationalize the pattern of inland freight movement, enlarge the port hinterland and attract additional traffic [5]. The service portfolio of inland container terminals can be ranged from providing only intermodal and cargo handling service to broad range of value added services. That means, that inland container terminals may be functioning as simple nodal point for bimodal or trimodal container flows, but also as an logistic centres.

The concept of inland container terminals come under different forms in international bibliography, such as "plataformes logistiques", "interport", "transport centres", "freight villages", "dry port", "logistic centre", etc. Although there are a many different names used to indicate inland container terminals, the basic concept is very similar. Inland container terminals represents a facility located in the hinterland of one or more seaports, where different services are available to carriers and shippers, such as: container stuffing and unstuffing, rail-road transhipping, temporary storage of import/export full and empty containers, customs clearance and inspection, container tagging and sorting, container repair, manipulation and processing of the containers' content for later marketing efforts at ultimate destinations [5]. These typical processes in inland container terminals are summarized in Figure 2.

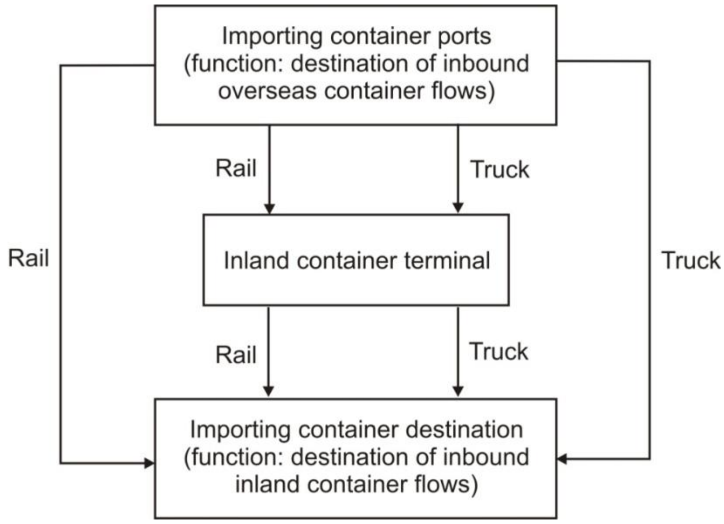

Figure 2: The concept of inland container terminals

Source: adapted from [5]

In existing port terminals there are often problems of space and traffic constraints because it is not possible to expand to the surrounding areas. Hence, a new logistic network systems which assumes dedicated rail connection between port yard and inland terminals are needed. Because of that, inland container terminals are gaining increasing importance in the global logistics networks, and therefore particular attention in terms of their planning, organization and processes optimization must be given to them.

3 INLAND CONTAINER MODELLING

Generally, modelling represents one of the basic human brain processes. There is a very strong connection between human way of thinking and problem solving. By modelling we express ability of thoughts and imaginings, use of symbols and language, communication, and performing generalizations based on experience, and dealing with unexpected. Modelling is a cost-effective use of something (model) instead of something else (real system) with the aim of reaching a particular knowledge. Result of modelling is model. In this section, the major components and operations of inland container terminals relevant to simulation model is presented.

An inland container terminal constitutes a connection in the container transport chain. In the terminal two essential operations are carried out:

- transfer of container from different modes of inland transport;
- temporary and intermediary deposit of containers between different transport phases (truck, train).

To perform these operations the inland container terminal must processes different components:

- a rail operation area, where the trains wait for further processing;
- transhipment areas for transfer container;
- yards, where containers are temporarily deposited while waiting to continue their trip;
- gates, through which containers enter or exit from the terminal by track or train.

The inland container terminal can be divided into entry, buffer and loading/unloading areas. The functional scheme of the inland container terminal is represented in Figure 3.

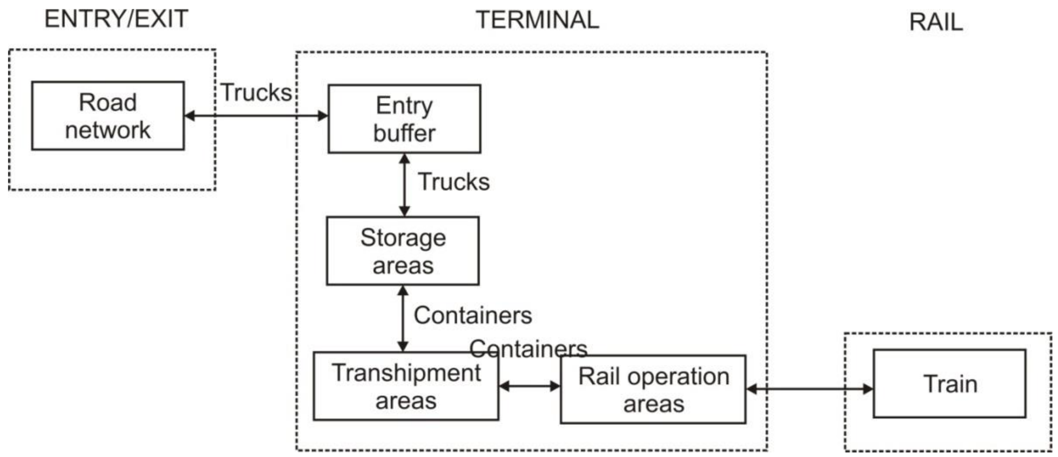

Figure 3: Functional scheme of the inland container terminal

Source: adapted from [4]

The basic equipments used for handling containers are gantry cranes, external trucks and yard transporters (forklifts, reach stackers, shuttle carriers). The typical container handling operations assumes [4]:

- discharging operation: unloading inbound containers and placing them in a storage yard;
- loading operation: moving outbound containers from storage yard to transhipment tracks and loading the container into a container train;
- delivery operation: transporting inbound containers from a storage yard to customers through gates in container terminals;
- receiving operation: picking up outbound containers from trucks and placing them in a storage yard; and
- re-marshalling operation: arranging containers in a storage yard to minimize rehandling in loading and delivery operations.

The description of fundamental container terminal processes, which will be modeled are as follows. When a container train arrives at a terminal, gantry crane is put in charge of stevedoring containers. While discharging, portal crane pick up containers from train and load them directly onto external trucks (direct transhipment) or transfer them to storage yard with container forklifts. The containers in storage yard are placed temporarily before they are moved to external trucks (indirect transhipment). Outbound containers arrive at a container terminal by external trucks are taken directly to transhipment trucks (they are picked up and loaded onto a relevant train) or taken to storage yard (picked up with forklifts and stored in relevant container blocks). Within storage areas there is a place for container repairing. Based on this descriptions, modelling of case study inland container terminal has been done.

4 SIMULATION MODEL

For modeling and building an simulation model, the academic version of software Arena was used. Arena is a discrete events simulator based on SIMAN language. Discrete-event modelling is a proven technology for the analysis of large and complex industrial and business systems. A computer model is developed that mimics the dynamic behavior of the simulated system over time. Simulation modelling allows container terminal to experiment and validate operational, infrastructure, or technology changes before spending money on construction, providing inexpensive insurance for project success [7].

In this paper, for the application of the model an inland container terminal in Serbia was chosen: the road-rail container terminal ZIT. The developed simulation model could be structured into three parts: the input section, the computation section and the output section, as already have been done in [6]. The input section assumes several data required by the model such as: the volumes handled by the terminal (average number of road vehicles and trains, number of daily containers, and handling equipment capacity, operational and organizational inputs (average times for performing particular operations). Input computation and application of the algorithms are performed only for the purpose of operational analysis in the mean of time analysis. This simulation model didn't perform cost analysis because of problems with collection of necessary data. As an output, the model provides a tables and graphs including operational information such as defined terminal performance for several different operational scenarios. The developed model is represented in Figure 4.

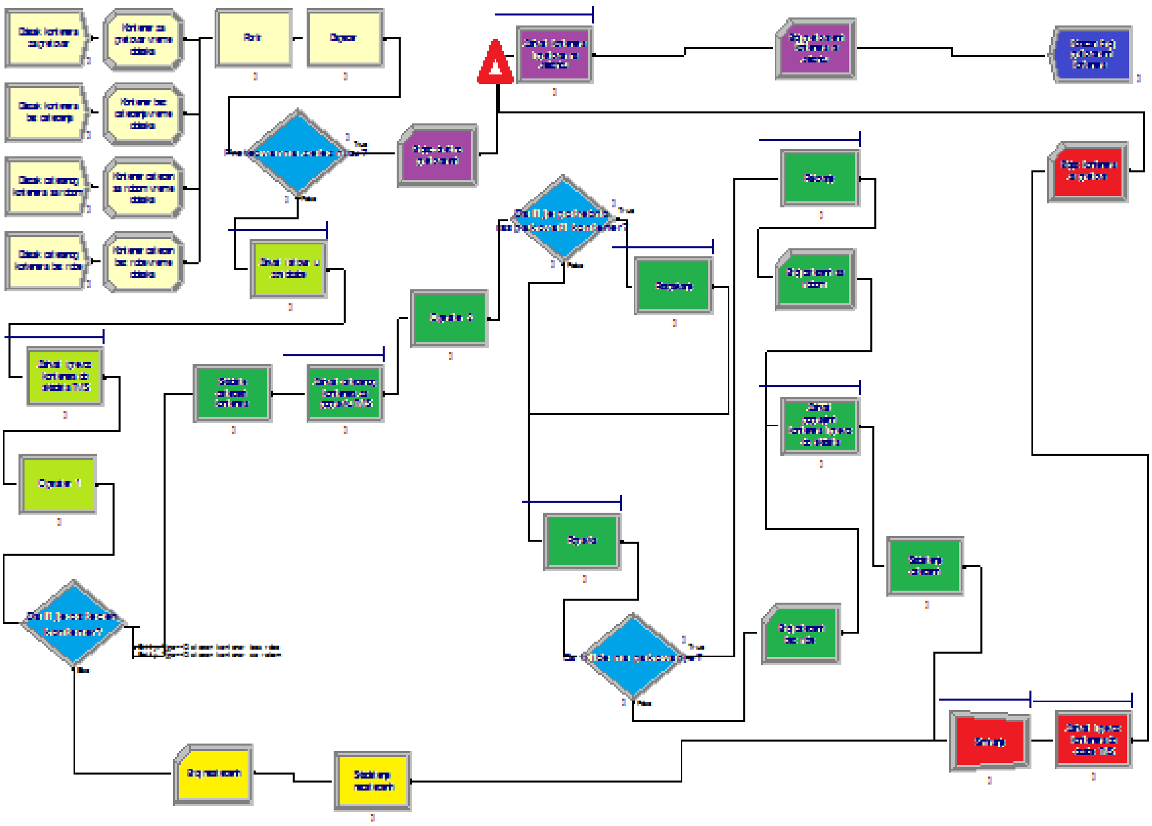

Figure 4: The developed simulation model for case study inland container terminal

First, two operational scenarios was modelled (with five days working week (named as S1) and six days working week (named as S2)). After that, for six days working week (S2) two additional operational scenarios was modelled regards with handling equipment capacity (the first scenario is current state (named as S21) and the second scenario assumes adding handling equipment capacity (S22)). The inland container terminal model assumes four different container flows: containers without repairing, empty containers for repairing, full containers for repairing and containers for transhipment. Figure 5 shows delay time (in minutes) for these four container flows for first two scenarios in one simulated year.

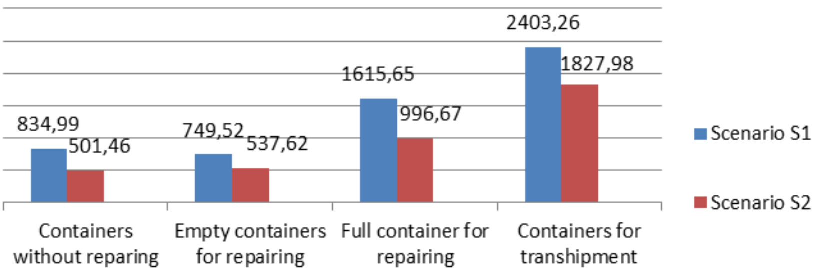

Figure 5: Delay time for different containers flows

Critical points or operational bottlenecks in viewed inland terminal could be identified on the basis of queuing time (or delays). One way to eliminate or at least mitigate these delays is to increase the capacity of resources and changes in working times. Figure 6 represents delay times (in minute) for scenario S2 for two cases: current handling capacity state (S21) and situation with expanding handling capacity (S22).

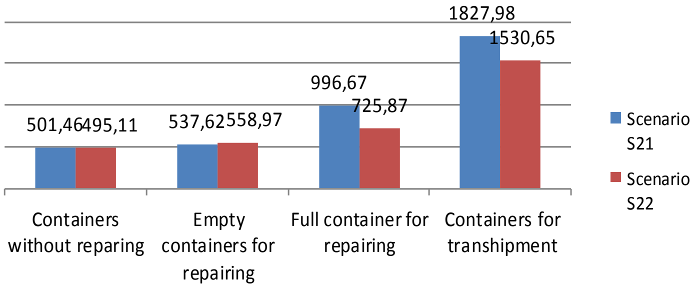

Figure 6: Delay time for different containers flows for two situations within scenarios S2

Results from Figures 5 and 6 reveal that decreasing in delay times could be achieved through operational changes due to working times and due adding extra capacity. They shows how big these improvement are. However, it have to be noticed that these model didn't include cost dimension. Hence, to evaluate the feasibility of each proposed scenario, a further analysis have to be performed taking into account costs of additional working times and extra handling capacity.

5 CONCLUSIONS

In this paper, we present inland container terminal simulation model based on Arena software. Our models represents basic processes with inbound and outbound container flows as well as the basic features of inland container terminals. With the model, we demonstrate what kind of results could be achieved with this simulation models. The time performance of viewed container terminal is assessed from several different simulation scenarios with various handling equipment capacity and terminal working days. The results show that the time operational performance of inland container terminal depends on the capacities of particular terminal facilities.

There are two future research directions regards to this paper. The first is to eliminate too many assumptions in simulation model. We expect that further work will allow us to eliminate the those assumptions. The second priority is to make correlation between the operational performances and operational and investment costs. The results are expected to be effectively employable in determining optimal level of investment costs with regard to the various constraints, including budgets and spaces.

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KALMAN FILTERING APPLIED TO FORECASTING THE DEMAND FOR RAILWAY PASSENGER SERVICES

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ABSTRACT

For future planning purposes, every industry must have a flow of information concerning the expected demand for its product. In the case of railways, both the capacities to be used and the expected total revenue depend on the level of future rail passenger traffic, so that the railways have a crucial need for forecasts of their passenger traffic. This paper presents a forecasting approach for railway passenger traffic using the popular Autoregressive Integrated Moving Average (ARIMA) models in state space form. It was found that the recurring pattern of the monthly rail passenger flows is well described by Seasonal ARIMA, that is SARIMA $(0,1,1)(0,1,1)_{12}$ model. The identified model was incorporated in the state space framework where classical Kalman recursion is applied for calculation of forecasting values. The Kalman procedure is presented as an elegant approach for prediction of SARIMA processes in state space form. Forecasting results are compared to the results of classic ARIMA approach and they demonstrate the capability and effectiveness of the proposed model, which can assist managers to better predict rail passenger demand.

Keywords: forecasting, railway, passenger service, SARIMA, State Space Models, Kalman filtering

1 INTRODUCTION

Passenger flow forecasting is a vital component of transportation systems which can be used to fine-tune travel behaviors, reduce passenger congestion, and enhance service quality of transportation systems. The forecasting results of passenger flow can be applied to support transportation system management such as operation planning, and station passenger crowd regulation planning. In some cases, it is used for establishing the daily train timetables which have direct impact on resource allocation and utilization. The success of strategic and detailed planning of public transportation highly depends on accurate demand in formation data. Also, passenger flow forecast represent a basic work for urban rail transport project investment decision analysis. It is a measure of the economic costs of construction projects. Therefore, scientific and reasonable passenger flow forecast helps the fundamental guarantee for investment decision.

The transportation forecasting approaches can be generally divided into two categories: parametric and non-parametric techniques (Smith et al., 2002). Parametric techniques and non-parametric techniques refer to the functional dependency assumed between independent variables and the dependent variable. In the traditional parametric techniques, historical average, smoothing techniques and autoregressive integrated moving average (ARIMA) have been applied to forecast transportation demand. For the non-parametric techniques, several methods have been used to forecast the transportation demand such as neural networks (Dougherty, 1995; Vlahogianni et al., 2004), non-parametric regression (Smith et al., 2002; Clark, 2003), Kalman filtering models (Wang and Papageorgiou, 2007) and Gaussian maximum likelihood (Tang et al., 2003).

In this paper, we studied the railway passenger demand in Serbia. On the base of available historical data we proposed a seasonal autoregressive integrated moving average (SARIMA) processes for modeling the rail passenger flow. For the purpose of forecasting the estimated SARIMA model was incorporated into the state space framework and classical Kalman recursion were applied. Results for multi-step ahead prediction were compared with the classic SARIMA model.

The remainder of this paper is organized as follows. The main characteristics of SARIMA models are given in Section 2. The state space representation of SARIMA models is presented in Section 3. In Section 4., Kalman filtering method for prediction and estimation of processes given by state space representations is described. The efficiency of proposed method is demonstrated by modeling the rail passenger demand in Section 5. Section 6 concludes the results of this work.

2 SARIMA MODELS

ARIMA is the method first introduced by Box and Jenkins (1976) and until now become the most popular for forecasting univariate time series data. This model has been originated from the Autoregressive model (AR), the Moving Average model (MA) and the combination of the AR and MA, the ARMA models (Suhartono, 2011). Seasonal autoregressive integrated moving average processes have been introduced in the literature to model time series with trends, seasonal pattern and short time correlations. The generalized form of $SARIMA(p,d,q)\times(P,D,Q)_s$ model for a series Y_t can be written as (Box et al., 2008; Cryer and Chan, 2008):

$$\phi_p(B)\Phi_P(B^s)(1-B)^d(1-B^s)^D Y_t = \theta_q(B)\Theta_Q(B^s)\varepsilon_t \tag{1}$$

where s is the length of the periodicity (seasonality) and ε_t is a white noise sequence.

$$\phi_p(B) = 1-\phi_1 B-\phi_2 B^2-\cdots-\phi_p B^p \tag{2}$$

$$\Phi_P(Bs) = 1-\Phi_1 B^s-\Phi_2 B^{2s}-\cdots-\Phi_P B^{Ps} \tag{3}$$

are the non-seasonal and seasonal autoregressive (AR) polynomial term of order p and P, respectively.

$$\theta_q(B) = 1-\theta_1 B-\theta_2 B^2-\cdots-\theta_q B^q \tag{4}$$

$$\Theta_Q(B^s) = 1-\Theta_1 B^s-\Theta_2 B^{2s}-\cdots-\Theta_Q B^{Qs} \tag{5}$$

are the non-seasonal and seasonal moving average part (MA) of order q and Q, respectively. $(1-B)^d$ is the non-seasonal differencing operator of order d used to eliminate polynomial trends and the seasonal differencing operator $(1-B^s)^D$ of order D used to eliminate seasonal patterns. B is the backshift operator, whose effect on a time series Y_t can be summarized as $B^d Y_t = Y_{t-d}$.

For the identifying an appropriate order of the polynomials and differencing operators the sample autocorrelation (ACF) and partial autocorrelation functions (PACF) can be compared with the theoretical ones (Online short term, Grosswindhager,). Competing SARIMA models can also be evaluated by considering information criteria, such as AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion).

3 STATE SPACE FORM OF SARIMA MODELS

The state space form provides a unified representation of a wide range of linear Gaussian time series models including ARMA and UC models (Hidrayanto, 2010). The Gaussian state space form consists of a transition equation for the $m\times 1$ state vector α_t and a measurement equation for the $N\times 1$ observation vector y_t for $t=1,\dots,n$. The model can be formulated as in Durbin and Koopman (2001):

$$\alpha_{t+1} = T_t\alpha_t + R_t\eta_t, \quad \eta_t \sim N(0,Q_t),\ t=1,\dots,n \tag{6}$$

$$y_t = Z_t\alpha_t + \varepsilon_t, \quad \varepsilon_t \sim N(0,H_t),\ \alpha_1 \sim N(a_1,P_1) \tag{7}$$

where η_t and ε_t represent the error terms assumed to be serially independent and independent of each other at all time points. The matrices $T_t, R_t, Z_t, \mathrm{Q}_t$ and H_t are referred to as the state space system matrices. The initial state vector is α_1 with mean vector a_1 and variance matrix P_1. Model (1)-(2) is linear and driven by Gaussian disturbances. Therefore, the state space model can be treated by standard time series methods based on the Kalman filter (Anderson and Moore, 1979; Durbin and Koopman, 2001).

The variance matrix P of the initial state vector α_1 may contain diffuse elements when non-stationary components are included in α_t. In this case, diffuse initialization methods for the Kalman filter exist to evaluate the exact or diffuse likelihood function (de Jong (1991), Koopman (1997).

State space representations of ARMA/ARIMA models are presented in (Brockwell, Davis, 2002; Box, Jenkins and Reinsel, 2008). SARIMA models can be dealt with by constructing ARMA models for the stationary differenced series $y_t^* = (1-B)^d(1-B^s)^D y_t$ and placing the non-stationary variables such as y_{t-i} and $(1-B)^d y_{t-i}$ in the state vector. y_t^* is a seasonal $ARMA(p^*,q^*)$ prosess with $p^* = p+SP$ and $q^* = q+SQ$. Appropriately constructed state vector of this ARMA process for $d=D=0$ can be defined as α_t^*, so that $y_t^* = y_t$. In this case there is

$$\begin{aligned}\alpha_t^* = (&y_t^*, \phi_2 y_{t-1}^* + \cdots + \phi_p \Phi_P y_{t-p*+1} + \theta_1 \varepsilon_t + \cdots \theta_q \Theta_Q \varepsilon_{t-q*+1}, \\ &\phi_3 y_{t-1}^* + \cdots + \phi_p \Phi_P y_{t-p*+2} + \theta_2 \varepsilon_t + \cdots \theta_q \Theta_Q \varepsilon_{t-q*+2}, \dots, \phi_p \Phi_P y_{t-1} + \theta_q \Theta_Q \varepsilon_t)\end{aligned} \tag{8}$$

With the dimension of α_t^* equal to $m = \max(p*, q*+1)$. The complete state vector α_t has dimension $SD + d + m$, and for the case of $d = 1$ and $D = 1$ can be written as

$$\alpha_t = (y_{t-1}, (1-B)y_{t-1}, \dots, (1-B)y_{t-S}, \alpha_t^*)^T \tag{9}$$

Where the term y_t^* in the state vector α_t^* changes according to the orders of d and D, but the structure of α_t^* stays the same (Hindrayanto, 2010). The MA parameters are included in the disturbance vector, which is given by

$$H_t \varepsilon_t = (0_{1\times(SD+d)}, \varepsilon_{t+1}, \theta_1 \varepsilon_{t+1}, \dots, \theta_{m-1} \varepsilon_{t+1})^T \tag{10}$$

The transition matrix T_t has dimension $(SD + d + m) \times (SD + d + m)$ and Z_t is a row vector of dimension $1 \times (SD + d + m)$. For seasonal models with $d = D = 1$, the T_t and Z_t matrices can be defined as follows:

$$T_t = \begin{pmatrix} 1 & 0_{1\times(S-1)} & 1 & 1 & 0 & 0 & \dots & 0 \\ 0 & 0_{1\times(S-1)} & 1 & 1 & 0 & 0 & \dots & 0 \\ 0 & I_{S-1} & 0 & 0 & 0 & 0 & \dots & 0 \\ 0 & 0_{1\times(S-1)} & 0 & \phi_1 & 1 & 0 & \dots & 0 \\ 0 & 0_{1\times(S-1)} & 0 & \phi_2 & 0 & 1 & \dots & 0 \\ . & . & . & . & . & . & . & . \\ . & . & . & . & . & . & . & . \\ . & . & . & . & . & . & . & . \\ 0 & 0_{1\times(S-1)} & 0 & \phi_{m-1} & 0 & 0 & \dots & 1 \\ 0 & 0_{1\times(S-1)} & 0 & \phi_m & 0 & 0 & \dots & 0 \end{pmatrix} \tag{11}$$

$$Z_t = (1, 0_{1\times(S-1)}, 1, 1, 0, 0, \dots, 0) \tag{12}$$

The $r \times r$ identity matrix is denoted by I_r and an $r \times c$ matrix of zeros is denoted by $0_{r\times c}$.

4 FORECASTING WITH KALMAN RECURSIONS

The Kalman filter represents a set of mathematical equations that provides an efficient computational (recursive) means to estimate the state of a process, in a way that minimizes the mean squared error. The filter supports estimations of past, present and future states (Welch and Bishop, 1995).

The Kalman filtering allows a unified approach to prediction and estimation for all processes that can be given by state space representation. The classical Kalman recursions were introduced by Rudolph E. Kalman in 1960 (Kalman, 1960). The objective is to obtain the conditional distribution of α_{t+1} based on the observations $Y_t = \{y_1, y_2, ..., y_t\}$. Since all distributions are normal, conditional distributions of subsets of variables given other subsets of variables are also normal. The required distribution is therefore determined by a knowledge of $a_{t+1} = E(\alpha_{t+1} | Y_t)$ and $P_{t+1} = Var(\alpha_{t+1} | Y_t)$. It is assumed that α_t given Y_{t-1} is $N(a_t, P_t)$. Recursive procedure for determining a_{t+1} and P_{t+1} from a_t and P_{t+1} is as follows:

Since $\alpha_{t+1} = T_t\alpha_t + R_t\eta_t$, there is

$$a_{t+1} = E(T_t\alpha_t + R_t\eta_t | Y_t) = T_t E(\alpha_t | Y_t) \tag{13}$$

$$P_{t+1} = Var(T_t\alpha_t + R_t\eta_t | Y_t) = T_t Var(\alpha_t | Y_t) T_t' + R_t Q_t R_t' \tag{14}$$

for $t = 1, ...n$. Let

$$v_t = y_t - E(y_t | Y_{t-1}) = y_t - E(Z_t\alpha_t + \varepsilon_t | Y_{t-1}) = y_t - Z_t a_t \tag{15}$$

Where v_t represents the one-step forecast error of y_t given Y_{t-1}.

$$\begin{aligned} E(\alpha_t | Y_t) &= E(\alpha_t | Y_{t-1}, v_t) \\ &= E(\alpha_t | Y_{t-1}) + Cov(\alpha_t, v_t)[Var(v_t)]^{-1} v_t \\ &= \mathrm{a}_t + \mathrm{M}_t \mathrm{F}_t^{-1} v_t \end{aligned} \tag{16}$$

Where $M_t = Cov(\alpha_t, v_t) = P_t Z_t'$, $F_t = Var(v_t) = Z_t P_t Z_t'$ and $E(\alpha_t | Y_{t-1}) = a_t$.
Substituting in (13) and (16) gives:

$$a_{t+1} = T_t a_t + T_t M_t F_t^{-1} v_t = T_t a_t + K_t v_t \tag{17}$$

Where

$$K_t = T_t M_t F_t^{-1} = T_t P_t Z_t' F_t^{-1} \tag{18}$$

It is clear that a_{t+1} has been obtained as a linear function of the previous value a_t and v_t, the forecast error of y_t given Y_{t-1}.

Since

$$Var(\alpha_t | Y_t) = P_t - P_t Z_t' F_t^{-1} Z_t P_t \tag{19}$$

Substituting it in (14) gives

$$P_{t+1} = T_t P_t L_t' + R_t Q_t R_t' \tag{20}$$

with $L_t = T_t - K_t Z_t$

The recursions (17)-(20) constitute the Kalman filter for model (6)-(7). They enable to update the knowledge of the system each time a new observation comes in (Durbin and Koopman, 2001)

Due to partially diffuse initial state vector of considered SARIMA model, minor extensions to the classical Kalman filter equations are necessary (Durbin and Koopman, 2001; Peng and Aston, 2006). In general, h-step ahead forecasts of future state values are recursively obtained as $a_{t+h} = T_{t+h-1} a_{t+h-1}$ with covariance matrix $P_{t+1} = T_{t+h-1} P_{t+h-1} T'_{t+h-1} + R_{t+h-1} Q_{t+h-1} R'_{t+h-1}$.

5 EMPRIRICAL CASE STUDY – SERBIAN RAILWAYS

5.1 SARIMA Modeling Process

In this section the applicability of proposed Kalman filtering approach is demonstrated by modeling the rail passenger demand for the case of national railway company of Serbia – Serbian Railways. Today, Serbian Railways perform rail passenger traffic on the network of length 3.809 km on which there is an approximate number of 600 stations open for passenger operations. Dataset is compossed from the 78 consecutive observations representing the monthly number of passengers travelled on Serbian rail network within the period from January 2006. to June 2012. (Source: Statistical Office of the Republic of Serbia). The dataset is depicted in Figure 1.

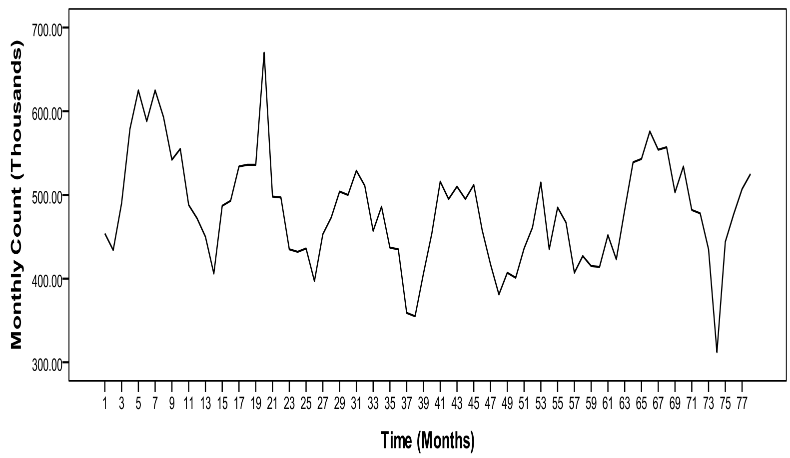

Figure 1: Time Series Plot: Monthly Passenger Flow

The time series plot illustrate that the data have seasonal pattern which indicates that the data are nonstationary. It is obvious that there are typical yearly cycles with high values occurring in summer months and low values in winter months. The ACF plot (Figure 2.) has the shape typical for seasonal time series – it has a recurrent pattern: there are significant peaks at the seasonal frequencies (lag 12, 24, 36, etc) which decay slowly.

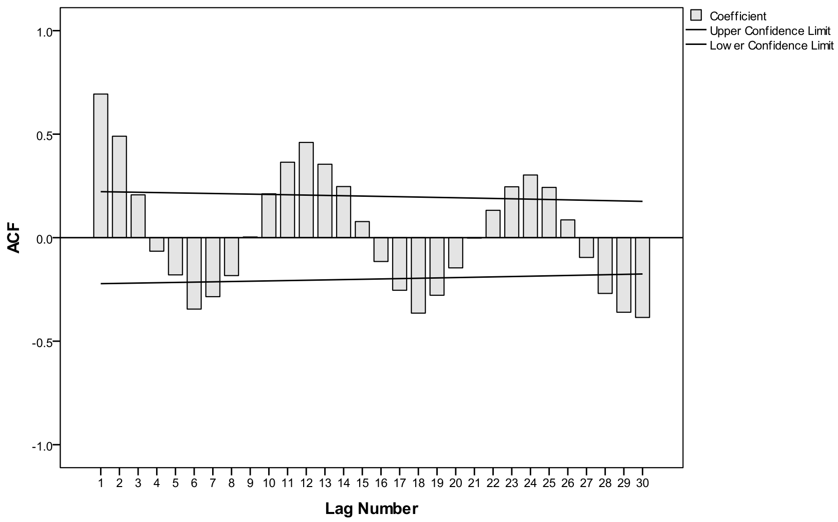

Figure 2: Autocorelation function of original time series

Therefore, the differencing process is necessary to obtain the stationary data. By taking difference d=1 for non-seasonal and D=1 with S=12 for seasonal the data become stationary series (Figure 3.).

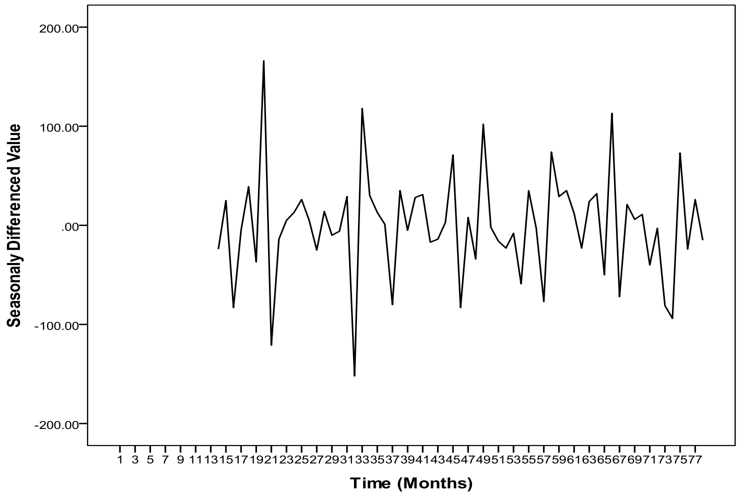

Figure 3: Seasonally differenced time series

The model selection procedure was performed in SPSS based on the Normalized Bayesian Information Criterion. The SARIMA(0,1,1)(0,1,1)$_{12}$ model achieved the lowest score for this specific dataset. After the chosen model has been fitted to the data, it is important to perform diagnostic checks to test the adequacy of the model. One way to accomplish this is through the analysis of residuals. The autocorrelation function of residuals and partial autocorrelation function of residuals show that all the spikes are now within the significance limits, and so the residuals appear to be white noise (Figure 4.).

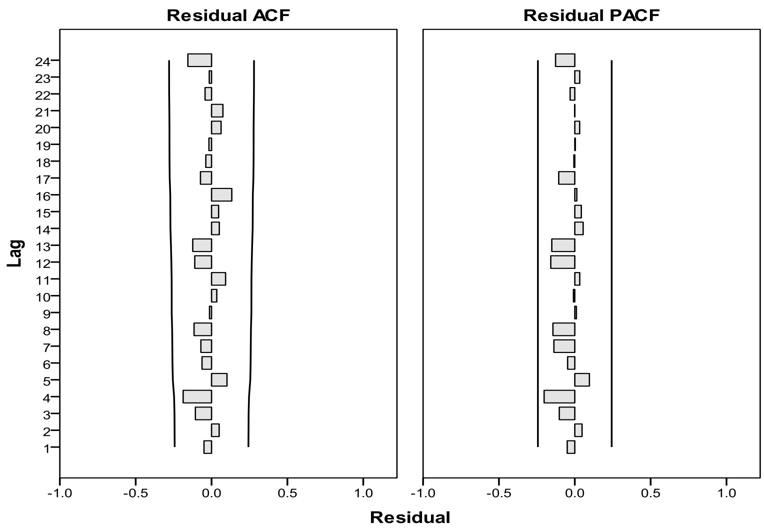

Figure 4: Residual diagnostic plots.

The model statistics and all coefficient estimates are summarized in Table 1. and Table 2., respectively.

Table 1: Model Statistics

Model	Model Fit statistics		Ljung-Box Q(18)		
	Stationary R-squared	Normalized BIC	Statistics	DF	Sig.
SARIMA Model	.463	7.539	11.783	16	.759

Table 2: SARIMA Model Parameters

			Estimate	SE	t
SARIMA Model	Difference		1		
	MA	Lag 1	.504	.110	4.586
	Seasonal Difference		1		
	MA, Seasonal	Lag 1	.998	31.204	.032

5.2 Kalman Recursions

The identified SARIMA model was incorporated into the state space framework for the purpose of forecasting. The forecasting process was performed in Matlab using the SSM Toolbox (Peng and Aston, 2006), where appropriate diffuse initialization methods for the state covariance matrix and Kalman filter recursions are already implemented. Table 3. contain a one year ahead forecast of total rail passengers within the Serbian railways. Upper Confidence Level (UCL) and Lower Confidence Level (LCL) of forecasts are also defined. The outputs of Kalman filtering approach are also presented in Figure 5.

Table 3: Forecasting data by Kalman recursions (thousands)

SARIMA - Kalman	Jul 2012	Aug 2012	Sep 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013	Jun 2013
Forecast	526.62	535.33	473.33	479.80	432.82	422.52	408.25	369.78	437.36	477.03	515.10	502.73
UCL	596.43	612.39	557.02	569.62	528.38	523.51	514.27	480.61	552.80	596.91	639.26	631.03
LCL	456.80	458.27	389.65	389.98	337.25	321.54	302.24	258.95	321.91	357.15	390.94	374.44

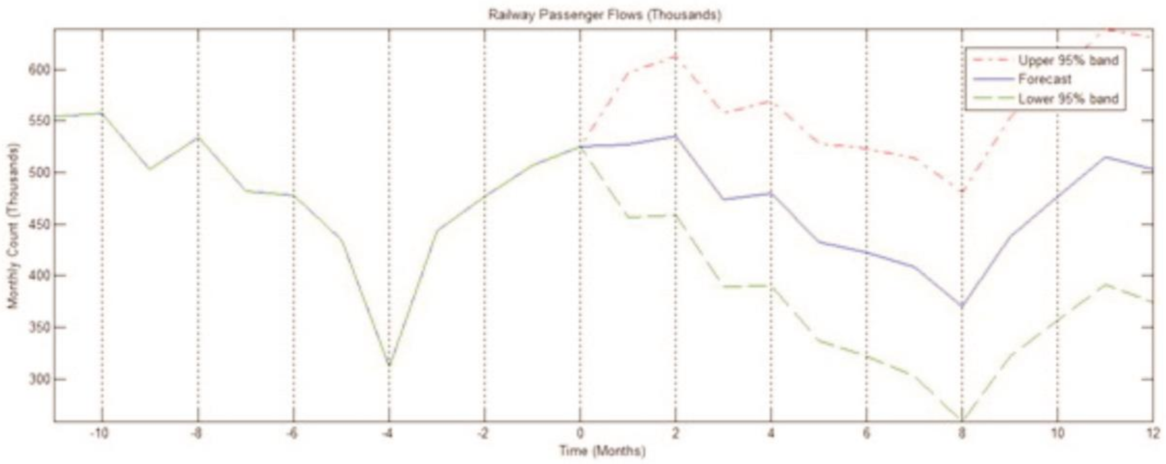

Figure 5: One-year ahead forecast of railway passenger flows via Kalman recursions.

When comparing the forecasting results of the SARIMA-Kalman model with that of the SARIMA model, they are very close to each other which can also be seen from the results of SARIMA model (Table 4.).

Table 4: Forecasting data by SARIMA (thousands)

Pure SARIMA	Jul 2012	Aug 2012	Sep 2012	Oct 2012	Nov 2012	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013	Jun 2013
Forecast	527.38	536.37	474.04	480.38	433.21	422.88	408.67	370.82	437.96	477.67	515.96	503.25
UCL	599.75	617.18	562.48	575.83	535.20	531.01	522.52	490.09	562.42	607.11	650.20	642.11
LCL	455.00	455.57	385.61	384.92	331.22	314.74	294.83	251.55	313.50	348.23	381.72	364.38

However, when comparing the performances, the SARIMA-Kalman model has better tracking performances then the SARIMA model. The results of Mean Average Error (MAE), Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSE) prove that this difference in performances exists.

Table 5: Estimated results of one-year ahead forecasts

Indexes	SARIMA-Kalman	SARIMA
MAE(Passengers)	23.589	29.588
MAPE(%)	5.795	6.388
RMSE(Passenger)	37.469	40.655

6 CONCLUSION

Rail passenger flow forecasting can provide useful information for decision makers of rail passenger systems. An accurate forecasting model can be applied to support transportation system management such as operation planning, revenue planning, and facility improvement. In this paper it was shown that the SARIMA$(0,1,1)(0,1,1)_{12}$ known as "airline" model is the most appropriate for modeling the rail passenger demand on Serbian railways. The identified model is embedded into the state space framework for the sake of applying the Kalman recursions for forecasting the future rail passenger flow. Structural models explicitly addressing trend, seasonal and cycle variations in the state space form with time varying coefficients can be considered in the future for modeling or rail passenger flows.

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THE AIRBUS MEDIUM RANGE AIRPLANE FLIGHT PERFORMANCE VERSATILITY

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ABSTRACT

The Airbus Industry recognizes customer efforts for revenue gain and dedicate own development to customers goals. This airplane customization in the Airbus Industry started with engine installation variation two decade ago. This mutual battle for profit, both airplane manufacturer and airlines, recently results in new airplane A320 series called A320New Engine Options or A320NEO. The paper shows effects of different aircraft engine installation on same aerodynamic setup on flight performance in case of airplane Airbus A320. The results presented in paper offers answer which combination of airplane engine and standard aerodynamic fusion has the best application depending on market where airline operating. In standard ISA and non ISA condition authors test different A320 engine–airframe compilations on different operative scenarios and obtain different range of optimal airplane flight performances. The paper objective was to calculate flight performance, which mean take off distances, the trip fuel and trip time taken to complete a mission with a given standard European range and standard European traffic load. Each mission is split into three main parts – the take off - initial climb phase, the en-route and the approach–landing phase. Each flight phase performance analysis (take off, climb, cruise, descent and landing) was operated in a certain way and by relevant parameters, such as climb rates and cruise altitudes, which are usually stipulated by European air company policy. Using the data available in the EASA type certification sheet and authors developed performance charts, flight performance for each phase of the flight was calculated. The trip fuel, trip time and take-off and landing distance required for each flight stage are calculated as in a systematic manner-starting with the ramp aircraft mass and proceeding through the total flight mission profile. The paper results emphasize aircraft flight performance versatility importance, as product of optimal aircraft engine and aerodynamic match, which secure the first place for medium range jet air transport for A320.

Keywords: Airbus, Airplane Flight Performance, Airplane Engine Installation, Airplane Aerodynamic

1 INTRODUCTION

The latest Airbus newsletter indicates introduction of new A320NEO as reaction on other aircraft manufacturer fuel and emission reduction strategies. This article reviews the flight performance parameters and flight cost parameters, which would allow the setting of more stringent comparison standard between classic A320 aircraft and A320NEO aircraft. It also stresses the fact that application new engine design, for A320NEO in 2015 will further increase aircraft efficiency and lower operating costs. This sometimes necessitates making choices about which costs is more significant from an operational viewpoint, so that a design of A320NEO may be finalized. In this sense, engine designers need the advice of aircraft operations scientists concerning which costs they should seek to minimize, at the possible neglecting of others.

The main strategies to achieve ICAO Oxides of Nitrogen (NOx) Emission Standards, comparing to fuel consumption, is to find out which combination of airframe improvement and developed engines, for which aircraft must be certified from EASA and FAA, will produce lowest emission with lower fuel consumption increase. Increase of fuel consumption deliver increase of CO_2 emission. Development of new engine especially for new type of A320 aircraft frame is time consuming and expensive process.

The main pollutant produced during high troposphere flight is CO2. These high temperatures, which are desirable from the viewpoint of minimizing fuel consumption and also minimizing carbon dioxide, CO and HC production, unfortunately create the conditions in which high quantity of oxides of nitrogen (NOx) are formed. The problem for the new engine designer for A320NEO will also be high fuel efficiency, with lower fuel consumption and production of high thrust, while at the same time preventing the formation of NOx. The designer faces further challenges relating to the safety and economic operation of the aircraft. The engine must operate smoothly and reliably at settings ranging from idle to maximum take-off thrust and it must be possible to restart the engine over a wide range of operative speeds and altitudes.

The first part of paper is deal with defining aircraft flight model. The second part is methodology for direct operating cost determination, in *enroute* flight phase. The third part is methodology to compare airframe modification by introduction of sharkelet on A320NEO, with accounted effects of drag, fuel consumption and change. In this part of paper we investigate future benefits form new engine on A320NEO which is expected in 2015. The forth part of paper summarize results and future innovative changes.

2 THE OPERATING FLIGHT MODULE

Among firs parameters which must be set is the operating flight module. We develop complex module which cover all operative aspects of transport aircraft flight. This module requires basic setting:

- Maximum take off mass m_{MTOM}(kg), which is our case for A320 is equal to 67000kg,
- Total flight distance D (Nm), which vary from 500Nm to 6000Nm,
- Alternate distance D_a(Nm), which is in our case 200Nm,
- Number of seats n_s, which in our case 180 passenger seats, single economy class,
- Passenger Load factor $(lf)_{passengers}$, which in our case 0.654,
- Mass of passengers with baggage m_{pass}(kg), which is in our case 91kg,
- Actual passenger payload *APPL*(kg), which is in our case calculated by equation (1),

$$APPL = ns \cdot lf \cdot m_{pass} \tag{1}$$

- Cargo capacity *CC*(kg), which is in our case 2876kg,
- Cargo load factor *c.l.f.*, which is in our case 0,
- Actual cargo payload *ACPL*(kg), which is in our case calculated by equation (2),

$$ACPL = (CC) \cdot (c.l.f.) \tag{2}$$

- Actual payload *APL*(kg), which is in our case calculated by equation (3),

$$APL = APPL + ACPL \tag{3}$$

- Operating Empty Weight m_{OEM}(kg), which is in our case 41244kg,
- Ground time t_{gr}(hr), which is in our case 0.167hr,
- Coefficient for block time *a* (Bhrs), which is in our case 0.271Bhrs,
- Coefficient for block time *b*(Bhrs/Nm), which is in our case 0.0023Bhrs/Nm,
- Reference block of time t_{BT0}(Bhrs), which is in our case calculated by equation (4),

$$t_{BTO} = t_{gr} + a + b \cdot D, where\ t_{gr}(hrs), a(hrs), b(hrs/Nm) \tag{4}$$

- Ground fuel m_{grf}(kg), which is in our case 135kg,
- Coefficient for block fuel *c*(kg), which is in our case 649.51kg,
- Coefficient for block fuel *d*(kg/Nm), which is in our case 5.535kg/Nm,
- Reference block of fuel m_{BF0}(kg), which is in our case calculated by equation (5),

$$m_{BF0} = m_{grf} + c + d \cdot D, where\ m_{grf}(kg), c(kg), d(kg/Nm) \tag{5}$$

- Holding time t_{hold}(min), which is in our case 45min,
- Fuel flow into a holding *ff*(kg/min), which is in our case 35 kg/min,
- Fuel required for holding regime $m_{f,hold}$(kg), which is in our case calculate by equation (6),

$$m_{f,hold} = t_{hold} \cdot (ff), where\ t_{hold}(min), ff(kg/min) \tag{6}$$

- Fuel required for alternate flight, which is in our case mf,alt.(kg) ,), which is in our case calculate by equation (7),

$$mf, alt. = c + d * Da, where\ c(kg), d(kg/Nm) \tag{7}$$

- Reserve fuel, which is in our case $m_{res.f.}$(kg), which is in our case calculate by equation (8),

$$mres.f. = 0{,}05 * m_{BF0} + m_{f,hold} + mf, alt. \tag{8}$$

- Actual Takeoff Mass m_{ATOM}(kg), which is in our case calculate by equation (9),

$$m_{ATOM} = m_{OEM} + APPL + ACPL + m_{BF0} + m_{res.f} \tag{9}$$

Available Engine data for A320 classic and expected engine data for A320 NEO are:

- Number of engines n_m ,which is in our case have value of 2,
- By-pass ratio *BPR*, which is in our case have value of 6.2,
- coefficient for available thrust *m* , which is in our case calculate by equation (10),

$$m = 0.7291 - 0.0253 \cdot BPR \tag{10}$$

- coefficient for available thrust *n*, which is in our case calculate by equation (11),

$$n = 0.7324 + 0.0033 * BPR. \tag{11}$$

- The equivalent available thrust T_{av}(N), which is in our case calculate by equation (12)

$$T_{av} = nm * T_{SL} * m * \sigma^{n} \tag{12}$$

- coefficient for required thrust *A*, which is in our case calculate by equation (13),

$$A = 0.5 \cdot \rho \cdot S \cdot c_{D,L=0} \tag{13}$$

- coefficient for required thrust *B*, which is in our case calculate by equation (14),

$$B = (2 * \kappa * (m_{AM,ICR} * g)2)/(\rho * S) \tag{14}$$

- Min cruise speed at FL $V_{min.TAS}$(m/s), which is in our case calculate by equation (15),

$$V_{min.TAS} = (((((T_{av} - (T_{av}^{2} - 4 * A * B)^{0.5}/(2 * A)))))^{0.5})/1.1 \tag{15}$$

- Min cruise speed at FL $V_{min.TAS}$(knot), which is in our case calculate by equation (16),

$$V_{min.TAS}(kt) = 1.9434335 * V_{min.TAS}(m/s) \tag{16}$$

- Min Mach number at FL $M_{min.FL}$, which is in our case calculate by equation (17),

$$M_{min.FL} = V_{min.TAS}\left(\frac{m}{s}\right)/a\left(\frac{m}{s}\right). \tag{17}$$

- Max cruise speed at FL $V_{max.TAS}$(m/s), which is in our case calculate by equation (18),

$$V_{max.TAS}(kt) = (((((T_{av} + (T_{av}^{2} - 4 * A * B)^{0.5}/(2 * A)))))^{0.5})/1.1 \tag{18}$$

- Max cruise speed at FL $V_{max.TAS}$(knot), which is in our case calculate by equation (19) and

$$V_{max.TAS}\left(\frac{m}{s}\right) = 1.9434335 * V_{min.TAS}\left(\frac{m}{s}\right) \tag{19}$$

- Maximal *Mach* number at *FL* is $M_{max.FL}$, which is in our case calculate by equation (20) .

$$M_{max.FL} = V_{max.TAS}\left(\frac{m}{s}\right)/a\left(\frac{m}{s}\right) \tag{20}$$

Climb part of calculation comprises following flight parameters:

- Average rate of climb, *R/C*(fpm), which is in our case 2000fpm,
- Time taken to climb t_{CLB}(min), which is in our case calculate by equation (21),

$$t_{CLB} = (FL)/(R/C), FL(ft), R/C(ftpm) \tag{21}$$

- Time taken to climb t_{CLB}(hr), which is in our case calculate by equation (22),

$$t_{CLB}(hr) = t_{CLB}(min)/60 \tag{22}$$

- Equivalent air speed at climb $V_{EAS,CLB}$(knot), which is in our case 250kt,
- Average relative air density into climb σ_{av}, which is in our case calculate by equation (24),
- $\sigma_{av} = 0.5 \cdot (1 + \sigma_{FL})$ (24)
- True air speed at climb $V_{TAS,CLB}$(knot), which is in our case calculate by equation (25),

$$V_{TAS,CLB} = (V_{EAS,CLB})/\sigma_{av}{}^{0,5} \tag{25}$$

- Climb angle θ_{CLB}(deg), which is in our case calculate by equation (26),

$$sin\theta_{CLB} = \left(\frac{0.00987473 \cdot \frac{R}{C}}{V_{TAS,CLB}}\right) \rightarrow \theta_{CLB}(rad) = arc\, sin\theta_{CLB} \rightarrow \theta_{CLB}(deg) = 57.325 \cdot \theta_{CLB}(rad) \tag{26}$$

- The distance covered climb D_{CLB}(Nm), which is in our case calculate by equation (27),

$$D_{CLB} = cos\theta_{CLB} \cdot V_{TAS,CLB} * t_{CLB}, \quad \text{where} \quad \theta_{CLB}(rad), V_{TAS,CLB} knot), t_{CLB}(Hrs) \tag{27}$$

- The fuel consumed in the climb $m_{f,CLB}$(kg), which is in our case calculate by equation (28).

$$m_{f,CLB} = m_{ATOM} \cdot (1 - \xi_{cr}) \tag{28}$$

Cruise part of calculation comprises following parameters:

- Distance for cruise segment D_{CR}(Nm), which is in our case calculate by equation (29),

$$D_{CR} = D - D_{CLB} - D_{DSC} \tag{29}$$

- Mass fraction for initial cruise mass ξ_{cr} , which is in our case have value of 0.9751
- Aircraft mass at end climb to cruise FL $m_{AM,ICR}$(kg), which is in our case calculate by equation (30).

$$m_{AM,ICR} = m_{ATOM} \cdot (\xi_{cr}) \tag{30}$$

- Cruise Flight Level *FL*(ft), which is in our case have value from 25000 ft to 35000ft
- Relative Air Density for Cruise Flight Level σ_{FL} which is in ISA case depends on cruise *FL*,
- Air Density for Cruise Flight Level ρ(kg/m^2), which is in ISA case depends on cruise *FL*,
- Relative Air Temperature for Cruise Flight Level $\theta=(T/T_0)$,which is in ISA case depends on cruise *FL*,
- Speed of sound for Cruise Flight Level *a*(m/s), which is in ISA case depends on cruise *FL*,
- Speed of sound for Cruise Flight Level *a*(Nm/h), which is in ISA case depends on cruise *FL*,
- Aspect Ratio *AR* which is in our case have value 9.39,
- Wing span *b*(m), which is in our case have value 33.91 m,
- Wing area *S*(m^2), which is in our case have value 122.44 m^2,
- Aerodynamic zero- lift drag coefficient c_{DZ} or c_{Z0} , which is in our case have value 0.023 for A320 classic and 0.022 for A320 NEO due sharklets,
- Take off thrust *T*(N), which is in our case have value 111200 N,
- Specific Fuel Consumption *SFC*(kg/Nhr), which is in our case have value of 0.0554 kg/Nhr,
- Lift depend drag factor κ, which is in our case calculate by equation (31),

$$\kappa = 1/(\pi * AR * e) \tag{31}$$

- Lift coefficient for minimum drag $c_{Lmd,}$ which is in our case calculate by equation (32),

$$c_{Lmd} = \left(\frac{c_{D,L=0}}{\kappa}\right)^{\frac{1}{2}} \tag{32}$$

- Minimum drag speed V_{md} (m/s), which is in our case calculate by equation (33),

$$V_{md} = \left(\left(2 * \frac{m_{AM,FL}}{\rho} * S\right)^{\frac{1}{2}}\right) \cdot \left(\frac{\kappa}{c_{D,Z=0}}\right)^{\frac{1}{4}} \tag{33}$$

- Minimum drag speed V_{md} (Nm/hr), which is in our case calculate by equation (34),

$$V_{md}\,(\mathrm{kt}) = 1.9434335 * V_{md}\left(\frac{m}{s}\right) \tag{34}$$

- The lift-drag ratio *L/D* $E_{max,}$ which is in our case calculate by equation (35),

$$Emax = 1/((2 \cdot (k \cdot czo)^{0.5})) \tag{35}$$

- Cruise Mach number *M*, which is in our case have value from 0.6 to 0.92
- True air speed-TAS at M V_{TAS}(Nm/hr), which is in our case calculate by equation (36),

$$VTAS\,(\mathrm{Nm/hr}) = Mach * a\left(\frac{Nm}{h}\right) \tag{36}$$

- Relative aircraft speed u, which is in our case calculate by equation (37),

$$u = V_{TAS}(Nm/hr)/V_{md}\,(kt) \tag{37}$$

- Range Factor *RF*, which is in our case calculate by equation (38),

$$RF = (V_{md,i}/(SFC) \cdot \theta^{0,5} \cdot g) \cdot (1/(2 \cdot \sqrt{\kappa} \cdot c_{D,L=0})) \tag{38}$$

- Mach number at minimum drag $M_{md,}$ which is in our case calculate by equation (39),

$$M_{md} = \frac{V_{md}\left(\frac{m}{s}\right)}{a\left(\frac{m}{s}\right)} \tag{39}$$

- Cruise -Constant altitude constant Mach number parameter ω, which is in our case calculate by equation (40),

$$\omega = 1/(TAN(((2 \cdot u \cdot RF \cdot ArcTAN((1/u^2)) - D_{cr})/(2 \cdot u \cdot RF))) * (u^2)) \tag{40}$$

- Aircraft mass at end of cruise $m_{AM,ECR}$(kg), which is in our case calculate by equation (41),

$$m_{AM,ECR} = m_{AMICR} * (1/\omega) \tag{41}$$

- The fuel consumed for the cruise $m_{f,CR}$(kg), which is in our case calculate by equation (42),

$$m_{f,CR} = m_{AM,ICR} - m_{AM,ECR} \tag{42}$$

- The time required for the cruise t_{CR}(Fhrs), which is in our case calculate by equation (43),

$$t_{CR} = D_{cr}/V_{TAS}(Nm/h) \tag{43}$$

Descent part of calculation comprises following parameters:

- Average rate of descent ROD(fpm), which is in our case 2000fpm
- Time taken to descent t_{DSC}(min), which is in our case calculate by equation (44),

$$t_{CLB} = \frac{FL}{ROD}, \quad \text{where} \quad FL(ft), ROD(ftpm) \tag{44}$$

- Time taken to climb t_{DES}(hr), which is in our case calculate by equation (45),

$$t_{DES}(hr) = t_{DES}(min)/60 \tag{45}$$

- Equivalent air speed at descent $V_{EAS,DSC}$(knot), which is in our case 270,
- Average relative air density into descent $\sigma_{av,}$ which is in our case calculate by equation (46),

$$\sigma_{av} = 0.5 \cdot (1 + \sigma_{FL}) \tag{46}$$

- True air speed at descent $V_{TAS,DSC}$(knot), which is in our case calculate by equation (47),

$$V_{TAS,DSC} = (V_{EAS,DSC})/\sigma_{av}^{0,5} \tag{47}$$

- Descent angle θ_{DSC}(deg), which is in our case calculate by equation (48),

$$sin\theta_{DSC} = \left(\frac{0.00987473 \cdot \mathrm{ROD}}{V_{\ TAS,DSC}}\right) \rightarrow \theta_{DSC}(rad) = arc\ sin\theta_{DSC} \rightarrow$$

$$\theta_{DSC}(deg) = 57.325 \cdot \theta_{DSC}(rad) \tag{48}$$

- The distance covered descent D_{DSC}(Nm),which is in our case calculate by equation (49),

$$D_{DSC} = cos\theta_{DSC} \cdot V_{\ TAS,DSC} * t_{DSC}, \quad \text{where } \theta_{DSC}(rad), V_{\ TAS,DSC} knot), t_{DSC}(Hrs) \tag{49}$$

- Mass fraction at end of descent mass ξ_{ds} , which is in our case have value of 0.98208
- The fuel consumed in the descent $m_{f,DSC}$ (kg) which is in our case calculate by equation (50),

$$m_{f,CLB} = m_{AME,CR} \cdot (1 - \xi_{ds}) \tag{50}$$

We obtained following results from given flight data relation ship:

- Block time t_{BT}(Bhrs) which is in our case calculate by equation (51),

$$t_{BT} = t_{gr} + t_{CLB} + t_{CR} + t_{DSC} \tag{51}$$

- Block fuel m_{BF}(kg) which is in our case calculate by equation (52) and

$$m_{BF} = m_{grf} + m_{f,CLB} + m_{f,CR} + m_{f,DSC} \tag{52}$$

- Block fuel per passengers and Nm, $m_{BF/PASS.Nm}$(g/Nm) which is in our case calculate by equation (53).

$$m_{BF/PASS.Nm} = 1000 \cdot (m_{BF}/(ns \cdot (l.f.) \cdot D)) \tag{53}$$

AIRCRAFT OPERATING COSTS MODULE

The next chapter of this paper is deducted to description of complex operative cost determination model. The A320 classic and A320NEO operating cost parameters are:

- Average distance on the network D_{av}(Nm), which is in our case 484Nm,
- Time for holding t_H(min), which is in our case have value 30min,

- Fuel flow into a holding ff(kg/min), which is in our case have value 35kg/min,
- Route reserve RR or contingency fuel with value of 5% form trip fuel. This parameter which is in our case have a value of 0.05,
- Extra fuel m_{EF}(kg), which is in our case have value have value 0kg,
- Operating empty mass m_{OEM}(t) which is in our case have value 41.244t,
- Maximum Mass of payload $m_{P/L}$(t) which is in our case have value 19.256t,
- Maximum Mass of cargo m_{cargo}(t) which is in our case have value 2.876t,
- Ground manoeuvre time t_{gr}(Hr) which is in our case have value 0.167 hr,
- Ground manoeuvre fuel m_{grf}(kg) which is in our case have value 135kg,
- Correction for block fuel c_{BF} which is in our case have value 1.721,
- Time transport demand in one day TTD(Hrs), which is in our case have value 12hrs,
- Time of aircraft ground handling t_{gh}(min), which is in our case have value 30min,
- Number of days a week when the a/c operational n_{doa}, which is in our case have value 5,
- Average delay of 100 flights n_{ad}, which is in our case have value 20,
- Average time delay t_{ad}(min), which is in our case have value 30min,
- Number of weeks in the year when the a/c operational n_{woa}, which is in our case have value 48,
- Monthly crew utilization $U_{cr,m}$(Bhrs), which is in our case have value 60Bhrs,
- Number of attendants $N_{att} = N_{cr}$,
- Monthly salary of crew MSC(USD), which is in our case have value 25885 USD,
- Monthly salary of attendants MSA(USD), which is in our case have value 800 USD,
- Cost of crew and attendants training $C_{(cr,att)tran.}$(USD/Bhr), which is in our case have value 0 USD/Bhr,
- Fuel price FP(USD/t), which is in our case have value 1150 USD/t,
- Unit rate for navigation fees UR_{nf}(USD/km), which is in our case have value 70 USD/km,
- Unit rate for landing fees UR_{lf}(USD/km) which is in our case have value 5,
- Cost of handling fees C_{hf}(USD) which is in our case have value 150USD,
- Unit cost of catering UC_{ctr}(USD) which is in our case have value 5 USD,
- Booking fees per passengers BF_{pass}(USD/pass) which is in our case have value 5 USD/pass,
- Unit rate passengers tax UR_{passt}(USD/pass) which is in our case have value 12 USD/pass,
- Emission index EI_{CO2} (t_{CO2} /t fuel) which is in our case have value 20 t_{CO2} /t fuel,
- "Value" of CO_2 VCO_2(USD/t_{CO2}) which is in our case have value 30 USD/t_{CO2},
- Mass of engine m_{eng}(t) which is in our case have value 2.27t,
- Manufacturers empty mass m_{MEM}(t) which is in our case have value 35.8t,
- Number of hours between engine overhaul H_{eng}(Hrs) which is in our case have value 6000Hrs,
- Number of aircraft, NA which is in our case have value 5,
- Spares levels for airframe SLA which is in our case have value 0.85,
- Number of years in service aircraft $n_{ysa/c}$(yrs) which is in our case have value 1 yrs,
- Residual value for airframe and its spares $RV_{af,s}$ which is in our case have value 0.15,

- Deprecation period for airframe and its spares $DP_{af,s}$(yrs), which is in our case have value 15,
- Residual value for engines and its spares $RV_{eng,s}$ which is in our case have value 0
- Deprecation period for engines and its spares $DP_{eng,s}$ (yrs) which is in our case have value 7yrs,
- Interest rate *IR* which is in our case have value 0.05,
- The loan payment period *LPP*(yrs) which is in our case have value 10yrs,
- Value of loans *VL* which is in our case have value 0.8,
- Insurance rate *IR* which is in our case have value 0.005,
- Value of man-hors to maintain the airframe *VMAF*(USD),which is in our case have value 25USD,
- The applied maintenance burden *AMB* which is in our case have value 0.5,
- Cost of heavy maintenance C_{hm}(USD/yrs) which is in our case have value 0(USD/yrs),
- Cost of heavy maintenance per flight C_{hmpf}(USD/flight) which is in our case have value 0(USD/flight),
- Cost of maintenance training $C_{m,tr}$(USD/yrs) which is in our case have value 0(USD/yrs) and
- Cost of maintenance training per flight $C_{(m,tr)/fl}$ (USD/flight) which is in our case have value 0(USD/flight).

On base of system of direct costs input we obtain some preliminary operative cost results:

- Flight time t_f(Fh) which is in our case calculate by equation (54),

$$t_f = t_{BF} - t_{gr} \tag{54}$$

- Trip fuel $m_{trip,fuel}$(kg) which is in our case calculate by equation (55),

$$m_{trip,fuel} = m_{BF} - m_{grf} \tag{55}$$

- Fuel for alternate flight $m_{f.altern.}$(kg) which is in our case calculate by equation (56),

$$mf.altern. = c + d * Dal \tag{56}$$

- Reference block of time t_{BT0}(Bhrs) which is in our case calculate by equation (57),

$$t_{BT0} = t_f + t_{gr} \tag{57}$$

- Reference block of fuel m_{BF0}(kg) which is in our case calculate by equation (58),

$$m_{BF0} = m_{trip,fuel} + m_{grf} \tag{58}$$

- Reserve fuel m_{RF}(kg) which is in our case calculate by equation (59),

$$m_{RF} = RR \cdot m_{BF0} + mf.alter. + t_{hold} \cdot f.f. \tag{59}$$

- Correction for block time c_{BT} which is in our case calculate by equation (60),

$$c_{BT} = \alpha * (1000 \cdot mOEM + lf_{pass} \cdot m_{pass} * ns + (lf)_{cargo} * mcargo + mEF + m_{RF})\beta \tag{60}$$

- Average block time on the network t_{ABT}(Bhrs) which is in our case calculate by equation (61),

$$t_{ABT} = t_{gr} + a + b \cdot D_{av} \tag{61}$$

- Daily aircraft utilization U_d(Bhrs) which is in our case calculate by equation (62),

$$U_d = TTD/((1 + ((tgh + tad)/60) * (nd/100)/tABT)) \tag{62}$$

- Annual aircraft utilization U(Bhrs) which is in our case calculate by equation (63),

$$U = ndoa * nwoa * Ud \tag{63}$$

- Cost of ownership aircraft $C_{a,own}$(USD/flight) which is in our case calculate by equation (64),

$$C_{a,own} = t_{BT} * C_{a,own.py}/U \tag{64}$$

- Number of crew N_{cr} which is in our case calculate by equation (65),

$$Ncr = (NA * U)/(10 * Ucr.mon.) \tag{65}$$

- Cost of crew and attendants $C_{cr,att}$(USD/flight) which is in our case calculate by equation (66),

$$C_{cr.att} = (((1/(NA \cdot U) \cdot (12 \cdot Ncr \cdot MSC + 12 \cdot Natt. \cdot MSA + C_{cr.att.traning}))) * t_{BT}) \tag{66}$$

- Cost of fuel C_{fuel}(USD/flight), which is in our case calculate by equation (67),

$$Cfuel = (mBF/1000) * FP \tag{67}$$

- Cost of navigation fees C_{nf}(USD/flight) which is in our case calculate by equation (68),

$$Cnf. = ((1{,}853 * Urnf * D)/100) * (m_{MTOM}/50)^{0,5} \tag{68}$$

- Cost of landing fees C_{lf}(USD) which is in our case calculate by equation (69),

$$Cl.f. = Urlf * mMTOM \tag{69}$$

- Cost of catering C_{ctr}(USD) which is in our case calculate by equation (70),

$$Cctr. = ns * (lf)_{pass} * UCctr \tag{70}$$

- Cost of booking fees $C_{bf,pass}$(USD) which is in our case calculate by equation (71),

$$Cbf,pass = ns * (lf)_{pass} * (BF)pass \tag{71}$$

- Cost of passenger tax C_{passt}(USD) which is in our case calculate by equation (72),

$$Cpass,t = ns * (lf)_{pass} * URpasst \tag{72}$$

- Cost of general administrative expenses C_{gae}(USD) which is in our case calculate by equation (73),

$$Cgae = (CEF_{2013}/CEF_{2002}) * (0{,}175 * Dav + 0{,}00068 * Dav * mMTOM + 0{,}00223 * ns * (lf)pass + 0{,}01938 * m_{cargo} * Dav \tag{73}$$

- Total cost per flight TC(USD/flight) which is in our case calculate by equation (74),

$$TC = C_{a,own} + C_{cr,att} + TMC + C_{fuel} + C_{nf} + Clf + C_{hf} + C_{ctr} + C_{bf,pass} + C_{pass,t} + C_{gae} \tag{74}$$

- Total cost per flight with "value" of carbon emission TC_{final}(USD/flight) which is in our case calculate by equation (75),

$$TC_{final}\left(\frac{USD}{flight}\right) = TC + EICO2\ (t_{CO2}\ /\ t_{fuel}) \cdot V_{CO2}\,(USD/tCO2) \tag{75}$$

- Average fare *AF*(USD) which is in our case calculate by equation (76),

$$AF = 23{,}96 \cdot D \cdot D^{-0{,}63} \tag{76}$$

- Airframe price *AFP*(USD) which is in our case have value 42802477USD in case of A320NEO and 44404554.1USD(which calculated by equation (78)) in case of A320classic,

$$AFP = (CEF_{2013}/CEF_{2002}) \cdot 1.187 \cdot 10^{(3.3191+0.8043 \cdot log(2.205 \cdot MTOM)}$$

$$where\ MTOM\,(t) \tag{78}$$

- Engine price *EP*(USD) which is in our case calculate by equation (79),

$$EP = 1.414 \cdot (CEF_{2013}/CEF_{2002}) \cdot 10^{((2.3044+0.8858*log(1000*2.205*Tto))}$$

$$where\ Tto(t) \tag{79}$$

- Value of spares parts for airframe *VSA*(USD) which is in our case calculate by equation (80),

$$VSA = 0.117 \cdot AFP \cdot (SLA)^{0.6004} \cdot (NA)^{-0.284} \tag{80}$$

- Value of spares parts for engine *VSE*(USD) which is in our case calculate by equation (81),

$$VSE = 0.39 * (EP) * (NA)^{-0.221} \tag{81}$$

- Aircraft operational price *AOP*(USD) which is in our case calculate by equation (82),

$$AOP = AFP + n_{eng} * (EP) + VSA + VSE \tag{82}$$

- Aircraft market price *AMP*(USD) which is in our case calculate by equation (83),

$$AMP = AFM + neng * EP \tag{83}$$

- Cost of airframe and its spares deprecation $CD_{af,s}$ (USD/yrs) which is in our case calculate by equation (84),

$$CD_{afs} = ((AFP + VSA) * (1 - RV_{afs})/DP_{afs} \tag{84}$$

- Cost of engines and its spares deprecation $CD_{eng,}$ (USD/yrs) which is in our case calculate by equation (85),

$$CD_{eng} = ((n_{eng} * (EP + VSE) * (1 - RV_{eng})) * DP\ engs \tag{85}$$

- Cost of airframe, engines and its spares deprecation CD_{AOP} (USD/yrs) which is in our case calculate by equation (86),

$$CD_{AOP} = CD_{afs} + CD_{eng} \tag{86}$$

- Cost of financing C_{fin}(USD/yrs) which is in our case calculate by equation (89),

$$C_{fin} = \left(\frac{AOP \cdot IR \cdot VL \cdot (1+IR)LPP}{((1+IR)LPP-1)}\right) \tag{89}$$

- Cost of the aircraft insurance C_{ins}(USD/yrs) which is in our case calculate by equation (90),

$$C_{ins} = IR \cdot AMP \tag{90}$$

- Cost of ownership aircraft $C_{a,own,py}$(USD/yrs) which is in our case calculate by equation (91),

$$Ca, own.py = CDAOP + C_{finan} + Cinsurance \tag{91}$$

- Direct labour cost of airframe $DC_{lab.af}$(USD/flight) which is in our case calculate by equation (92),

$$DC\ lab, af = VMAF * (t_{BT} - t\ gr) * (1{,}425 + 0{,}152 \cdot m_{MEM}) \cdot 1{,}925 * {n_{ysa/c}}^{-0{,}1166} \tag{92}$$

- Direct airframe maintenance material cost $DC_{mat,af}$(USD/flight) which is in our case calculate by equation (93),

$$DC\ mat, af = (t_{BT} - t\ gr) * (40{,}498 + 0{,}79 * AFP * 10 - 6) * 0{,}585 * {n_{ysa/c}}^{0{,}37911} \tag{93}$$

- Value of man-hours to maintain the engines VME(USD) which is in our case have value 50

- Direct labour cost of engines $DC_{lab,eng}$ (USD/flight) which is in our case calculate by equation (94),

$$DC_{lab.eng.} = n\ eng \ * VME \ * (t\ BT - tgr\ ) * 1{,}2 * (0{,}962 + 0{,}937 * T\ t0\ ) * (0{,}1 + 1100/H\ eng\ ) \tag{94}$$

- Direct engines main. material cost $DC_{mat.eng}$ (USD/flight) which is in our case calculate by equation (95),

$$DC_{mat.eng} = n\ eng \ * (t_{BT} - t_{\ gr}) \cdot ((7{,}2762 * EP * \ 10^{-5} - 0{,}63))/((0{,}769 + 0{,}021 \cdot H\ eng\ /100)) \tag{95}$$

- Direct maintenance cost *DMC*(USD/flight) which is in our case calculate by equation (96),

$$DMC = DC_{lab.af} + DC_{mat.af} + DC_{lab.eng} + DC_{mat.eng} \tag{96}$$

- Total maintenance cost *TMC*(USD/flight), which is in our case calculate by equation (97),

$$TMC = DMC + DMC \cdot AMB + \ C_{hmpf} \ + C\ (m.tr)/flight \tag{97}$$

- Cost escalation factor CEF_{2002} which is in our case calculate by equation (98),

$$CEF2002 = ((4.1366 + 0.1049 \cdot (2002 - 1997))) \tag{98}$$

- Cost escalation factor CEF_{2013} which is in our case calculate by equation (99),

$$CEF2013 = ((4.1366 + 0.1049 \cdot (2013 - 1997))) \tag{99}$$

Cost results can be sublime in following final results:

- Break even point bep_{pass}(number of passengers), which is in our case calculate by equation (100),

$$bep_{pass} = \frac{TC}{AF} \tag{100}$$

- Break even point *bep* (%)which is in our case calculate by equation (101),

$$bep(\%) = \left(\frac{bep_{pass}}{ns}\right) * 100 \tag{101}$$

- Unit cost *UC*(USD/Pass.Nm) which is in our case calculate by equation (102),

$$UC = ((TC/(ns \cdot (lf)_{pass} \cdot D)) \tag{102}$$

- Operating cost per flight *OC*(USD/flight) which is in our case calculate by equation (103) and

$$OC = TC_{final} - C_{a,own} \tag{103}$$

- Unit operating cost per flight *UOC*(USD/Pass.Nm) which is in our case calculate by equation (104).

$$UOC = \frac{OC}{D \cdot ns \cdot (lf)_{passengers}} \tag{104}$$

4 COPARISON MODULE

The developed complex flight and direct operating cost model in previous chapters allow development of comparison between A320Classic and A320NEO. This comparison investigation can be start from comparison of block fuel per passengers and Nm, $m_{BF/PASS.Nm}$(g/Nm) shown in equation (53) for various operative Mach numbers(Figure 1.), for distance *D* (Nm) of 1000Nm and *FL*=31000ft. In this examination we also introduce increase of engine thrust by 10% (and aircraft mass) and lower *SFC* of new engine for 10% which is expected values for A320NEO engines. For same operative conditions we explore parameters of costs in Figure 2, Figure 3 and Figure 4. From illustrated comparisons it is obvious advantage of A320NEO in flight operative parameters and in direct operating cost parameters.

5 CONCLUSIONS

A new approach to defining conditions for minimum aircraft total operative costs technique determination was introduced in this paper, but with application in process of comparison between A320classic and A320NEO. We also defined an improvement which brings new aerodynamic feather and possible further improvement with new engines. In the process of defining optimal direct operating costs, the influence of choice of optimal *FL* on en route total costs was shown. Recalling assumptions of flight profile, the existence of further development of cost optimization in climb, cruise and decent flight phase becomes obvious.

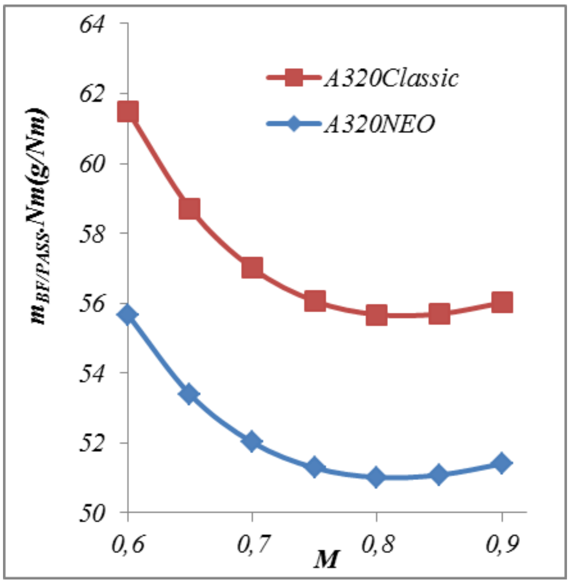

Figure 1: Comparison of A320Classic and A320 NEO $m_{BF/PASS.Nm}$ for different operative Mach numbers

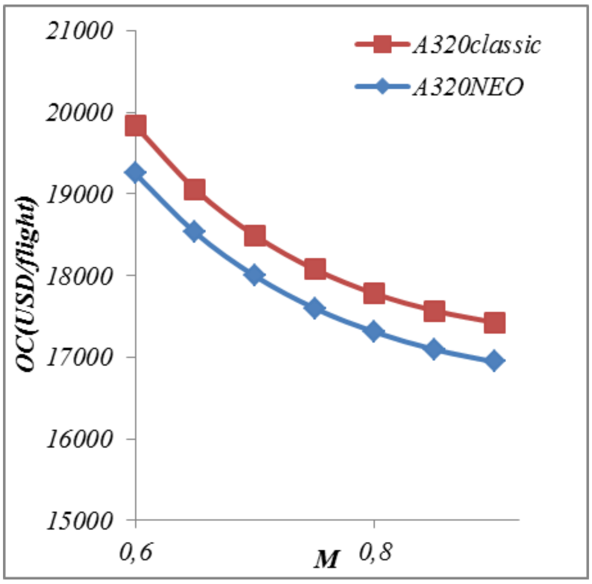

Figure 2: The comparison of A320Classic and A320 NEO OC (USD/flight)for different operative Mach numbers

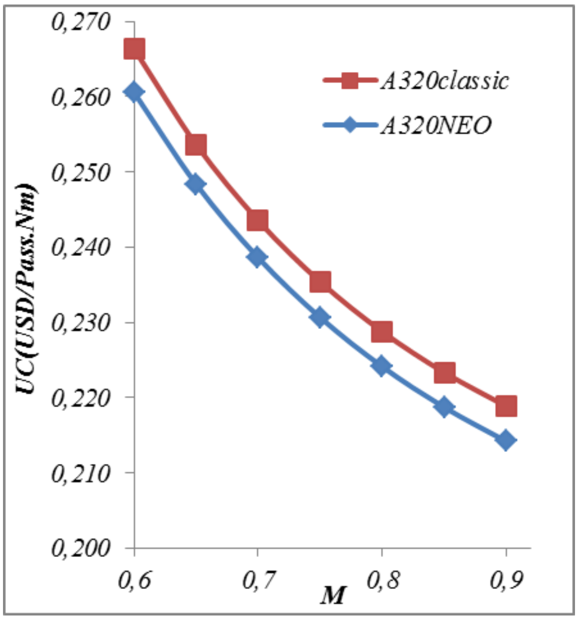

Figure 3: Comparison of A320Classic and A320 NEO UC(USD/PassNM) for different operative Mach numbers

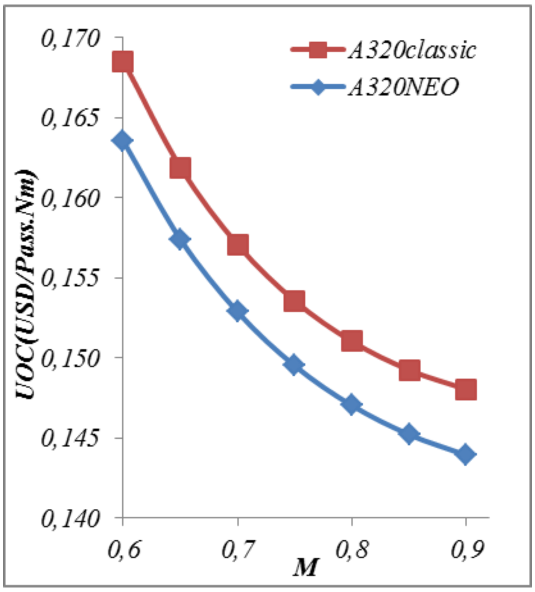

Figure 4: Comparison of A320Classic and A320 NEO *UOC(USD/Pass.Nm)* for different operative Mach numbers

The presented operating cost determination technique is especially applicable on short-haul flights, where climb and descent range can have a length of about 50% of total range. The practical benefit from proposed flight and direct operating costs method is to air operator, which can be synthesized in conclusion that old airframe with small changes and total new engine design can achieve minimum operating cost and contribute to aircraft efficiency in total.

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LAW ON PROTECTION OF THE SEA FROM POLLUTION BY VESSELS OF MONTENEGRO

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ABSTRACT

The Law on protection of the sea from pollution by vessels which was passed by the Parliament of Montenegro on 31 March 2011 was published in the "Official Gazette of Montenegro", nos. 20/11 and 26/11. There was the need for enactment of such a law since the Government realized the danger that threatens the marine environment from pollution by vessels, either directly by discharging various substances, or indirectly through the atmosphere. The main aim of its adoption was to prevent, reduce and eliminate, as far as possible, the pollution of the marine environment. The subject matter of the Law is to protect the sea from pollution by vessels which sail or are located in internal waters and territorial sea of Montenegro, waste collection and disposal practices at ports, as well as liability and compensation for damage in the case of pollution.
The Law comprises 69 articles and XVI chapters that include: measures and notification procedures when entering and leaving ports of Montenegro, substances prohibited to discharge from vessels at sea, construction, equipment and conditions to be met by vessels carrying oil as cargo or using it as fuel when entering the waters of Montenegro, equipment and conditions for ships carrying noxious liquid substances in bulk, conditions and manners of packaging harmful and polluting substances, conditions and method of packaging harmful and polluting substances, conditions and manner of discharge of sewage from ships, throwing waste from ships, air pollution from ships, ballast water (measures and procedures for their replacement, replacement control) manner of disposal into the sea and burying the waste, waste acceptance and waste management, liability, compensation for damages, and the like. Comment of the content of this Law represents the subject matter of this paper.

Keywords: the law, sea pollution, protection of the sea, vessels, ship.

1 INTRODUCTION

Montenegro adopted the Law on Protection of the Sea from Pollution by Vessels. The legal basis for its decision is contained in the provisions of Article 16, paragraph 1, item 5 of the Constitution of Montenegro[1], which provides that the Law in accordance with the Constitution shall define the issues of interest for Montenegro.

Work on the legislation began in 2004, and its passing was anticipated in 2008/09, however due to complexity of the matter addressed therein, and the process of harmonization with the EU, the law was not passed on time. The law governs the protection of the sea against pollution from vessels that sail or are located in internal waters and territorial sea of Montenegro, waste collection and handling at ports, as well as liability and compensation for damage in case of contamination[2]. Upon the entry into force of the related law, the Law on Maritime and Inland Navigation shall not be valid anymore, in the specific provisions relating

[1] „Official Gazette of Montenegro“ No. 01/07
[2] Article 1 of the Law

to marine pollution by hazardous and noxious substances[3]. Related by-laws shall be passed for the purpose of law enforcement within 12 months of its entry into force. The implementation of this Law shall be supervised by the Ministry of Transport, Maritime Affairs and Telecommunications of Montenegro[4]. The law provides penalties for non-compliance with its provisions, the amount of which varies from € 500 to 20 000. Given the complexity of the law, it is impossible to show all provisions in detail, so, we will present some provisions thereof.

2 STRUCTURE, OBJECT AND PURPOSE OF THE LAW

The law is designed in XVI Chapters. These are: I General Provisions, II Ship-generated pollution, III Ship for transport of oil or fuel as cargos, IV Ship for transport of hazardous liquids in bulk, V Ship for the transport of hazardous substances in packaged form, VI Sewage waste, VII Municipal waste, VIII The emission of harmful substances into the air, IX Ballast water, X Hull anti-fouling systems XI Deliberate dumping of waste, XII Reception and waste management, waste oil, cargo residues and sediment from ballast tanks in ports, XIII Responsibility and compensation in case of sea pollution by vessels, XIV Monitoring, XV Penalties, XVI Transitional and Final Provisions.

The content of the chapters is distributed in 69 Articles which govern the following: the substances banned to be discharged from vessels to the sea, measures and notification procedures during sail in and out the ports of Montenegro, construction, equipment and conditions to be met by vessels, terms and conditions of the package for polluting substances, conditions and manner of discharge of sewage waste from ships, throwing waste from ships, air pollution from ships, ballast water (measures and procedures for their replacement, replacement control), the disposal at the sea and bury of the waste, collection and waste management, accountability and compensation, etc.

The purpose of the Law is to protect the sea against pollution from vessels that sail or located in internal waters and territorial sea of Montenegro[5], waste collection and handling at ports, as well as liability and compensation for damage in case of contamination. The aim of its adoption is to prevent, reduce and eliminate pollution of the marine environment as far as possible.

3 LAW COMPLIANCE WITH EUROPEAN LEGISLATION AND INTERNATIONAL CONVENTIONS

The most important European directives and international conventions that deal with this matter were the starting point for making the Law. The Law incorporates the best solutions and practices from the developed world, and recommendations of the EU and many Conventions. Particular emphasize is given to the Law's compliance with:

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[3] The provisions of the Articles 56, 102, 112, 113, 156, 157, and 161 of the Law on Maritime and Inland Navigation shall not be valid anymore, „Official Gazettes of the Federal Republic of Yugoslavia“ No. 12/98, 44/99, 74/99 and 73/00

[4] Hereinafter referred to as "the Ministry".

[5] Pursuant to the Law on Sea of the Republic of Montenegro („Official Gazette of the Republic of Montenegro "No. 17/07) inland sea waters include ports, bays and islands, river estuaries and the parts of the sea between the coastline and the base line of the territorial sea. Inland sea waters include the waters of the Skadar Lake, Crnojevića River and the River Bojana up to the line of their seaworthiness. Pursuant to the Article 13 of the related Law, territorial sea of Montenegro is 12 nautical miles wide sea area, counting form the sea baseline in the direction of the sea.

1. The European Union Directive, establishing a Community vessel traffic monitoring and information system, Directive 2002/59/EC,
2. EU Directive on port reception facilities for ship-generated waste and cargo residues**,** Directive 2000/59/EC,
3. Resolution MEPC 2 (VI) - containing recommendations on international standards for treated sewage wastewater and guidelines for the testing of the system for the treatment of the same,
4. Resolution MEPC 159 (55) - contains the revised guidelines for the enforcement of standards for treated sewage wastewater, as well as standards for the testing of the system for the treatment of the same,
5. Resolution MEPC 83 (44) - provides guidelines for ensuring the adequacy of port reception facilities,
6. International Convention on the Control of Harmful Anti fouling Systems on Ships, AFS Convention 2001,
7. International Convention for the Control and Management of Ships Ballast Water and Sediments, BALLAST WATER 2004,
8. International Convention on Civil Liability for Bunker Oil Pollution Damage, BUNKERS 2001,
9. International Convention on Civil Liability for Oil Pollution Damage (CLC)1969,. - Protocol 1992,
10. International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage , FUND 1971. - Protocol 1992,
11. International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS), 1996,
12. Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (LC), 1972 (and the 1996 London Protocol),
13. International Convention for the Prevention of Pollution from Ships, MARPOL 73/78,
14. International Convention on Oil Pollution Preparedness, Response and Co-operation, OPRC, 1990,
15. Protocol on Preparedness, Response and Co-operation to pollution Incidents by Hazardous and Noxious Substances, 2000 (OPRC-HNS Protocol)
16. International Convention for the Safety of Life at Sea, SOLAS 1974,
17. Convention for the Protection of the Mediterranean Sea Against Pollution, BARCELONA CONVENTION 1995.

3 DEFINITION OF CERTAIN TERMS

The Article 3 of the Law defines and determines the meaning of certain terms (expressions) that are used therein, in order to provide a complete explanation and application of certain statutory provisions. They are: address, ballast water, vessel calibration, boat, clean ballast, separate ballast, emission, sewage waste, municipal waste, waste, waste oil, bilge water, soaking, vessel, port user, shipper, operator etc.

- "Address" is the name, or the name and the communication link through which it is possible to get in touch with the owner of the vessel, the agent, the authorized body who has information relating to the vessel,

- "Ballast water" means water taken from the sea, river or lake in order to redress the longitudinal and transverse slope, draft, stability and pressure of the vessel, which is not transported as cargo.
- “Vessel calibration” is determination of the vessel tonnage.
- "Vessel" is a passenger, cargo, fishing, public or scientific research vessel designed to sail at sea which is longer than 12 meters and a minimum capacity of 15 tons or is designed to carry more than 12 passengers.
- "Clean ballast" in the ballast water in the tank, which is, after the last transport of oil, cleaned and which after discharge in the clean and peaceful seawater on a nice day does not produce visible traces of oil on the surface of the water or on nearby land or causing deposition of heavy oil or emulsion residue beneath the surface of the water or on nearby land, not exceeding 15 ppm.
- "Separate ballast" the ballast water that enters the tank and is intended solely for the transport of ballast, which is separated from the liquid cargo and fuel system.
- "Emission" is the release of harmful gases into the atmosphere or the sea, generated by combustion of waste in the ship's incinerators, combustion of fuel and gas from the ship's systems and equipment.
- "Sewage waste" means waste that is discharged from the ship's toilets, medical facilities (pharmacies, hospitals etc.), through the sink, bathtub, sink holes located in such premises, from the space with live animals and other waste water mixed with emissions.
- "Municipal waste" means all types of animal waste, waste from the galley and works on the board, excluding fresh fish and its parts, which were created by regular work, and can be removed.
- "Waste" means unnecessary, undesirable or superfluous material left over after the completion of a process on the vessel.
- "Waste oil" means oil, unfit for use, produced or created on the vessel.
- "Bilge water" means oily water collected in machinery spaces, and water from the ship's bilges warehouses, formed from the remnants of cargo and precipitation.
- "Dumping" means any deliberate disposal of wastes or other substance from the ship into the sea.
- "Vessel" is a ship, floating plant, boat and other property which is located in the marine environment and includes hydrofoil boats, hovercrafts, submarines, floating crafts and fixed or floating platforms.
- "Port user" is the administrative authority or legal entity that manages the port or the part thereof or a legal or natural person who is assigned the right to use the port or the part thereof (concessions).
- "Shipper" means a person who delivers cargo to the operator for transport, pursuant to the contract.

  "Operator" means a person who has signed a contract with the shipper, and it can be a vessel owner, lessee, manager or the vessel’s agent.

4 SOME PROVISIONS OF THE LAW

The main provisions of the Law define seaworthiness. Article 2 states that in the waters of Montenegro it is permitted sailing of the vessel with the flag of Montenegro and the vessel with a foreign flag in accordance with the provisions of the Law and the law governing the safety of navigation[6], if their construction and navigable properties, machinery, appliances and equipment that serves to maintain the safety of sailing ships, the technical characteristics, quantity, type and arrangement of the ship, meet the technical requirements of the IMO.

In the further text of the Law, there is, inter alia, an obligation to submit the information by the shipper and operator of the ship carrying harmful substances, then the substances prohibited to be discharged into the sea are specified, and the technical requirements to be met by ships that are in the waters of Montenegro, in terms of protection of the sea from pollution.

Pursuant to Article 3, item 38 of the Law, harmful substances are all hazardous and noxious substances other than oil, which discharged into the marine environment, may cause pollution of the marine environment and endanger human health. If the harmful substances or radioactive cargo are embarked on the vessel, the shipper shall, before their embarkation, supply the master or owner of a vessel with a statement of technical data, names, UN numbers, classes[7] of hazardous goods, the quantities of these substances, address, and identification marks of portable tanks and containers[8]. If radioactive cargo is embarked, data on the type of ship and the amount of radioactive cargo must be delivered to. There is obligation on the side of the ship operator to deliver data, but difference is made between the operators of ships carrying harmful substances, and comes from a port that is a member state of the EU and non-EU country. According to the provisions of Article 6 prior to departure from the port, the ship operator is required to provide to the nearest available port authorities: name, reference number, IMO number or Maritime Mobile Service Identity number, details of the port of destination, estimated time of departure and arrival at the port of destination, the data from previous article provided by the shipper; statement that on the board there is a list or manifest, stowage plan, as well as the place of storage of hazardous substances on board. Ship operator may be released from the obligation to provide information by the Ministry[9].

If a ship comes from a port of non EU Member States and entering the port or anchorage in Montenegro, after departure from the previous port of embarkation the operator shall immediately submit to the port authorities all the above information. However, if the ship comes from a port of any EU member-state of, in this case the ship operator is required to provide the name, reference number, IMO number or MMSI number, then the information on the port of destination, estimated time of departure and arrival at the port of destination, as well as data on the total number of persons on board. The submission of other information is not required. The law foresees the time when the data must be delivered, it is a period of 24 hours before departure of the ship or at the latest at the time of departure of the ship from the previous port of embarkation, if vessel sailing lasts less than 24 hours.[10]

Article 4 regulates which substances are prohibited to be discharge by vessels into waters of Montenegro. “Discharge” means "any discharge from the vessel, including: outflow, removal, spilling, leaking, pumping, eject or emptying" So the law regulates that the following is forbidden:

- Discharge of oil, oily mixtures, oily bilge water and waste;
- Discharge of hazardous substances that are temporarily designated as such, the washing water tanks or other mixtures containing such substances;

[6] Montenegro has not yet adopted the Law governing the safety of navigation, but the Law on Maritime and Internal Navigation of the Federal Republic of Yugoslavia is still applied.
[7] Article 5, paragraph 2 provides that hazard class is the class of hazardous substances in accordance with the International Maritime Dangerous Goods Code (IMDG Code) defined by IMO according to the properties of goods.
[8] Article 5 of the Law.
[9] Article 6, paragraph 3 of the Law.
[10] Article 7 of the Law.

- Discharge and disposal in the seabed of harmful substances in packaged form;[11]
- Discharge of municipal waste;
- Discharge of pollutants into the air;
- Discharge of ballast water and sediment from ballast tanks if they contain harmful substances, pathogenic organisms and invasive species;
- The application of anti-vegetative systems, i.e. hull antifouling system if they contain biocidal organic compounds of tin;
- Deliberate dumping, burning and burying waste on the seabed, or other substances.

The same Article in the paragraph 4 emphasizes that this prohibition shall not apply to actions done for the safety of the ship or rescue of human lives at sea, the activities that have occurred as a result of damage to the vessel or its equipment and activities that have taken place because of pollution prevention and elimination of consequences thereof.

Despite this prohibition principle, as set out in Article 4, in the following Articles, it is still permitted upon the fulfillment of certain conditions, to discharge certain substances. Thus, the provisions of Article 33 stipulate that the waste of food (which belongs to the municipal waste) may be discharged from the ship into the sea at the distance of three nautical miles from land, if it is shredded by the appropriate devices with openings smaller than 25 mm. Article 32 provides that "discharge of sewage waste from the ship into the sea is prohibited, except in the following cases: 1) release of shredded and disinfected sewage waste at the distance of three nautical miles from the nearest land, or discharge of sewage wastes gradually, which is not shredded and disinfected, which is stored in storage tanks while the ship sales at speed of at least four nodes, at a distance of more than 12 nautical miles from the nearest land, and 2) if the ship has a system for the treatment of sewage waste[12] 3) when the discharge of sewage waste is made to rescue people's lives and ensure safety of the ship, and 4) when the discharge of sewage wastes is produced as a result of damage to the ship or its equipment, or other reasons that could not have been avoided, and all measures were taken to prevent the discharge of sewage waste. Article 35 stipulates that it is prohibited to discharge pollutants from the vessel into the air, except in the case of research and exploitation of the seabed and lying of submarine cable, as well as in the case of imminent danger to human health and the environment,

In Article 46, paragraph 4 it is envisaged that the prohibition to discharge ballast water and sediment from ballast tanks, if they contain harmful substances, pathogenic organisms and invasive species, will not apply to the actions and activities that are made for the safety of the ship or safety of life at sea, then the actions that occurred as a result of damage to the vessel or its equipment and operations made in order to prevent pollution and eliminate the effects of pollution. Also, in certain cases, discharges can be done, but on the basis of

[11] It is emphasized in Article 29 of the Law that harmful substances being transported as a cargo must be packed and labeled in a prescribed manner. Their package must contain technical names of the substances and label saying that the packed substances are pollutants. This designation must be visibly displayed and manufactured of waterproof material with the duration period of at least 3 months following the date of its installation.

[12] Article 31 stipulates that the ship with carrying capacity of 400 tons carrying more than 15 passengers and crew members and the ship with carrying capacity of at least 400 tons must have built-in a system of facilities for sewage waste, which must be in good condition. The Law states 3 systems, such as: system to handle sewage waste; system for shredding and disinfection of sewage wastes with appropriate storage space for temporary storage of sewage waste, when the vessel is within three nautical miles from the nearest land; and the storage tank, with a capacity sufficient for total sewage waste storage up to delivery to waste reception and handling facilities at the port; the content of which must be drained via the standard discharge connector located on the open deck.

approval, at the request of the master or owner of the vessel, issued by the competent government authority.

5 NOTIFICATION, TAKING AND ANALYZING SAMPLES

If the master observes pollution in the sailing route, he is obliged to inform thereof the port authorities without delay, and to submit the report with a summary of the log, within 24 hours of arrival in the port[13]. If contamination occurred during navigation in international waters, the master of the ship under the flag of Montenegro is obliged to report on pollution with an extract from the log to the diplomatic or consular representative of Montenegro in the country in the port of which first entering, within 24 hours of entering.

If pollution is actually occurred, taking and analysis of samples shall be carried out in order to determine the types of pollution and to take measures to eliminate pollution and identification of the perpetrator[14]. Jobs of sample taking and analysis may be performed by an authorized legal entity that: is registered for carrying out activities in the field of environmental protection, and have a professional staff, appropriate equipment and devices. Authorized entity performs analysis and sample taking according to the order given by the inspector of navigation safety[15]. Pursuant to Article 14 administrative authority shall take the necessary measures to prevent, reduce and eliminate pollution consequences in accordance with the emergency plan[16]. Prevention, reduction and elimination of consequences of marine pollution from the vessel may be performed only by a legal person registered for this activity, if it meets the requirements in respect of professional and technical expertise[17].

In the Article 46 of the chapter that regulates ballast water it is provided that the analysis of samples and testing of discharged ballast waters will be carried out, if the inspector suspects that ballast water contains micro-organisms, invasive species, or other harmful substances. Also, in relation to the pollution of ballast water in the port area, Article 48 provides that the obligation of the user of the port will be to carry out analysis of the condition of the sea every three months, to make a report thereof to the Ministry and Government body in charge of environmental protection within two days from the date of preparation of the report[18].

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[13] Pursuant to Article 9 of the Law, within 24 hours of observed pollution, the master must make a note and enter it in the log

[14] Article 12 of the Law

[15] Article 13, paragraph 1 of the Law

[16] In April 2011 the Government of Montenegro adopted the national plan for emergency response in case of marine pollution from vessels. This plan establishes the principles of work, duties and responsibilities, measures and procedures to prevent, reduce and eliminate consequences of marine pollution from vessels. The purpose of the Plan is to ensure the timely and efficient response at national level to maritime accidents caused by pollution from vessels. The plan shall be implemented in the event of maritime accidents that caused or could cause pollution in coastal areas, the seabed or beneath the seabed of Montenegro, which include inland waters and territorial sea. The overall objective of the Plan is to organize initial and effective response in the event of oil spills and hazardous noxious substances (HNS) that adversely affects, or could have adverse affect on the marine environment of Montenegro and its coastal area as well as providing national and international cooperation in the Adriatic and Mediterranean seas.

[17] Article 15 of the Law

[18] Article 48 of the Law

6 RECEPTION AND HANDLING OF THE WASTE, WASTE OIL, CARGO RESIDUES AND SEDIMENT FROM BALLAST TANKS

Articles 51 to 54 of the Law contain provisions on the acceptance and handling of waste, waste oil, cargo residues and sediment from ballast tanks of vessels. In this sense, according to the provisions of Articles 51 and 52 there are obligations of the user of the port to equip the port with waste reception and handling facilities and to have the plan of acceptance and handling of the waste, waste oil and cargo residues from the vessel, certified by the Ministry.

The shipmaster is obliged to submit a report on waste amount to the port authorities when entering the port and to keep the report up to the entering in the next port. The law sets the period within which the report must be submitted as follows: if the destination port is known, at least 24 hours before entering the port, and if the destination port is not known, immediately after learning of the destination port. If the travel time is less than 24 hours, then the report must be submitted immediately after the departure from the previous port[19].

According to the provisions of Article 54 of the master is obliged, before departure of the port to deliver the waste, waste oil and cargo residues to reception facilities unless there is on board storage space for waste disposal, waste oil and cargo residues generated while staying in port. Also, the provisions of Article 47 provides that the master of the ship shall collect residue which remains after the discharge of ballast water, solely by using mechanical tools and devices and dispose them in the ground facilities for the reception and handling.

7 REGULATION OF BALLAST WATER

In Articles 40 to 48 the Law treats ballast waters. The law prescribes measures and procedures of ballast water replacement for ships going to the ports in Montenegro, as well as the replacement control procedures of ships' ballast water and performance analysis.

Master shall, to the extent that it does not jeopardize the safety of navigation and protection of the marine environment, avoid or limit the loading of ballast water in certain areas. These are areas in which there are: harmful microorganisms, factory outlets, particularly high differences between tide and low tide, the high turbidity of the water due to operation of marine propulsion devices, or areas where underwater dredging is done, fish spawning areas, or where there is a collision of sea currents. Before entering the waters of Montenegro, the master who embarked the ballast water is required to perform certain actions. He shall: replace ballast water or ballast water treatment or discharge ballast water into the reception facilities for the handling or retention of ballast water on board. However, Article 42 provides that it is not mandatory for the master to perform these actions in cases where the safety of the ship and the lives of people are endangered, and when there is a threat of pollution with harmful substances. According to Article 41 replacement of ballast water is allowed at a distance of 200 nautical miles from the nearest land and sea depth of 200 meters. If the ship is not able to make replacement of ballast water, in order to meet the above criteria, it is provided that the replacement shall be performed at a distance of at least 50 nautical miles from the nearest land and in the sea depth of 200 meters. This replacement must cover at least 95% of existing ballast water on board. The vessel that embarks ballast water in the fuel tank is permitted discharging exclusively in inland devices for receiving and handling or at sea or through oil filtering equipment with alarm and automatic stopping[20].

[19] Article 53 of the Law
[20] Article 43 of the Law

According to the provisions of Article 44 the vessel designed for loading ballast water, which arrives into the port of Montenegro must have a ballast water management plan. The plan is kept in Montenegrin and English, and contains information on the procedures to be implemented for the safety of the ship and the crew in relation to ballast water, actions and activities to be undertaken in the management of ballast water, sludge disposal practices from ballast tanks at sea and on the mainland, methods of coordination with the competent authorities of the State in the waters of which the discharge of ballast water is conducted, the manner of reporting, the person on the ship who is in charge of implementing the plan, as well as other information relevant to the management of ballast water.

In addition to the Ballast Water Management Plan, the provisions of Article 45 of the Law provide for the obligation of keeping the books for the tanker deadweight capacity of at least 150 tons and a ship load of at least 300 tons. These vessels are obliged to report the amount and origin of ballast water to the marine authorities, not later than 48 hours prior to arrival at the port of Montenegro. In the book of ballast it should enter the following information: name of tanker or ship, IMO number, the gross tonnage, the flag under which the vessel or tanker sales, the capacity of ballast water tanks. Book of ballast water is kept in Montenegrin and English.

8 LIABILITY AND COMPENSATION IN CASE OF MARINE POLLUTION FROM VESSELS

Separate Articles govern the issue of responsibility for the damages caused by vessel carrying oil as bulk cargo or vessel carrying hazardous materials in bulk, due to leakage or expulsion of oil or hazardous substances into the sea. By the provision of Article 55, it is provided for that responsibility for such damage shall be taken by the owner of the vessel. However, the law provides in the same Article, paragraph 1 and 2, the possibility of its complete or partial exemption from liability, if the owner of the vessel proves that related spill or discharge was caused by war or force majeure, solely by an act or omission to act of a third party with the intent to cause damage, solely by act or omission to act of the Port or related authorities or if he proves that the damage in whole or in part was caused by the injured party.

The claim may be made against: a person employed by the ship owner or the owner's agent or crew members, pilots or other persons who are not members of the crew, and who perform services on the ship, cargo shipper of any kind, including charterer without crew or persons who have taken preventive and operational measures, unless the damage is caused due to their direct action or omission to act with the intent to cause damage, if such person knew or should have known that such damage could occur[21]. If damage occurred due to marine pollution was a result of an accident with two or more vessels have participated in and it is not possible to determine from which vessel and which part of the damage was caused, the owners of these vessels shall be jointly liable[22] for the whole damage.

9 CONCLUSION

In recent years Montenegro has made significant progress in protecting the sea from pollution from vessels. In this sense, it passed the Law on Protection of the Sea from pollution by Vessels which is the first and basic legal instrument regulating the issue of protection of the marine environment from pollution from ships and other vessels. The route to the final

[21] Article 55, paragraph 3 of the Law
[22] Article 56 of the Law

version of this Law was long and complex. However, the Law fulfills all the obligations set by various international organizations of global and regional character. The Law provides the legal basis for the adoption of several by-laws in this area. Certainly the most important by-law is a National Plan for Emergency Response in case of marine pollution from vessels, which represents unique response of the country in terms of personnel and equipment in cases of accidental spills of oil (crude oil) into the sea. Among the other by-laws, development of these ones is in progress: Regulations on Technical Requirements to be Met by Fixed and Floating Platforms for the Prevention of Pollution, Regulations on the Conditions of the Professional and Technical Competence of the Legal Entity for Performing of the Prevention, Reduction and Elimination of the Consequences of the Vessel Generated Sea Pollution and Rules of Treatment of Ballast Water on Board.

What follows in the next period is certainly to create better conditions for the consistent enforcement of legislation, not only by the public administration, ship-owners and shipbuilders, but also by all other participants in the maritime industry, as well as the provision of resources for enforcement of the law.

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NETWORK CAPABILITY AND AIR TRANSPORT CROSS-SUPPLY IN THE ADRIATIC SEA BASIN

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ABSTRACT

The aim of the paper is to provide an overview of the current air transport supply on the Adriatic sea basin and among the countries surrounding its shores. The last month of the IATA Summer Season 2012 and the first two months of the IATA Winter Season 2012-2013 have been analysed, taking into account aircraft movements data collected in a target week at a sample of relevant airports. Moreover, runway length, airplanes' technical characteristics like the average range covered and the average seating configuration on board have been investigated. Tables and graphs highlight the relationships among airports, carriers and aircrafts employed to detect the total traffic share of each airport affecting the Adriatic Sea basin and, finally, the O-D couples with actually operated routes.
Given the amount of data collected, a further analysis on the supply variation during time and between working days and holidays has been carried out.
The analysis of main results shows that the cross-demand between the opposite shores is affected by the scarce business dealings among the countries, while the basin is heavily crossed by air routes linking the south-east with the north-west of the EU as long as the EU with the Middle East.

Keywords: Adriatic sea basin, air transport, supply variation, network, range.

1 THE AIR TRANSPORT NETWORK

Systems such as the internet, friendship phenomena in social networks, metabolic networks and transportation systems are, as a whole, fields in which the network theory might be used to investigate and illustrate the operating principles. Also cross-citations between scientific papers and delivery routes are notable example of networks. A network system is usually composed of nodes and connections (arcs) which link together two nodes. A connection might be associated with a direction and other information such as, for example, frequency or its desirability (cost). Scientific literature usually distinguishes between scale-free, random graph and small-word networks. The degree distribution of a scale-free network is the so-called power law, expressed by the (1)

$$P_k \approx k^{-\gamma} \tag{1}$$

where γ is called the degree exponent, while the degree distribution of a random graph is of Poisson type (2), as it had been proven by Erdos & Renyi's researches in the 1950s [1].

$$P(k) = \frac{<k> e^{-<k>}}{k!} \tag{2}$$

Many scientific researchers, among those Bangler (2008) and many others, used network theory to study air transportation system as well, the nodes being the airports and the connections being the air routes. Therefore, airport network looks like a graph (network) whose properties could be computed using graph theoretical formalism; for example, air transport networks are directional (flights from/to an airport are usually grouped in "in-coming" and "out-coming") and it is possible to assign a "weight" to each route according – say - to the frequency, the number of flights per day or the number of seats sold.

Similarly to each network system, air transport network systems have performance parameters to describe or to assess the efficiency of the performance. The most known parameters in the scientific literature have been Characteristic path length (L), Clustering coefficient (C), Closeness (CL) and Betwenness (B), as reported in the following formulas (3) (4) and definitions.

$$L = \frac{1}{N(N-1)} \sum_{i,j=1}^{N} l_{ij} \tag{3}$$

$$C = \frac{1}{N} \sum_{i=1}^{N} c_i \tag{4}$$

Characteristic path length (L) is an average measure of the shortest path lengths between all possible pairs of nodes N, where the shortest path length between nodes I and j is l_{ij}. The smaller is L, the more compact and reachable the network is. A network has a good performance when L is small and vice-versa. Network's characteristics that must be kept in mind when discussing about L parameter are the number of airports and the morphology of the territory: narrow countries, hierarchically fragmented from the governmental authority point of view, are likely to have low values of L (for example Japan, Italy and the states situated in the north-east coast of the USA).

Clustering coefficient (C) represents the probability that two nodes in the network are connected to each other given that they are already (independently) both connected to a third common node. As it is easy to realize, when an air transport network's C is close to 1, it means that that network is easily accessible. C=1 would mean, indeed, that each pair of airport in the network is directly connected.

Closeness (CL) is defined as the average of (N − 1) shortest paths between node 'i' and the rest of the nodes. CL is a powerful parameter to measure the connectivity of 'a node' to the rest of the network. Generally speaking, low values of CL show better connectivity.

Betweenness (B) of a node 'k' is defined as the ratio of number of shortest paths passing through 'k' to the total number shortest paths in the network. It exemplifies the centrality of a target node in the network and therefore is a typical parameter to describe the performance of hub-airports [2].

The shape and extension of the network may vary on a daily or a seasonal basis according to the flight schedule developed by carriers and airport management on the occasion of IATA seasonal conferences. Network shifts are also undeniable when we compare the target airport's flight schedules at working days and on national holidays. In particular, it has been found by many researches that Monday is usually the busiest day while Saturday is at the opposite end of the list. This is particularly true for airline with a high percentage of flight carried out for business reasons.

Ding-Ding Han et al (2007) found interesting results for Austrian airline, which are summarized in Table 1 and Figure1 (each point in Figure1 represents the data of a day in one week). Figure 1a shows the correlation of total flight numbers (M_{flight}) and the power-law exponents of the weight flight distributions (γ_{flight}): the larger the total flight numbers, the smaller the exponents, therefore the flatter the weight flight distribution. Figure 1c and 1e display the positive correlation between k_{in} and k_{out}, and γ_{in} and γ_{out}, respectively, assessing that there is similar behavior for both incoming flight network and outgoing flight network (it couldn't have been different, as for passenger airports one flight movement is the sum of an in-bound and an out-bound flight). Figure 1f shows the positive correlation between γ_{out} and $\gamma_{flight-out}$, assessing that there seems to be a positive correlation between the degree distribution and weight flight distribution. Figure 1b and 1d shows the relationship between the k_{out} and γ_{out} (or $\gamma_{flight-out}$ respectively), which indicates that the degree or weight flight distribution which has larger mean value of the degree or weight flights has flatter distributions. From these correlation plots, authors found that the flight network shows its evolving feature day by day in a week, and therefore different exponent values of network distributions are traceable in different week-days; this is apparently related to the total number of flights per day [3].

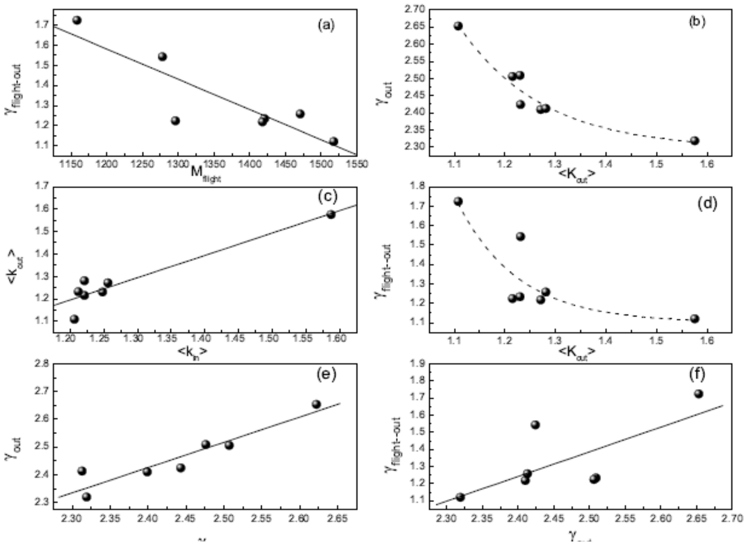


Figure 1: Correlation between indicators for Austrian Airline in 2007

Source: ([3])

Table 1: Comparison of relevant variables: number of the airports N; numbers of fights M;exponent γ of first segment of degree distribution; <k> the average degree; $\gamma_{flight\text{-}out}$ the exponents of weight flight distribution; C the clustering coefficient of the system; r the assortment coefficient

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
$N_{airport}$	133	136	134	136	136	130	134
M_{flight}	1518	1421	1418	1296	1471	1158	1278
γ_{in}	2.319	2.476	2.399	2.507	2.312	2.622	2.443
γ_{out}	2.319	2.509	2.410	2.506	2.413	2.653	2.424
γ_{all}	2.331	2.319	2.478	2.519	2.495	2.649	2.457
$\langle k_{in} \rangle$	1.587	1.248	1.256	1.221	1.221	1.206	1.212
$\langle k_{out} \rangle$	1.576	1.230	1.271	1.215	1.281	1.108	1.256
$\langle k_{all} \rangle$	1.609	1.221	1.306	1.250	1.309	1.177	1.231
$\gamma_{flight-out}$	1.120	1.234	1.218	1.224	1.258	1.724	1.543
C	0.202	0.204	0.195	0.206	0.242	0.180	0.210
r	-0.529	-0.515	-0.519	-0.517	-0.517	-0.562	-0.543

Source: ([3])

2 AIR TRAFFIC TRENDS

The present situation of air transport is different among the continents according to all the industry's forecasts and reports: Middle East, Asia and South America have recently been the leading market in terms of growth trends, while in North America and Australia the trend is less evident; due to different reasons, Africa and European market are facing a phase of stagnation and – in some cases – recession (Figure 2 and 3).

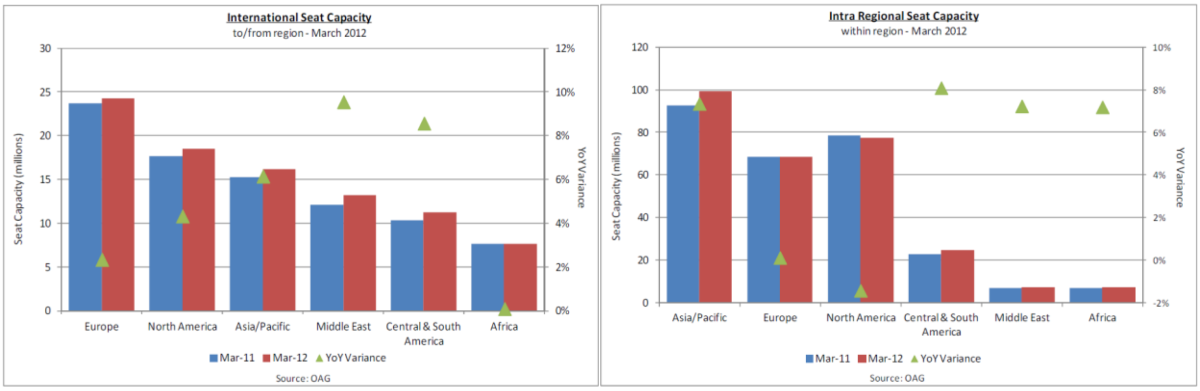
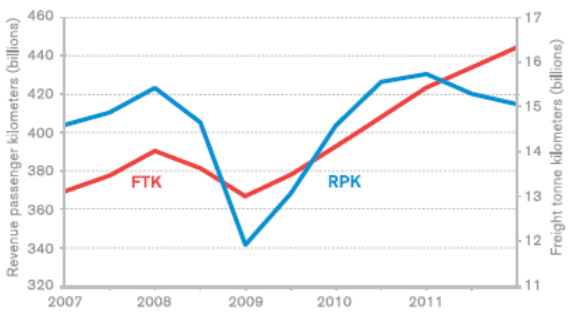


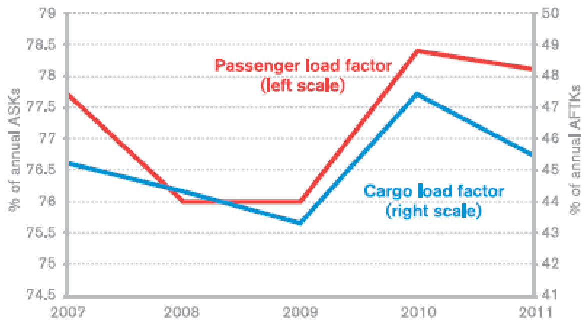
Figure 2 - 3: Year on Year performance international and intra-regional seat capacity

Source: ([4])

After the strong crisis of 2009, the industry is still trying to recover: in 2010 revenues, load factors and yields scored a fair improvement, but in 2011 levels went back to 2007's values with a marked decline. (Figure 4-6)

With regard to 2012 European market performances, not even European football championship helped to counter the traffic falling trend. The overall passenger traffic grew of just +1,8% with reference to 2011, but the situation is twofold: on the one hand air traffic at EU countries is in stagnation or recession (less than +2% growth from 2008 onwards), on the other hand non-EU countries – led by Turkey and Russia – are posting significant results (more than +38% traffic from 2008). Freight and air traffic movements posted a decrease of -2,8% and -2,1% respectively.





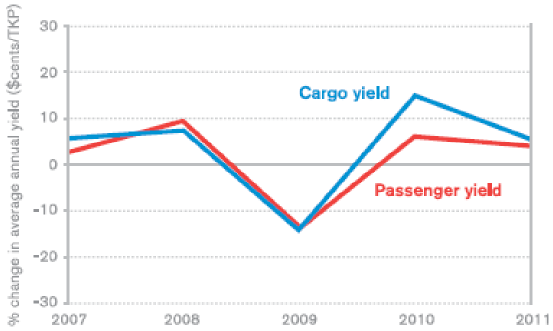


Figure 4: Total passenger and air freight traffic, seasonally adjusted

Figure 5: Passenger and cargo load factors

Figure 6: Passenger and cargo yields

Source: [(5)]

Director General ACI EUROPE O. Jankovec is worried about the spiraling weak confidence in EU due to record unemployment levels, economic recession and jobs cutting policies introduced from airlines and airports as well as firms. More recent data on 2013 show the persistence of declining trend in EU countries as far as traffic levels and movements are concerned, while non-EU countries are still on the positive [6].

The traditional view of most airport as natural monopolies is increasingly being questioned because of the improved forces of competition which have occurred after the market deregulation and the consequent airline liberalisation and airport commercialisation. The traditional prototype of the late 1990s with a single scheduled airline for each country operating both domestic and inter-continental flights is still present only in partially un-grown markets around the world, for example Africa, somewhere in Asia and in other countries with a lack of mature international demand.

From 1990s on, Low-cost airlines brought in a new business model: they operate short-haul services in a point-to-point network with a lower cost structure in order to pursue lower fares. Their cost structure relies mostly on an increased aircraft and crew utilisation and on the use of single type of aircraft with a single-class and an higher seat density, thus enhancing efficiency and money savings.

Low cost carriers made flying accessible to new segments of population and opened to air traffic new routes and destinations as Figure 7 shows with reference to Germany; a modal shift from former flag carriers to low cost carriers has been observed as well.

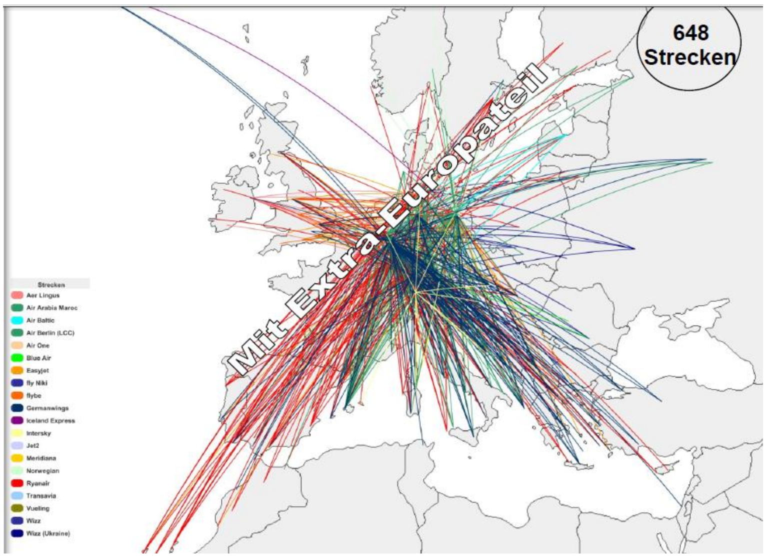


Figure 7: LCC market in Germany as of Autumn 2012

Source:[(7)]

LCCs came out of the 2009 meltdown generally with a stronger health if compared with their network rivals, benefiting from a high rise in demand and a pronounced improvement in their financial outlook. The biggest issues nowadays are how to cope with rising prices and where to find new market segments to set upon. In both Europe and North America analysts agree in saying that the market is almost mature and that no more double-digit growth rates will be seen in the next future (Figure 8 and 9).

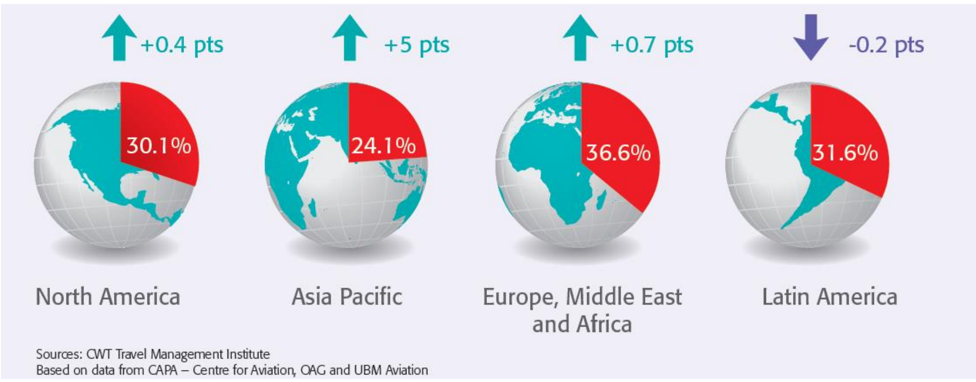


Figure 8: LCC's share of capacity in 2012 and year-on-year growth

Source: [(8)]

Nevertheless, there are still markets that are underserved and overpriced, for example France and other countries with a strong presence of network carriers. Moreover, a shift is still being observed from charter and second-tier network airlines to LCCs thanks to the former's recent bankruptcies. Finally, a new trend is being observed as LCCs are increasing their average sector length: in North America JetBlue and Southwest are flying trans-continental and in Europe both EasyJet and Ryanair are trespassing the former threshold of 3hrs flight time. Flying further brings extra-costs from the operational and security point of view and brings with it a change in the LCCs' revenue scheme [9].

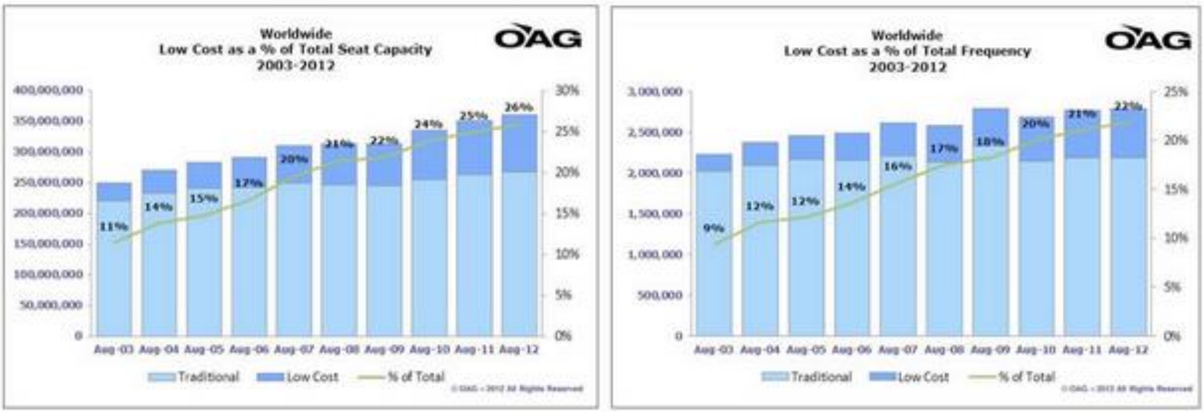


Figure 9: Worldwide LCCs' incidence (2003-2012) from the seat capacity and total frequency point of view

Source:[(10)]

As we had foreseen two years ago [11,12], the difference between LCCs and NCs is blurring and some airlines that were born as low costs now are more and more similar to low-fares-high-service carriers (Air Berlin and Virgin Blue just to name a few). Some LCCs are now present on the GDS, offer fidelity programs and are diversifying themselves in order to be attractive for business traffic as well (thus adding service and generating extra-revenues, keeping a strict supervision on costs); on the other hand network carriers are restructuring their structure cutting jobs, enhancing fleet usage, simplifying their fare design and offering lower fares especially on short-haul services; the practice of alliances and merges is also becoming ordinary as allied airlines would rather operate a single flight in code-share instead of two with a relevant cost reduction.

Doing so, recently, the cost per available seat kilometre as well as the revenue has been narrowing to its smallest. Moreover, LCCs like JetBlue, West Jet, Gol, Virgin Blue, Air Berlin and Germanwings have stepped up co-operation programs with network carriers. LCCs claim to be experiencing cost issues especially at airports: redundancy in the infrastructure, check-in and security bottlenecks as well as little possibilities to self-handling in addition to fuel and flying taxes.

High perspectives of development for LCCs remain high elsewhere, notably in Asia and Latin America. The presence of mature markets is limited to Australia and Brazil; in other countries the leading obstacle to development is the high regulation from the central governments and the presence of entry barriers. Southeast Asia remains the region's engine for low-cost travel, although Indonesia's Lion Air and the Philippines Cebu Pacific have largely restricted themselves to their domestic market. That has left Kuala Lumpur-headquartered AirAsia and Singapore-based Jetstar Asia and Tiger Airways to expand to other countries in the region [9].

The last topic it seems worth discussing about in this introduction is the recent trend of volatility in the market: in the last few years, the phenomena of launching and withdrawing new routes has been exacerbated both by LCCs and NCs in response to the aforementioned need to cut costs and to follow profitability. In addition to that, central government is no more injecting large amounts of money in airport management and therefore the inflated and artificially created air traffic demand is vanishing. Routes unprofitable for NCs have been taken over by LCCS in the past, but if LCCs as well consider a target route unprofitable the result is a crescent market volatility.

3 THE ADRIATIC SEA BASIN

The Adriatic Sea is the northernmost arm of the Mediterranean Sea, extending from the Strait of Otranto (where it connects to the Ionian Sea) to the northwest. The countries with coasts on the Adriatic are Italy, Albania, Montenegro, Bosnia-Herzegovina, Croatia, and Slovenia. The Adriatic's shores are populated by more than 3.5 million people; the largest cities are Bari, Venice, Trieste and Split. The earliest settlements on the Adriatic shores were Etruscan, Illyrian, and Greek

Italy and former Yugoslavia (now split in 6 different countries plus the self-proclaimed Republic of Kosovo) defined their Adriatic continental shelf delimitation in 1968 and again in 1975 with reference to the Gulf of Trieste boundary, following the Treaty of Osimo. All successor states of former Yugoslavia kept the agreements in force. In the Adriatic's southernmost areas the border was not determined in order to avoid prejudicing the location of the tripoint with the Albanian continental shelf border, which remains undefined. Before the breakup of Yugoslavia, Albania, Italy and Yugoslavia initially proclaimed 15-nautical-mile (28 km; 17 mi) territorial waters, subsequently reduced to international-standard 12 nautical miles (22 km; 14 mi) and all sides adopted baseline systems (mostly in the 1970s). Albania and Italy determined their sea border in 1992 according to the equidistance principle. Following Croatian EU membership, the Adriatic is expected to become an internal sea of the EU.

To promote trans-regional and trans-national cooperation in the Adriatic Sea area, the Adriatic Euroregion was established in Pula in 2006. The Adriatic Euroregion consists of 23 members, mostly regions or municipalities whose territory overlooks the Sea. The Adriatic Euroregion has been developed with specific reference to the transhipment traffic to/from the coastal countries, which is the main typology of modal choice existent in the area. There are 28 major ports overlooking Adriatic Sea with the respective freight/passenger routes (Ancona - Zadar, Bari - Dubrovnik, Bari - Durres just to name a few).

The other fast and feasible mean of transport across the Adriatic Sea would be the air. In order to analyse the network and investigate the actual relations among the countries and their importance, a sample of airports has been individuated in the vicinities of the Adriatic coasts. The unique criterion of choice is the distance between the airport and the coast: all the civil airports whose distance from the sea is around 100 kilometres have been included in the sample; in this way also airports which are located in countries not directly overlooking Adriatic Sea have been included: this is the case of KLU airport in Austria and PRN airport in Serbia. Once that one airport from a target country is included in the sample, also this country’s capital city airport has been included even if its distance from the Adriatic Sea was above 100 kilometres. Table 2 and Figure 10 summarize the airport sample taken into account for our analysis.

Table 2: Sample of airport per country

COUNTRY							
Albania	**Austria**	**Bosnia**	**Croatia**	**Italy**	**Montenegro**	**Serbia**	**Slovenia**
Tirana	Klangenfurt	Banja Luka	Dubrovinik	Ancona	Podgorica	Belgrade	Ljubljana
	Wien	Sarajevo	Pula	Bari	Tivat	Pristina	Portoroz
			Rijeka	Bologna			
			Split	Brindisi			
			Zadar	Foggia			
			Zagreb	Forlì			
				Perugia			
				Pescara			
				Rimini			
				Rome CIA			
				Rome FCO			
				Taranto			
				Treviso			
				Trieste			
				Venice			
				Verona			

Figure 10: Sample of airport

4 FEATURES OF THE SAMPLE OF AIRPORTS AND METHODOLOGY

The sample is composed of 34 airports. Data collection has been made during the period October-December 2012 with the help of the search engine *flightstats.com*; for each airport arriving and departing flights have been taken into account. For codeshare flights, only the airline which actually operated the flight has been taken into consideration. For each ORIGIN airport (DESTINATION), a spreadsheet has been prepared in order to arrange all the information: airport DESTINATION (ORIGIN), flight number, carrier, aircraft, seats on board, maximum distance covered (as declared by both the aircrafts' manufacturer and the airline), month, day of the week (from 1=Monday to 7=Sunday) and a flag for Arriving/Departure. The construction of other two spreadsheets has been necessary: a database including fleet information, for each airline operating from/to one of the airport sampled and a database with the airports' technical features (n° of runways, orientation, length, ICAO Airport Classification Code and runway Load Classification Number – where made available from the airport operator) as well as ownership/management information.

Table 3: Example from the fleet information spreadsheet

Airline	Tyrolean Airways		
Aircraft	**SEATS ON BOARD**	**Range airline (km)**	**Range manufacturer (km)**
100	100	2000	2450
319	138	4500	6850
320	168	4300	6150
321	200	1900	5950
738	188	4680	5765
763	265		10000
767	230	9800	10200
772	280	11500	11900
DH4	76	1550	2500
F70	80	2740	2574
Total	**1725**	**42970**	**64339**

Data have been arranged and analysed with the help of Visual Basic Macro, Pivot Tables and Graphs. For each airport, three tables have been derived. The first one organizes destination and flight number on the rows and day of the week on the columns. Each cell contains, therefore, the daily number of seats offered on the target flight to the target destination. It is then possible to derive information on the scheduling of the target flight, for example if it is a daily flights or it is operated only on target days; moreover, where the number of seats offered is different, it is possible to understand that the airline decided to allocate a different (bigger or smaller) aircraft for that specific flight in order to better cope with the traffic demand derived from their GDS. Finally, it is possible to derive on a daily basis the total number of seats (and flight frequencies as well) offered for a target destination if there is more than one flight that links the O/D couple.

The second table has been drawn to define which aircraft is the most frequent user of the airport (similar - but slightly simpler to define - to the concept of critical plane used to structurally design the apron, runways and taxiways) and which percentage of the total amount of seats offered is under its competence. As it is obvious to understand, frequently the most frequent plane is not the most impacting plane.

The third table has been used to derive which airlines are the ones that offer passengers more travel options in terms of flights, destinations and seats offered. Therefore, a distinction has been made among airlines according to the kind of service offered; broadly speaking 4 categories have been identified: Low cost, Network Carrier, Charter, Regional Carrier (freight flights have not been considered in this section, despite having been surveyed in the earlier steps). Thus, it has been possible to derive the share of each category at each airport and its variation during time.

Table 4: Weekly flight scheduling at BNX Airport

APT ORIG	CITY ORIG	N° FLIGHT	CARRIER	AIRCRAFT	SEATS O/B	RANGE (carrier)	RANGE (manufacturer)	MONTH	DAY	ARR/DEP
SJJ	Sarajevo	JA 306	BH Airlines	AT7	66	2665	1350	OTT	3	ARR
ZRH	Zurich	JA 307	BH Airlines	AT7	66	2665	1350	OTT	3	ARR
SJJ	Sarajevo	JA 306	BH Airlines	AT7	66	2665	1350	OTT	5	ARR
ZRH	Zurich	JA 307	BH Airlines	AT7	66	2665	1350	OTT	5	ARR
SJJ	Sarajevo	JA 306	BH Airlines	AT7	66	2665	1350	OTT	6	ARR
ZRH	Zurich	JA 307	BH Airlines	AT7	66	2665	1350	OTT	6	ARR
SJJ	Sarajevo	JA 306	BH Airlines	AT7	66	2665	1350	OTT	7	ARR
ZRH	Zurich	JA 307	BH Airlines	AT7	66	2665	1350	OTT	7	ARR

Table 5: Seat offered per Destination, Flight number and Day

DESTINATION	SEATS OFFERED/DAY							
N°FLIGHT	1	2	3	4	5	6	7	Total
SJJ								
JA 306	0	0	66	0	66	66	66	264
ZRH								
JA 307	0	0	66	0	66	66	66	264
Total	**0**	**0**	**132**	**0**	**132**	**132**	**132**	**528**

Table 6: Determination of the most frequent aircraft at a target airport

Aircraft	N° FLIGHT	% on total	SEATS offered	% on total
AT7	22	29,73%	1452	18,75%
DH4	13	17,57%	988	12,76%
738	9	12,16%	1564	20,20%
319	9	12,16%	1278	16,51%
100	7	9,46%	700	9,04%
320	5	6,76%	840	10,85%
CR2	3	4,05%	144	1,86%
739	2	2,70%	302	3,90%
E95	1	1,35%	120	1,55%
F70	1	1,35%	80	1,03%
CR9	1	1,35%	86	1,11%
73H	1	1,35%	189	2,44%
Total	**74**	**100,00%**	**7743**	**100,00%**

Table 7: Determination of the dominant carrier and service

Airline	N° FLIGHT	% on total	SEATS offered	% on total	Service
BH Airlines	15	20,27%	990	12,79%	NC
Tyrolean Airways	13	17,57%	1580	20,41%	RC
Croatia Airlines	13	17,57%	988	12,76%	NC
Turkish Airlines	10	13,51%	1678	21,67%	NC
Jat Airways	7	9,46%	462	5,97%	NC
Lufthansa	6	8,11%	918	11,86%	NC
Germanwings	4	5,41%	588	7,59%	LC
Adria Airways	4	5,41%	230	2,97%	NC
Lufthansa Cityline	1	1,35%	120	1,55%	RC
Norwegian Air Shuttle	1	1,35%	189	2,44%	LC
Total	**74**	**100,00%**	**7743**	**100,00%**	

As it is easy to imagine, Italian market is by far the most important in the Adriatic Sea basin and for the number of airports taken into account in the sample and in absolute terms. The second market in terms of importance is Austria, whose passenger output is 5 times bigger than the third and fourth market (respectively Slovenia and Serbia with the former that is developing at the fastest pace in the Balkan area – together with Albania – and has recently overtook the latter). Figure from 11 to 16 below show passenger and aircraft movements output in the last years at the main airport from the Balkan area considered in the sample. Figure 11-12 show that traffic at Belgrade airport is more or less constant but the average load factor has improved. Figure 13 shows the decreasing trend at an Austrian secondary airport, similar trend is being observed at the capital city's airport as well. Another evident component in the traffic area is the strong seasonality of the traffic (Figure 15-16): in the semester from April to October is concentrated the majority of both aircraft movements and passenger output.

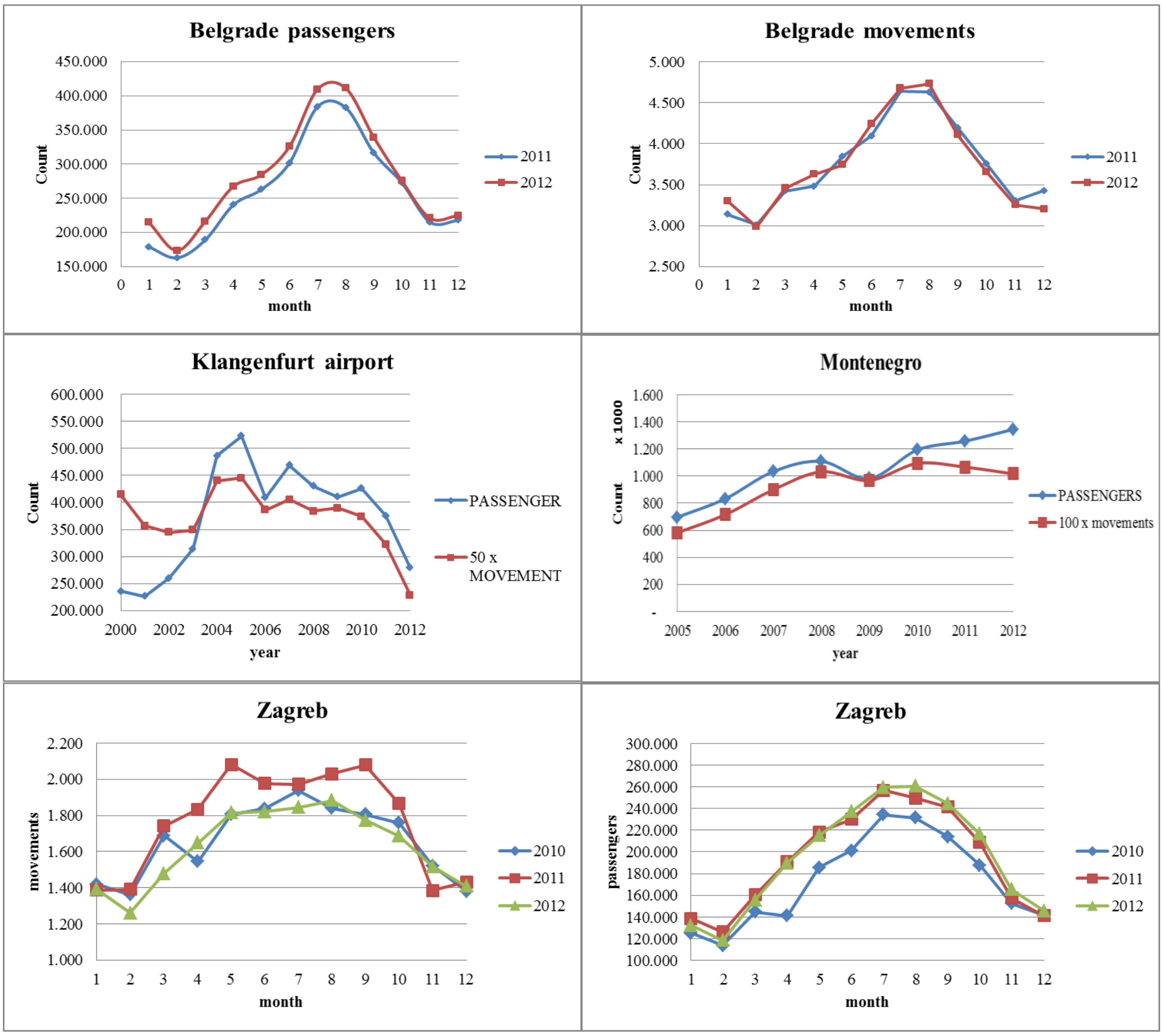


Figure 11-16: Air traffic figures in the Balkans

Sources: [(14)])

As for Italy, the 16 airports in the sample account for less than 50% of the total annual traffic. Moreover, half of those airports counts for less than 1% to the total national traffic. The declining trend is evident at principal airports of Rome FCO and Venice due to traffic contraction and also at secondary airports on the edge of bankruptcy or un-operating (Table 8).

Airports taken into account have at least one runway each; 5 airports have also a second runway and another one has even a third runway (Rome FCO; at Vienna airport there are rumours about the realization of a third runway, but the traffic trend is decreasing at the moment). Left alone minor airports of Foggia and Portoroz, which have been found to be fundamentally non-operative at the moment, runway length is considerable as those airport have been mostly built with military purposes and then modified to suit commercial traffic.

As for airport management ownership, the most common form is the mixed participation of public and private shareholding, with private equities being either banks or other large and renowned airport management group (this is the case of Tirana and Pristina airports).

Table 8: Air traffic figures in Italy

Rank	Airport	Tot pax	% on 2011	% tot	% domestic	% non domestic	Flight type
1	Rome FCO	36.742.475	-1,8	25,2	32,2	67,8	NC
5	Venice	8.110.520	-4,7	5,6	22,2	77,8	NC
7	Bologna	5.879.627	1,1	4	29,1	70,9	LC
10	Rome CIA	4.490.699	-6	3,1	22,7	77,3	LC
12	Bari	3.763.124	1,5	2,6	72,7	27,3	LC
15	Verona	3.152.081	-5,7	2,2	33,3	66,7	NC
16	Treviso	2.309.669	116,3	1,6	20,9	79,1	LC
18	Brindisi	2.095.726	2,2	1,4	83,7	16,3	LC
24	Trieste	878.690	2,6	0,6	59,8	40,2	LC
25	Rimini	787.028	-14,1	0,5	20,7	79,3	NC
27	Ancona	557.557	-7,6	0,4	32,8	67,2	LC
28	Pescara	555.105	1,7	0,4	43,4	56,6	LC
29	Forlì	261.464	-24,1	0,2	0,6	99,4	LC
31	Perugia	199.503	15,1	0,1	26,2	73,8	LC
40	Foggia	6.730	-89	0	98,4	1,6	-
44	Taranto	507	-23,8	0	52,1	47,9	-
	Total	69.790.505		47,9			

Source: [(15)]

Data have been collected – as previously mentioned – in the period ranging from October to December 2012. In this report data of October and November are presented, as they appear to be more representative not being influenced by traffic peaks for tourism purposes during Christmas holidays.

For each country a recapitulatory table has been drawn with information on nation destination and grand total of seat offered; partial sum have been calculated to derive the seat offered from the departing airport to airports located in countries overlooking the Adriatic Sea. Therefore it is possible to understand to which countries is allocated the seat offer and the respective share. For example the route with highest seat offer departing from Italy is a domestic route from BRI to VCE (11909 seats/week), while the international routes with highest offer are FCO-TIA (2782 seats/week) and FCO-BEG (2058 seats/week). No routes departing from Slovenia cross the Adriatic sea as the highest offer is to VIE, PRN and TGD. As for Croatia, the routes which cross the Adriatic Sea are the linkages between SPU-FCO, ZAG-BLQ and DBV-FCO. No routes departing from Bosnia cross the Adriatic sea as the highest offer is to VIE and ZAG. From Montenegro, the highest seat offer is to BEG. Routes from Albania to many Italian airports are operated every day; therefore the highest seat offers are on the routes from TIA to Milan, Rome and VRN. The highest seats offer from Serbia to Italy are the ones from BEG to Milan and Rome and from PRN to VCE. Finally, from Austria the highest seat route to another Adriatic country is to TIA. From Table 9 it is possible to understand that there are many other routes that actually fly over the Adriatic sea (for example those from Montenegro to France) but this is not considered as a cross-supply because only one of the ends overlooks the Adriatic Sea.

Table 9: Seat on board offered from Montenegro to other countries, with O-D couples

RANK	NATION	APT DEST	CITY ORIG	SEATS OFFERED		GRAND TOTAL
1	**SERBIA**	TGD	Belgrade	2706		
			Nis	714		
		TGD Totale			*3420*	
		TIV	Belgrade	1656		
		TIV Totale			*1656*	
	SERBIA Totale					**5.076**
2	russia					**3.583**
3	**AUSTRIA**	TGD	Vienna	968		
		TGD Totale			*968*	
	AUSTRIA Totale					**968**
4	turkey					**695**
5	**SLOVENIA**	TGD	Ljubljana	556		
		TGD Totale			*556*	
	SLOVENIA Totale					**556**
6	germany					**524**
7	switzerland					**510**
8	**ITALY**	TGD	Rome	320		
		TGD Totale			*320*	
	ITALY Totale					**320**
9	france					**320**
10	**CROATIA**	TGD	Zagreb	228		
		TGD Totale			*228*	
	CROATIA Totale					**228**
11	uk					**102**
	GRAND TOTAL	**OCTOBER 2012**				**12.882**

The variation of Seat offered from October to November has been analysed for each airport taken into account. Results are shown in Table 10, sorted according to the service operated by the airlines (Low cost, Network, Regional, Charter). As it is possible to see, there is a marked reduction of LCCs' offer at Italian, Croatian and Austrian airports. Overall, the reduction is of 110.000 seats. Reductions occur also for NC and RC (65.000 and 22.000 seats respectively) in a similar way; as for CH, generally speaking a reduction is as well present but not everywhere: there are airport from which the seat offer increased in November, likely to exotic countries. There are two possible reasons to explain this dramatic loss of offer: the first one is an expected schedule reduction operated by airlines on the shift from Summer to Winter IATA season (this shift takes place in the middle of October); the second one is more pertaining to the present economic situation and is somehow related to the concept of market volatility mentioned before: both NC/RC and LCCs are deeply focused on their cost control; therefore cutting unprofitable routes or reducing the capacity in order to guarantee higher load factors and high employment rates for both fleet and crew is one of the best solutions. It is worth noticing the fact that RC and LCCs as well usually offer flights to tourist destinations, that become unprofitable in autumn and Winter. That could be the main reason why Croatian destinations have been largely cut in November.

Finally, Table 11 is focused on the cross-supply between the Adriatic sea shores at a macroscopic level. Larger operated routes are usually domestic or short to medium range. Therefore we can assume that – according to the data gathered – the cross demand on the Adriatic sea is very low (were it otherwise, there would be an higher seat offer), probably because flight schedule is still affected by geo-political issues (the Balkan area is still freeing itself from the sway of Soviet bloc) and from the recent wars in the late 1990s. Germany and Turkey appear to be the most desired destinations for people living in the Balkans. According to Table 12, it is possible to distinguish feeder airports like PUY, ZAD, BNX, KLU where the % of seat provided by the frequent aircraft is higher and dominated airport like CIA, TSF, PSR and PEG where the frequent and the larger aircraft correspond. Those are the airports where the stronger airline is Ryanair with its 738 with 189 seats on board.

Table 10: Variations in SEAT offer – sorted per service - at the airport sampled

COUNTRY	APT	SEATS LC		SEATS NC		SEATS RC		SEATS CH		VARIATION
		OCT 12	NOV 12	OCT 12	NOV 12	OCT 12	NOV 12	OCT 12	NOV 12	
ITALY	VCE	31.497	22.830	59.842	46.528	19.297	16.679	885	378	- 25.106
	TSF	31.340	23.898	-	-	-	-	-	-	- 7.442
	TRS	5.164	2.268	3.767	3.224	4.580	4.318	-	-	- 3.701
	VRN	6.007	3.836	16.044	12.393	6.926	5.050	2.787	2.362	- 8.123
	BLQ	33.079	25.938	29.138	22.629	14.944	13.886	276	1.536	- 13.448
	FRL	2.160	1.800	136	-	-	-	-	-	- 496
	RMI	-	-	1.844	804	1.210	1.090	268	-	- 1.428
	FCO	74.462	56.324	344.442	323.153	27.898	24.490	17.133	14.407	- 45.561
	CIA	57.339	42.606	-	-	-	-	-	-	- 14.733
	AOI	4.702	1.837	476	476	2.924	2.726	-	-	- 3.063
	PEG	3.024	1.323	272	424	-	-	-	-	- 1.549
	PSR	6.993	4.725	1.167	1.032	279	214	-	-	- 2.468
	BRI	26.501	22.577	13.290	10.505	4.942	4.153	745	894	- 7.349
	BDS	15.483	12.343	7.693	6.803	1.368	345	-	-	- 5.053
SLOVENIA	LJU	1.392	1.824	13.740	11.376	-	-	-	-	- 1.932
	POW	-	-	-	-	-	-	-	-	-
CROATIA	DBV	4.545	-	7.880	3.831	1.792	90	655	-	- 10.951
	PUY	2.037	-	912	532	-	-	-	-	- 2.417
	RJK	294	-	-	-	-	-	-	-	- 294
	SPU	3.412	588	4.964	3.716	955	-	174	-	- 5.201
	ZAD	3.843	-	1.368	1.064	90	-	-	-	- 4.237
	ZAG	2.775	1.800	26.964	21.142	2.748	2.131	-	-	- 7.414
BOSNIA	SJJ	777	441	5.266	4.116	1.700	2.256	-	-	- 930
	BNX	-	-	528	528	-	-	-	-	-
MONTENEGRO	TGD	-	-	7.241	7.126	532	380	-	-	- 267
	TIV	-	-	3.286	1.654	896	328	927	776	- 2.351
ALBANIA	TIA	1.862	2.952	17.420	18.601	5.136	6.012	444	148	2.851
SERBIA	BEG	6.467	5.880	25.893	23.770	6.402	6.817	677	300	- 2.672
	PRN	6.676	6.927	6.313	4.019	2.846	2.142	296	1.987	- 1.056
AUSTRIA	KLU	1.449	1.344	-	-	2.432	2.356	-	-	- 181
	VIE	47.322	25.308	91.730	96.084	151.584	143.569	1.701	1.200	- 26.176
	TOT	**380.602**	**269.369**	**691.616**	**625.530**	**261.481**	**239.032**	**26.968**	**23.988**	- 202.748
	%	**-29,23%**		**-9,56%**		**-8,59%**		**-11,05%**		-14,90%

Table 11: Variations in SEAT cross-supply

NATION	OCT	NOV	
SERBIA	5.076	5.544	MONTENEGRO
AUSTRIA	968	686	
SLOVENIA	556	362	
ITALY	320	306	
CROATIA	228	228	

NATION	OCT	NOV	
AUSTRIA	1.182	998	SLOVENIA
SERBIA	766	680	
MONTENEGRO	556	362	
ALBANIA	374	336	
CROATIA	230	240	

NATION	OCT	NOV	
AUSTRIA	1.580	1.416	BOSNIA
CROATIA	988	836	
BOSNIA	528	528	
SERBIA	462	462	
SLOVENIA	230	240	

NATION	OCT	NOV	
ITALY	15.016	14.110	AUSTRIA
AUSTRIA	13.235	13.290	
SERBIA	5.716	5.676	
CROATIA	4.414	2.508	
ALBANIA	1.876	1.776	
BOSNIA	1.580	1.416	
SLOVENIA	1.008	998	
MONTENEGRO	968	686	

NATION	OCT	NOV	
ITALY	311.967	279.360	ITALY
ALBANIA	9.621	10.187	
AUSTRIA	8.492	7.980	
SERBIA	2.950	2.431	
CROATIA	1.235	1.014	
MONTENEGRO	320	306	

NATION	OCT	NOV	
AUSTRIA	5.704	5.692	SERBIA
MONTENEGRO	4.332	4.714	
ITALY	4.022	3.707	
SLOVENIA	766	680	
BOSNIA	462	476	
CROATIA	456	462	
ALBANIA	180	304	

NATION	OCT	NOV	
ITALY	15.856	19.313	ALBANIA
AUSTRIA	1.876	1.776	
SLOVENIA	374	336	
SERBIA	364	624	

NATION	OCT	NOV	
CROATIA	14.296	10.816	CROATIA
AUSTRIA	4.414	2.356	
ITALY	1.235	1.014	
BOSNIA	988	836	
SERBIA	456	304	
MONTENEGRO	228	228	

Table 12: Use of airport capacity

	CAPACITY					
APT IATA CODE	LARGER PLANE	SEATS	FREQUENT PLANE	SEATS	%S	%T
VCE	343	267	320	166	29,81	0,62
TSF	738	189	738	189	75,13	1,00
TRS	738	189	E75	88	20,63	0,47
VRN	767	276	AT7	64	10,83	0,23
BLQ	767	276	738	189	36,81	0,68
FRL	320	180	320	180	100	1,00
RMI	321	198	S20	50	39,6	0,25
FCO	388	503	320	165	36,38	0,33
CIA	738	189	738	189	34,93	1,00
AOI	738	189	F70	80	31,75	0,42
PEG	738	189	738	189	75,73	1,00
PSR	738	189	738	189	79,13	1,00
BRI	321	200	738	189	48,08	0,95
BDS	321	200	738	189	55,27	0,95
FOG	-	-	-	-	-	-
TAR	-	-	-	-	-	-
LJU	320	180	CR2	48	35,27	0,27
POW	-	-	-	-	-	-
DBV	320	164	319	132	50,5	0,80
PUY	DH4	76	DH4	76	100	1,00
RJK	738	189	738+319	168	82,45	0,89
SPU	320	164	DH4	76	38,85	0,46
ZAD	DH4	76	DH4	76	100	1,00
ZAG	321	177	DH4	76	34,76	0,43
SJJ	738	172	AT7	66	19,37	0,38
BNX	AT7	66	AT7	66	100	1,00
TGD	737	136	E95	116	38,64	0,85
TIV	320	164	AT7	66	16,75	0,40
TIA	321	200	320	179	52,28	0,90
PRN	321	198	319	146	35,86	0,74
BEG	321	200	733	124	30,08	0,62
KLU	738	189	DH4	76	63,68	0,40
VIE	773	460	320	168	27,73	0,37

5 CONCLUSIONS

The present paper analyses the present situation with reference to air traffic in the Adriatic Sea basin. The area is located in the central-southern Europe, where the damages caused by the recent economic downturn are far from being yet overcome. Although recent data highlight some clues of recovery, the difficult scenario is proved by the strong air traffic contraction as well as by the airlines' choice to heavily cut some routes during the shift from Summer to Winter 2012 IATA Seasons. The Adriatic Sea is an area with an higher degree of overflowing flights from the North-western Europe to the South and to the Middle East rather than a cross-supply network. Interchanges among the countries overlooking the sea are mostly held by ship, with air traffic playing a minor role only on a few specific routes (for example those which link Albania and Italy). However, the majority of the traffic in the area has at least one end on a country's capital city airport.

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VEHICLE AND CREW SCHEDULING PROBLEM IN REGULAR PERSONAL BUS TRANSPORT - THE STATE OF ART IN SLOVAKIA

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ABSTRACT

Let us have a set of bus trips, a set of available buses and a set of drivers. The goal is to assign trips to buses and drivers. There are several objectives of this assignment: to minimize the number of assigned vehicles, to minimize dead trips and to minimize the number of drivers.
There are several constraints imposed on bus scheduling. These constraints make the vehicle and crew problem very complex.
This paper specifies Slovak conditions, requirements and constraints laid on vehicle and crew scheduling and presents a survey of methods developed during 40-years period in Slovakia.

Keywords: vehicle and crew scheduling, personal bus transport, optimization

1 INTRODUCTION

The widespread use of computers in the second half of the last century has caused fundamental changes in the attitude to many human activities performed till then manually using only human experience and intuition. Vehicle and crew scheduling of public transport is a good example of just mentioned changeover. In 1975, a workshop was held in Chicago on Automated Techniques for Scheduling of Vehicle Operators for Urban Public Transportation Services. By the time of second Workshop, in Leeds 1980, several systems were in regular use in west Europe and in North America. Subsequent workshops were held in Montreal (1983), Hamburg (1987), again in Montreal (1990), Lisbon (1993) and Cambridge (1997).
A lot of literature issued from that time. More and more practical mathematical methods were designed with skyrocketing computer speed and memory accompanied by falling computer cost.

In former Czechoslovakia several attempts to computer aided vehicle and crew scheduling before 1980. The mentioned attempts were based on a simulation of dispatcher's work when creating a bus schedule. These experiments were condemned to crash before they started since the mentioned attempts could not make use of human experience and intuition of dispatchers.

A serious research in vehicle and crew scheduling in Czechoslovakia started in period 1980 – 1984 at Transport Research Institute in Žilina (Slovakia). This research was supported by grant "Optimization of Personal Bus Transport of enterprises ČSAD (Czechoslovak Automobile Transport)" and fully financed by government and state-owned enterprises ČSAD. Since that time, the subject of vehicle and crew scheduling is continuously developed at Transport Research Institute in Žilina and at Faculty of Managements Science and Informatics, University of Žilina, after 1991, too.

2 FUNDAMENTAL NOTIONS

The essential element of regional and/or municipal bus transport is a bus **trip** (sometimes called a **journey**). Bus trip is one move of a bus from a starting bus stop to a finishing bus stop. Several additional bus stops can occur during this travel however these stops are not important for bus scheduling purposes. A trip is defined by four data:

$dp(t)$ – departure place of the trip t | $ap(t)$ – arrival place of the trip t
$dt(t)$ – departure time of the trip t | $at(t)$ – arrival time of the trip t

Let's have two trips t_1 t_2.

We will say that the trip t_2 is **linkable** after trip t_1, or the trip t_1 **precedes** the trip t_2, and we will write $t_1 \prec t_2$, if

$$dp(t_2) - at(t_1) \geq travel\_time\big(ap(t_1), dp(t_2)\big), \tag{1}$$

i.e. if there exists enough time for a bus to transfer from arrival place $ap(t_1)$ of the trip t_1 to the departure place $dp(t_2)$ of the trip t_2 so that it arrives to $dp(t_2)$ sufficiently early so that it can make the trip t_2.

A **running board** of a bus is a sequence of trips $t_1, t_2, \dots, t_k$ such that $t_1 \prec t_2 \prec \dots \prec t_k$.

A **bus schedule** is a set of running boards.

The linkage $t_i \prec t_j$ is penalized by a cost $c(t_i, t_j)$ which can express dead mileage expenses, line change penalty, waiting time penalty etc.

3 FUNDAMENTAL VEHICLE SCHEDULING PROBLEM

Given a set of trips $T = \{t_1, t_2, \dots, t_n\}$, we can formulate the following fundamental vehicle scheduling problem:

FVSP: To arrange all trips from T into minimum number of running boards with minimum total cost of all linkages.

If no any additional requirements are laid FVSP is a polynomial problem and can be solved as a assignment problem: Let x_{ij} be a decision variable, $x_{ij} = 1$ if and only if the trip t_j immediately follows the trip t_i is in a running board of the same bus, otherwise $x_{ij} = 0$. Let $c_{ij} = c\big(t_i, t_j\big)$, if $t_i \prec t_j$ and $c_{ij} = \infty$ otherwise. Then FVSP can be formulated as follows:

Minimize:

$$\sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij} x_{ij}$$

Subject to:

$$\sum_{i=1}^{n} x_{ij} = 1 \text{ for } j = 1,2, \dots n$$
$$\sum_{j=1}^{n} x_{ij} = 1 \text{ for } i = 1,2, \dots n$$
$$x_{ij} \in \{0,1\}$$

If the buses return to one depot after end of their scheduled work pull-out and pull-in expenses have to be added to the total objective function. Let $pull\_out(t_i)$, $pull\_in(t_i)$ are pull-out and pull-in expenses of the trip t_i. The complexity of FVSP problem with one depot remains still polynomial and can be solved as a assignment problem with objective function $\sum_{i=1}^{n}\sum_{j=1}^{n}\overline{c}_{ij}$, where $\overline{c}_{ij} = c(t_i,t_j) - pull\_in(t_i) - pull\_out(t_j)$ if $t_i \prec t_j$ and $\overline{c}_{ij} = \infty$ otherwise.

4 GRAPH FORMULATION AND ALGORITHM FOR FVSP

Let T be a set of trips. Trip digraph of T is a digraph $G = (T, A)$ with the vertex set T and with the arc set $= \{(i,j) \mid i,j \in T,\ i \prec j\}$. The set A contains all ordered pairs of trips such that trip j is linkable after trip i. Digraph G is a transitive acyclic digraph. Every path in G is a feasible running board. Hence the problem FVSP – to arrange all trips from T into minimum number of running boards with minimum total cost – can be solved in corresponding trip digraph as to cover all vertices of G with minimum number of disjoint paths with minimum total cost.

The following auxiliary edge weighted digraph $\overline{G}$ is useful for solving just formulated graph problem: $\overline{G} = (V, E, d)$, where $V = \{(i,1) \mid i \in T\} \cup \{(i,2) \mid i \in T\} \cup \{s,f\}$ and where $E = E_1 \cup E_2 \cup E_3 \cup E_4$ with

$$E_1 = \{((i,1)(i,2)) \mid i \in T\} \qquad E_2 = \{((i,1)(j,2)) \mid i,j \in T, i \prec j\}$$
$$E_3 = \{(s,(i,1)) \mid i \in T\} \qquad E_4 = \{((j,2),f) \mid j \in T\}$$

Let $d: E \to \mathbf{R}$ be a real function defined on E as follows:
If $e \in E_1$ then $d(e) = -\infty$, if $e \in E_2$ (in this case $e = ((i,1)(j,2))$ where $i,j \in T$ and $i \prec j$) then $d(e) = c(i,j)$, if $e \in E_3$ then $d(e) = pull\_out(i)$ and if $e \in E_4$ then $d(e) = pull\_in(i)$,

The auxiliary digraph is still acyclic. Every (s,f)-path in $\overline{G}$ uniquely defines a path in G and vice verse. Every (s,f)-path in $\overline{G}$ represents a feasible running board and vice verse. To solve FVSP means to cover digraph $\overline{G}$ with minimum number of disjoint (s,f)-paths with minimum total cost. (Two paths in $\overline{G}$ are considered to be disjoint if they have no common vertex but s and f.)

Let P be a set of disjoint paths in $\overline{G}$. An edge e is called used, if there is a paths in P containing the edge e, otherwise the edge e is called unused. A semipath in digraph $\overline{G}$ is an alternating sequence of vertices and edges of the form $(v_1, e_1, v_2, e_2, \dots, e_{k-1} v_k)$, where $e_i = (v_i, v_{i+1})$ or $e_i = (v_{i+1}, v_i)$ and where every vertex occurs at most once. (Roughly speaking – a semipath in a digraph is a path in which edges can be used in reverse direction.)

A semipath is called improving semipath if all it's edges used in right direction are unused edges and all it's edges used in reverse direction are used edges. The length of an improving semipath is the sum of costs of edges used in right direction minus the sum of costs of edges used in reverse direction.

Algorithm 1:

Step1: Find a shortest (s, f)- path in $\overline{G}$. Mark the edges of that path as used, all other edges as unused.

Step2: While the set E_1 contains an unused edge do:

- Find a shortest improving (s, f)- semipath in $\overline{G}$.
- Mark edges with right direction of that semipath as used.
- Mark edges with reverse direction of that semipath as unused.

Step3: Edges from E_2 define trip linkages from what corresponding bus running boards can be constructed.

Used edges define $k+1$ paths in $\overline{G}$ immediately after procedure in Step 2 has finished for the k-th time. These paths contain as much as possible vertices of $\overline{G}$ with minimum total cost of used edges from the set E_2. By other words, these paths define $k+1$ running boards containing as much as possible trips and these trips are scheduled so that the total cost of corresponding running boards is minimal.

Computer implementation uses a large number L instead of ∞ – it suffices to set $L = \max_{i,j}\{c(i,j)\}.n$ where $n = |T|$ is the number of trips in T.

5 VEHICLE AND CREW SCHEDULING IN SLOVAKIA

In West European countries vehicle and crew scheduling are made as two consequential steps. First an optimum bus schedule is computed. Running boards of vehicles are divided into so called pieces of work by many ways in the second step. Then a huge number of theoretical driver shifts is created as various combinations of pieces of work. The real set of driver shifts is chosen from the set of theoretical shifts as a result of corresponding set covering problem. This attitude supposes that any driver can drive any bus. Many references to just mentioned approach can be found in proceedings [4], [5], [14], [15].

In former Czechoslovakia the ties between drivers and buses were – and till now are – very stiff. There are only two possibilities: one bus – one driver or one bus two drivers. This means for vehicle and crew scheduling: one bus running board – one driver shift or one bus running board – two driver shifts (i.e. one morning shift and one evening shift). Labor Code and several safety rules impose several very strict constraints to worker shifts. Therefore every running board has to comply with all safety standards and all requirements of Labor Code as safety break, meal break, duration of driver shift etc. Detailed specifications of Czech and Slovak conditions and corresponding mathematical models can be found in [1], [8], [9], [10].

The most complicated requirement is so called safety break constraint (SB) which is defined by law. We will say that running board fulfills safety break condition (SB) or is feasible if in every time interval 270 minutes long there exists at least 30 minutes of safety break. This safety break can be in one continuous piece or two or three time intervals, every one of them is at least 10 minutes long.

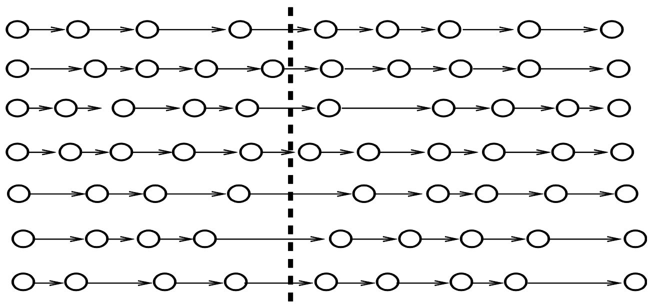
Most of mentioned requirements can be modeled as vehicle scheduling problem with a complicated nonlinear but separable objective function. Resulting mathematical problem is NP—hard and therefore a suboptimal heuristic optimization procedure can only be used.

6 VEHICLE SCHEDULING WITH A GENERAL OBJECTIVE FUNCTION

Regional bus transport has the property that passengers travel out in the morning from villages to downtown and return after work back from the downtown to their villages. Therefore the vehicles use to stay overnight at the same place where they have to start in the morning. That is why return expenses from the last arrival place of every running board to it's starting departure place has to be added to the total objective function. The resulting return vehicle scheduling problem – RVSP is no longer polynomial. We have developed a crossing procedure which started with a solution of corresponding FVSP and tried to combine two running boards in order to lower the total cost including return expenses.

There are a lot of additional constraints imposed on running boards. These constraints depend on legislation of corresponding country, on the way of driver duties scheduling, regional traditions and can even vary from bus provider to bus provider. This is the reason why vehicle and crew scheduling attitudes cannot be carried among various countries without any change.

Many special requirements can be modeled by nonlinear objective function. If the objective function of whole bus schedule is the sum of objectives of all running boards the following procedure can be applied:



All running boards are cut into heads and tails. Then we try to find an optimum combination of heads and tails of various running boards what leads to an assignment problem. If such assignment brings an improvement we accept it and try another cutting place until no improvement can be found. A substantial enhancement of just mentioned attitude can be obtained by dividing running boards into heads, mids and tails and by assigning mids to various fixed heads and tails. Just described optimization procedure proved to be very successful. Approximately 4 million assignment procedure calls occurred in computation for 1000 trips of a regional bus transport.

Just described procedure is treated in author's work [8].

7 SCHEDULING WITH FLEXIBLE TRIPS

Departure (resp. arrival) time of some trips cannot be changed. Such trips are trips carrying employees to work or students to schools. However, departure (resp. arrival) of other trips can be moved sooner or later without any negative consequences for passengers. Such fixed trips are called flexible trips. Significant savings can be achieved if we allow a small time shift for all or several trips. Scheduling with flexible trips means to find a feasible time position for all trips and then to minimize number of buses and to minimize a general objective function for shifted trips.

Several attitudes were developed for bus schedule optimization with flexible trips. Peško designed a heuristic procedure in [12] trying to make use of earliest trip time position and another suboptimal procedure in [13] allowing time overlaps of trips and consequently solving eliminating overlaps by shifting trips ins time. Engelthaller in his dissertation [6] designed and implemented a man machine attitude based on stepwise identification and manual elimination of bottlenecks in precomputed bus schedule.

The following procedure appeared most successful in practice.

We will consider trips t_1, t_2 to be linkable – will write $t_1 \prec t_2$, if

$$dp(t_2) - at(t_1) \geq travel\_time\big(ap(t_1), dp(t_2)\big) - \Delta, \tag{2}$$

i.e. we allow to link trip t_2 after trip t_1 even if their travel times overlay less or equal then Δ.

Such overlay allows to diminish the number of vehicles. Subsequent minimization of a general objective function can have a side effect of minimization of total overlay if a penalty of overlay is incorporated into corresponding objective function. However, the resulting bus schedule contains several overlaid trips. These infeasibilities have to be solved manually with cooperation with dispatcher who can decide whether the overlays can be eliminated by trips shifts or not.

8 TWO BUS TYPE PROBLEM

In many real cases available bus fleet consists of several bus types. This situation leads to so called heterogeneous bus fleet scheduling problem. Several types of this problem are treated in [2], [3], [7] and [11].

In the two bus type problem we have two types of trips and two types of buses. The trips of the first type are crowded trips requiring service by high capacity buses of the first type like hinged buses (we will call them maxibuses). The rest of trips are ordinary trips of the second type requiring ordinary buses. Ordinary trip can be serviced by maxibus too, but this is not a desirable instance and should occur only if necessary.

The simplest attitude to this problem is to decompose it into two independent scheduling problem - one for crowded trips and maxibuses and one for ordinary trips and ordinary buses. However, this attitude needn't be optimal since maxibuses can service several ordinary trips what can decrease the number of ordinary buses. Nevertheless just mentioned decomposition gives us the exact number of necessary maxibuses and a upper bound of ordinary buses.

Let us partition the set of trip T into two subset - the first the set of must-trips and the set of may-trip. Algorithm 1 can be modified in order to give a bus schedule with minimum number of vehicles containing all must-trips and maximum possible number of may-trips. Here is the following modification:

Algorithm 2:

Let $L = \max_{i,j}\{c(i,j)\}.n$ where $n = |T|$ is the number of trips in T.

Step1: For all $e \in E_1$ set $c(e) = L^2$, if $e = ((i,1),(i,2))$ where i is a must-trip,
$c(e) = L^2$, if $e = ((i,1),(i,2))$ where i is a may-trip
Find a shortest (s, f)- path in $\overline{G}$. Mark the edges of that path as used, all other edges as unused.

Step2: While the set E_1 contains an unused edge $e = ((i,1),(i,2))$ where i is a must-trip do:

- Find a shortest improving (s, f)- semipath in $\overline{G}$.
- Mark edges with right direction of that semipath as used.
- Mark edges with reverse direction of that semipath as unused.

Step3: Edges from E_2 define trip linkages from what corresponding bus running boards can be constructed.

Several may-trips remain not scheduled after finishing Algorithm 2.

Now we are prepared to formulate an algorithm for exact minimization of maxibuses and suboptimal minimization of ordinary buses.

Algorithm 3:

Step1: Declare all crowded trips as must-trips and all other trips as may-trips.
Run Algorithm 2.

Step2: Declare all unscheduled trips from the Step1 as must-trips and all ordinary trips as may-trips.
Run Algorithm 2.
The result is the set of running boards for all ordinary buses with several unscheduled ordinary trips which do not increase the number of maxibuses.

Step3: Run Algorithm 1 for all crowded trips and all unscheduled ordinary trips from the Step2.
The result is the set of running boards for maxibuses containing all must-trips and all till now unscheduled may-trips.

Mathematical methods and algorithms described above were was successfully used in municipal and regional bus transport of following Czech and Slovak towns: Trinec, Jablunkov, Havířov, Tachov, Uherské Hradiště, Most and Litvínov, Prachatice, Strakonice, Nymburk, Lysá n/L., Milovice, Prievidza, Martin - Vrútky, Piešťany, Považská Bystrica, Trenčín and others. Different operators demanded very often various requirements and unlike constraints. Therefore the objective function had to be adapted to the individual case and sometimes we had to change some optimization algorithms.

Optimization savings ranged from 5% to 20% of dead mileage and 5% to 10% of number of used vehicles. However, in several cases the number of vehicles could not be reduced due to very strong morning peak.

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CONCERNING TRANSITION FROM CLASSICAL TO DIGITAL NAVIGATION: A MARITIME DIDACTICAL APPROACH

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ABSTRACT

This article as a particular review of some blended historical and nautical facts concerns in brief developing navigational aids starting with astrolabe and chronometer through radio, radar and satellite navigation, toward ECDIS and upcoming and still developing concept of digital, or e-navigation. Navigational devices which are interesting now-a-days only from the aspect of navigational history will be presented concisely, as well as still active and well-known devices like radar and satellite navigation, while the greater attention will be paid to ECDIS as a concept that is *beyond* the previously used classical navigational devices. At the end, the short overview of e-navigational concept as those that it has still been developing shall be given. All mentioned navigational devices will be considered with the aim to give a modest contribution to the maritime didactic and to emphasize the importance of developing and implementing shortly a novel concept of fully digitalized e-navigation.

Keywords: navigational history, ECDIS, e-navigation

1 INTRODUCTION

The efforts of people (seamen) to make their long-ocean travels as safe as possible through history came up with advances in technology toward creation of better, more accurate and even *smarter* devices to track and locate (own) other vessels, collision avoidance, avoidance of risks in the narrow strait areas, in the coastal areas and in the ports. In the beginning, most of the devices that will be considered in brief within the paper were reserved for military purposes, but with increasing the number of vessels in merchant fleets, the transition of their usage occurred: from exclusively navy purposes to those of the merchant fleet, as well. By the appearance of great number of producers who have mastered the new technologies, and consequently by opening and spreading new markets of the navigation devices, their commercialization occurred, and they became over the time mostly mandatory equipment onboard all vessels.

The perpetuator of navigational devices discoveries through the history and their improvements and adaptations to the users, was a question of determining exactly the longitude of the ship position at vast sea. While the latitude can be determined by observing the angular height of the sun during its meridian passage, or the angular height of the pole star above the horizon, with a sextant, longitude was much harder to fix. Though, since the Columbus discovery of the New World in 1492, there had been incentives and efforts to accurately determine ship's position as defined by latitude and longitude, and later by the altitude [1]. After several centuries of research and experimental efforts, the credit for the discovery of the applicable practical marine chronometer of satisfactory accuracy, belonged even in the 18th to John Harrison [2]. Accurate determination of time was also crucial for the next epoch-making advance in positioning and navigation, i.e. Global Positioning System (GPS). This time it was the atomic clock used for the precise measurement of time that elapses from emission to reception of EM signals between a ship whose latitude, longitude, and altitude is to be determined and the reference objects in the cosmos, i.e. the satellites. However, it is to be noted that besides in positioning, tracking, and navigating the ship, GPS is using in surveying, search and rescue operations, car theft detection, pay as you drive, fleet management, aircraft lending, etc. The cardinal steep forward in maritime navigation came with Electronic Chart Display and Information System (ECDIS). Namely, knowing ship's position at sea is the first steep in providing safe and efficient navigation. Knowing the hydrographic and traffic conditions in the sailing zone is equally important. Besides keeping sharp lookout, the navigational charts are/were the crucial aids to safe navigation. But, with the rapid and huge IT/IS development, they became firstly just a digitalized, and then transformed to the data bases and user friendly oriented IS. If we continue going ahead on the scene of navigation development then we are faced with the concepts of e-Navigation, e-Marine, and finally e-Transportation [15] which are currently under conceiving, standards harmonizing and preparations for upcoming implementation.

2 STARTING WITH ASTROLAB

The mariner's astrolabe, also called sea astrolabe, was an inclinometer used to determine the latitude of a ship at sea by measuring the sun's noon altitude, or the meridian altitude of a star of known declination (Fig 1). Not an astrolabe proper, the mariner's astrolabe was rather a graduated circle with an alidade used to measure vertical angles. They were designed to allow for their use on boats in rough water and/or in heavy winds, which astrolabes are ill equipped to handle. In the 16th century, the instrument was also called a ring.

An ancient instrument used widely in medieval times by navigators and astronomers to determine latitude, longitude, and time of day. The device employed a disk with 360° degrees marked on its circumference. Users took readings from an indicator that pivoted around the centre of the suspended device like the hand of a clock. The astrolabe was replaced by the sextant in the 18th century. The earliest date, 1295, is offered by the Majorcan astronomer Ramon Llull. Mariner's astrolabes were made of brass. As the accuracy of the instrument is related to the radius of the divided circle, these were made as large as practical. Mariner's astrolabe is made with a frame form. The openings in the frame allow wind to pass through, inducing less motion in the instrument. The essential function of the device was to measure angles, i.e. the angle between the horizon and the star (Figure 2). Thus the instrument featured a ring graduated in degrees. Early instruments were only graduated for 90°; later instruments were graduated for the full 360° circle around the limb.

Figure 1: Marine astrolabe[1]

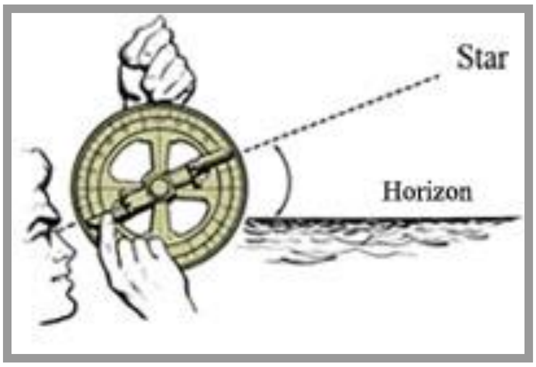

Figure 2: Using marine astrolabe[2]

The Mariner's Astrolabe was used to determine the latitude of a ship at sea by measuring the noon altitude of the sun or the meridian altitude of a star of known declination. It was not possible to determine longitude at sea in the early days of transoceanic navigation, but it was quite easy to determine latitude. To go to a place of known latitude, the ship was sailed to that latitude and then sailed east or west along the latitude line until the place was reached. To find the latitude of the ship at sea, the noon altitude of the sun was measured during the day or the altitude of a star of known declination was measured when it was on the meridian (due north or south) at night. The sun's or star's declination for the date was looked up in an almanac. The latitude is then 90° - measured altitude plus declination. An astrolabe can be used to measure the altitude of an object, including changes in the sun's path over the course of the year. Tracking these changes can help explain why days are longer in the summer and shorter in the winter [16].

3 GOING AHEAD BY MARITIME HRONOMETER

To utilize accurate clocks for the measurement of longitude while sailing the high seas was first proposed by Gemma Frisius, in 1530. Christiaan Huygens' tried his pendulum clock as such a marine clock in 1664, and in 1675 invented a marine timepiece with his spiral-spring balance wheel, but ocean tests showed that these lacked the accuracy required for marine use. With a highly refined version, which had technical improvements including temperature compensation, John Harrison demonstrated the first sufficiently accurate marine chronometer in 1762. The marine chronometer was developed out of the necessity to have a timekeeper of great accuracy that would function at sea. The need for this was to enable the ship's navigator to find longitude out of the sight of land and thus his position on the seas and oceans of the world. Latitude is the imaginary line that runs parallel to the equator, the fixed datum north and south 0-90° degrees in each direction to the poles. This has always been relatively simple to find by means of celestial observations and was used by Columbus. Longitude is also measured in degrees 0-360° running from pole to pole. One hour is equal to 15° thus 1° is equal to 4 minutes.

[1] Internet resource: http://upload.wikimedia.org/wikipedia/commons/4/48/Astrol%C3%A1bio_N%C3%A1utico_-_Aveiro.gif
[2] Internet resource: http://en.wikipedia.org/wiki/File:Astrolabe_(PSF).png

Figure 3: John Harisson marine chronometer[3]

A typical chronometer is mounted in a three piece box that has a lid which opens so you can see the face through a glass pane, but not touch the chronometer itself. This was designed to protect this essential timekeeper from unauthorized meddling. Until World War II the middle tier, which has the glass top, could only be opened by someone with a key, and only one or two people on board had one. The key had to be used once a day to open the box so the chronometer could be wound. This was done at the same time every day, and reported to the captain. There was an up-down indicator which shows the state of wind, and tells when the instrument needs to be wound. Most ships had two or three chronometers, whose times were compared, so that any problem with one could be detected [17].

4 A STEP FORWARD IN NAVIGATION HISTORY: RADIO NAVIGATION

Radio as a navigational tool: Radio provides the navigator with information, including radio time signals, regular weather reports, storm warnings, and general navigational warnings concerning such hazards as derelict ships, extinguished navigational lights, and buoys adrift. Radio as an aid to navigation was first used in the early 1900s, and aircraft in the 1930s were fitted with communications equipment [18].

The hyperbolic navigation system known as Loran (<u>Lo</u>ng <u>Ra</u>nge <u>N</u>avigation) was developed in the U.S. between 1940 and 1943. It uses pulsed radio transmissions from master and slave stations that are received onboard and recorded as small waves on the screen of a cathode-ray tube. The distance between the waves corresponds to the difference in time between the arrivals of the signals from the two stations.

The Decca Navigator System was a hyperbolic low frequency radio navigation system (also known as multilateration) that was first deployed during World War II when the Allied forces needed a system which could be used to achieve accurate landings. As was the case with Loran C, its primary use was for ship navigation in coastal waters [3;4;19].

Radio as a communication tool: Marine radio was first installed on ships around the turn of the 20th century. In those early days, radio, or "wireless" as it was known, was used primarily for transmission and reception of passenger telegrams. Radio watch keeping hours were not standardised, and and there was no regulatory requirement for carriage of radio by ships. Indeed, there was a general lack of regulation of the radio spectrum. Amateur/experimental stations often interfered with commercial stations and vice-versa. All

[3] Internet resource: http://enlightenedage.blogspot.com/2012/08/take-long-way-home.html

that changed one clear and cold April night in 1912, when he most modern passenger liner of the time, RMS Titanic, sank on her maiden voyage after a collision with an iceberg. Marine VHF radio is installed on all large ships and most seagoing small craft. It isused for a wide variety of purposes, including summoning rescue services and communicating with harbours, locks, bridges and marinas, and operates in the very high frequency (VHF) range, between 156 and 162.025 MHz. A marine VHF set is a combined transmitter and receiver and only operates on standard, international frequencies known as channels (Figure 4). Channel 16 (156.8 MHz) is the international calling and distress channel. Channel 9 can also be used in some places as a secondary call and distress channel. The accepted conventions for use of marine radio are collectively termed *proper operating procedure*. These conventions include: listening for 2 minutes before transmitting; using Channel 16 only to establish communication (if necessary) and then switch to a working channel; and, using a set of international *calling* procedures such as the *Mayday* distress call, the *Pan-pan* urgency call, and *Securite* navigational hazard call [19].

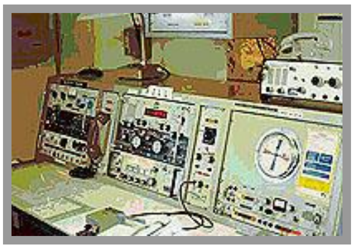

Figure 4: Typical merchant ship radio room - mid 1980's [4]

The similar procedure remains as a part of actual GMDSS protocol(s). The GMDSS is specifically designed to automate a ship's radio distress alerting function, and, as a consequence, removes the requirement for manual/human watch keeping on distress channels. The new system is quicker and, most importantly, more efficient and reliable than the old manual Morse code and radiotelephone alerting systems. The basic concept of the GMDSS is that Search and Rescue (SAR) authorities ashore, as well as shipping in the immediate vicinity of the ship or persons in distress will be rapidly alerted so that they can assist in a coordinated SAR operation with the minimum of delay. One of the principal advantages of the GMDSS is that the system is actually an amalgam of various individual radio systems, both terrestrial and satellite. Distress alerts may be sent and received over short and/or long distances, by ships of all sizes [19].

4.2 Radar

The history of radar starts with experiments by Heinrich Hertz in the late 19th century that showed that radio waves were reflected by metallic objects. This possibility was suggested in James Clerk Maxwell's seminal work on electromagnetism. The term *RADAR* was coined in 1940 by the United States Navy as an acronym for Radio Detection And Ranging; this was a cover for the highly secret technology.

[4] Internet resource: http://www.gmdss.com.au/history.html

Figure 5: Maritime equipment – RADAR: MR-1000RII CRT[5]

The availability of low cost microprocessors and the development of advanced computer technology during the 1970s and 1980s have made it possible to apply computer techniques to improve commercial marine radar systems (Figure 5). Radar manufactures used this technology to create the Automatic Radar Plotting Aids (ARPA). ARPAs are computer assisted radar data processing systems which generate predictive vectors and other ship movement information. Over the past 10 years, the most significant changes to the ARPA systems have been in their design. The majority of ARPAs manufactured today integrate the ARPA features with the radar display. The initial development and design of ARPAs were stand-alone units. That is because they were designed to be an addition to the conventional radar unit. All of the ARPA functions were installed on board as a separate unit but needed to interface with existing equipment to get the basic radar data. The primary benefits were cost and time savings. This of course was not the most ideal situation and eventually it was the integral ARPA that gradually replaced the stand-alone unit. The modern integral ARPA combines the conventional radar data with the computer data processing systems into one unit. The main operational advantage is that both the radar and ARPA data are readily comparable [9;18].

5 REACHING THE STARS BY SATELITE NAVIGATION

A satellite navigation or SATNAV system is a system of satellites that provide autonomous geo-spatial positioning with global coverage. It allows small electronic receivers to determine their location (longitude, latitude, and altitude) to within a few metres using time signals transmitted along a line-of-sight by radio from satellites. Receivers calculate the precise time as well as position, which can be used as a reference for scientific experiments. A satellite navigation system with global coverage may be termed a global navigation satellite system, or GNSS. The first satellite navigation system was Transit, a system deployed by the US military in the 1960s. Transit's operation was based on the Doppler effect: the satellites travelled on well-known paths and broadcast their signals on a well known frequency. The received frequency will differ slightly from the broadcast frequency because of the movement of the satellite with respect to the receiver. Modern systems are more direct. The satellite broadcasts a signal that contains orbital data (from which the position of the satellite can be calculated) and the precise time the signal was transmitted. The orbital data is transmitted in a

[5] Internet resource: http://www.maritimeequipment.com/ShowAd.aspx?id=107734

data message that is superimposed on a code that serves as a timing reference. The satellite uses an atomic clock to maintain synchronization of all the satellites in the constellation. The receiver compares the time of broadcast encoded in the transmission with the time of reception measured by an internal clock, thereby measuring the time-of-flight to the satellite and back.

Now-a-day actual Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defence. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS. GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this information and use triangulation to calculate the user's exact location. A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude). Once the user's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination, sunrise and sunset time and more [5-9].

6 GATHERING ALL SHIP'S NAVIGATION INFORMATION: ECDIS

An Electronic Chart Display and Information System (ECDIS) is a computer-based navigation information system that complies with International Maritime Organization (IMO) regulations and can be used as an alternative to paper nautical charts. An ECDIS system displays the information from electronic navigational charts (ENC) or Digital Nautical Charts (DNC) and integrates position information from position, heading and speed through water reference systems and optionally other navigational sensors. Other sensors which could interface with an ECDIS are radar, Navtex, automatic identification systems (AIS), Sailing Directions and fathometer. ECDIS provides continuous position and navigational safety information. The system generates audible and/or visual alarms when the vessel is in proximity to navigational hazards.

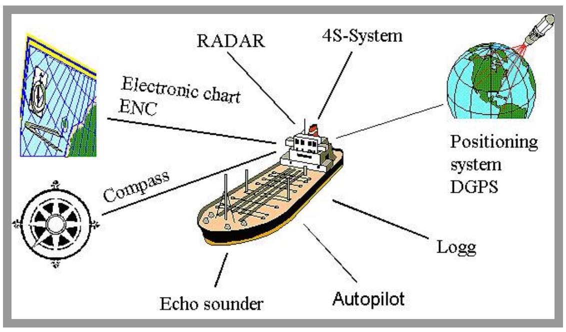

Figure 6: ECDIS system components [6]

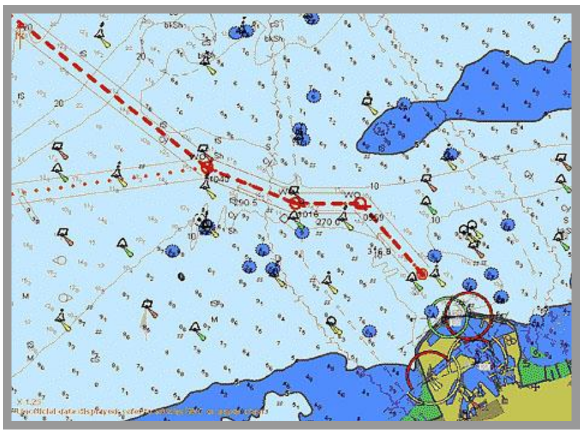

Figure 7: ECDIS – chart area

[6] Internet resource: www.proceedings.esri.com

The ENC data is the only data of IHO S-57 (concerning new S-100, S-101 [10]) standards transformed into the ECDIS for display and use. The standardized colour and symbol is required in accordance with IHO S-52 standards. The updating of the ENC promulgated through NTM is easy and can be done automatically onboard ship reducing the time consuming workload manual correction of paper charts. The scale in display the ENC can be changed by the user freely by means of the display scale. Additional navigational-related information depends on the layer of display can be manipulated by the user.

The ECDIS is a sophisticated navigational system that provides alarms or indications with regard to preset safety parameters, e.g. safe depth, safe contour etc. Other navigational sources such as Global Navigational Satellite System (GNSS/GPS), Automatic Identification System (AIS) and Radar and ARPA picture, etc. can be overlaid on the ECDIS screen for navigation purpose. ECDIS provide warnings (deviating from a planned route, approach to waypoints, failure of the positioning system, vessel crossing safety contour, system malfunction or failure, etc.), and the appropriate alarms, as well. It combines several different functions into one computerized system which is possible to provide alarms or display warnings (indication) when certain parameters are met or exceeded as determine by the navigator.

Although there have been some recent incidents involving ECDIS and its improper use [20], ECDIS when used by a competent operator who has been specifically trained in its use can provide the mariner with a greater perspective of the navigational picture and greatly increase his/her situational awareness. The benefits can include: navigational awareness increases; integration of separate spare navigation systems into ECDIS; efficiency of passage planning: time taken to plan and appraise route is greatly diminished; efficiency of chart updating: reducing work load on navigation officers to maintain charts; fatigue may ultimately be reduced as a result of the reduction or elimination of manual chart corrections or lengthy passage planning, etc. ECDIS is not only an adequate replacement for the paper navigational chart but also a system containing all information important for navigation. It reduces the time-consuming manual correction of paper charts. The ECDIS display can be superimposed with radar images and with the radar targets of ARPA, and the vessel's positions is continuously shown on the chart display and stored at regular intervals. Hence manual chart exchange is no longer required. The elements of route planning in ECDIS are waypoints and leg lines to ensuring safe track keeping. The cross distance along the leg lines can be set for activation of the alarm if the vessel deviates from the scope of leg lines. ECDIS *knows* whether a vessel can pass safely through an area, on the basis of the vessel's information fed in [2;9;10;11].

7 TOWARD E-NAVIGATION CONCEPT

E-navigation is in the most concise way defined by The International Maritime Organization (IMO) adopted a "Strategy for the development and implementation of e-Navigation" (MSC85-report, Annexes 20 and 21). In particular, IMO adopted the following definition of e-Navigation: "e-Navigation is the harmonized collection, integration, exchange, presentation and analysis of maritime information onboard 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". IMO has stated the driving forces and the consequential goal for their e-Navigation concept as follows: "There is a clear and compelling need to equip shipboard users and those ashore responsible for the safety of shipping with modern, proven tools that are optimized for good decision making in order to make maritime navigation and communications more reliable and user friendly. The overall goal is to improve safety of navigation and to reduce errors. However, if current technological advances continue without proper coordination there is a risk that the future development of marine navigation systems will be hampered through a lack of standardization on board and ashore, incompatibility between vessels and an increased and unnecessary level of complexity" (IMO MSC 85, Annex 20) [13].

In the technological sense e-Navigation is ITC (Informatio Technology and Communications) based integration of both Integrated Navigation System (INS) and the Integrated Bridge System (IBS). The key element of this integration is a transciever ststion on the ship's side. It collects all relevant data from the ship's sensors and applications. There are many of them, and via the comman telecommunication chanels they are conectors between the ships and shore based e-Navigation technical services (Figure 8).

E-Navigation is therefore a vision for the integration of existing and new navigational tools, in a holistic and systematic manner that will enable the transmission, manipulation and display of navigational information in electronic format. In short, based on the IMO definition, three fundamental elements must be in place as pre-requisite for the e-Navigation. These are: worldwide coverage of navigation areas by Electronic Navigation Charts (ENC); a robust and possibly redundant electronic positioning system; and an agreed infrastructure of communications to link ship and shore but also ship and ship. In fact, the IMO e-Navigation strategy offers a vision for a web service infrastructure that lends itself to delivery of a wide rang of such new added value marine information services in addition to mandatory ECDIS, as a key feature in progressing e-Navigation [12-15].

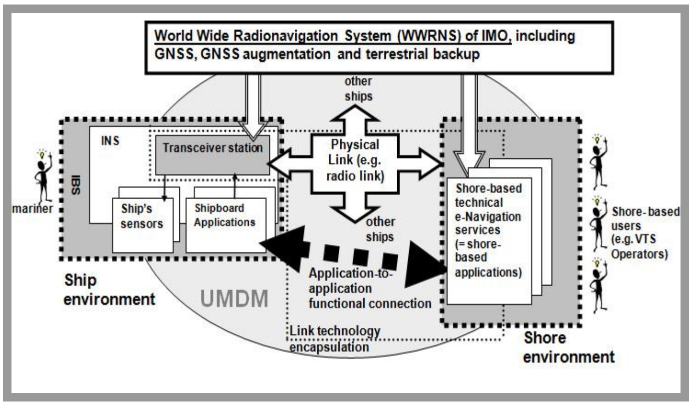

Figure 8: E-Navigation basic conceptual scheme [7]

8 CONCLUSIONS

This paper gives an overview of the historical facts that led to the key changes in maritime navigation. This is always problematic, due to a number of different sources, which can lead to different conclusions. And, the history of developing navigational aids is not linear one, though it is not so easy tracking it without frequent omissions. However, it is undeniable that development of the key aids to navigation goes chronologically as follows: (a) astrolabe – for determining ship's latitude; (b) navigational compasses – for measures directions in a frame of reference that is stationary relative to the surface of the earth; (c) chronometer – for measuring the elapsed time, and consequently ship's longitude; (d) radio – for communication

[7] Resource: ref. [13;14]

and position determination, i.e. it allows radio telecommunications and radio navigation; (e) radar and later ARPA – for measuring distances and angels and calculating different parameters relevant for the safe navigation; (f) GPS – global positioning system for determination of ship's latitude, longitude and altitude; (g) ECDIS – for integration all relevant navigational data into one computer system onboard a ship and at VTS (Vessel Traffic Service) centre(s) ashore, and finally (h) e-Navigation – for integrating into one network ships' and ashore based e-Navigational technical services into one ITC system. These *powerful* navigation devices have been briefly described, but with a view of continuity in their development, and by the intention to point out the way in which this development is going on. Though, the future trends are undoubtedly oriented towards integrated digital information and communication technologies. What is in this context necessary, should be described as follows: "the need for convergence between maritime technology and marine science in order to realize the degree of knowledge integration needed to provide the types of sophisticated maritime information services required today [15]."

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CONSTRAINT PROGRAMMING FOR THE NETWORK REDUCTION PROBLEM

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ABSTRACT

We deal with solving a NP-hard problem that occurs in reduction of transport networks. The reduction means to omit some edges. There are requirements imposed on the resulting reduced network. The total length of reduced network should be as small as possible and the distance between arbitrary two points in reduced network should not exceed q-multiple of distance in original network, where q>1 is given. We present a constraint programming formulation based on graph theory and an exact solution using MiniZinc model.

Keywords: constraint programming, network reduction problem, minimization

1 INTRODUCTION

In practice, one can often meet a different decision problem how to choose a reduction of transport network. The common features of all of them is that a subgraph fulfilling some constraint has to be found for the given graph. Černá, at al [1] studied the family of subgraphs not lengthening some important trip more that for the given percentage. A Czimmermann [2] studied the computational complexity of the problem Admissible Lengthening of Important Routes and showed that problem is NP-hard for any lengthening parameter q>1. Přibyl [3] deals with a single bus route design problem where a goal of reduction of network is to minimize the mean walking distance of passengers to the nearest stops of bus route.

2 MATHEMATICAL FORMULATION

We deal with the following mathematical formulation of network reduction problem: Suppose we are given a weighted graph $G=(V,E,d)$ and a number q greater than 1. The goal is to find a connected spanning sub-graph $G_q=(V,E_q,d_q)$ of G with minimal total weight such that the distance between each pair of vertices of removed edge is at most q-times of the length of this edge. More precisely, we find a connected spanning sub-graph $G_q=(V,E_q,d_q)$ such that

$$d_q(u,v) = d(u,v) \qquad \forall\{u,v\} \in E_q \tag{1}$$

$$d_q(u,v) \leq q \cdot d(u,v) \qquad \forall\{u,v\} \in E - E_q \tag{2}$$

$$\sum_{\{u,v\}\in E_q} d_q(u,v) \rightarrow minimum \tag{3}$$

where $d(u,v)$ resp. $d_q(u,v)$ is length of shortest u-v path in graph G resp. G_q. Note that $q \approx 1.1 - 1.5$ usually specifies the upper bound of extension of the length of shortest paths in reduced graph G_q.

3 MINIZINC MODELS

MiniZinc [4] is a language designed for specifying constrained optimization and decision problems over integers and real numbers. We first define used parameters, domains and we formulate a model for computing a distance matrix in a weighted graph. Then we will formulate our reduction problem which is based on computing the distance matrix.

3.1 MiniZinc model for computing distance matrix

Goal of this model is to find a matrix $X=(x_{ij})$ where x_{ij} is length of the minimal *i-j* path in graph $G=(V,H,d)$. We will use following notation:

Parameters

- nVertix – number of vertices,
- nEdge – number of edges,
- infinity – satisfactory big integer number, in general no less than length of average path,
- V = {1,..,nVertix} – set of vertices,
- E = {1,..,nEdge} – set of order of edges ,
- Edges – matrix of weighted edges of size nEdge × 3 where k-th edge {*i*,*j*} weighted by integer d_{ij} is represented by k-th row with Edges[k,1]=i, Edges[k,2]=j, Edges[k,3]= d_{ij}.

Variables

- X – matrix of distances of size nVertix × nVertix with domain {0,…,infinity},
- total_cost = sum(i in V, j in V where i<j) (X[i,j]) in the MiniZinc notation.

Note that variable total_cost gives us the sum of all distances between any distinct vertices of graph. It is used as variable equal to the result of goal function of model. A reader can be surprised that total_cost is maximized in our model and not minimized. Minimal paths are here modeled as a sum of lower bounds of lengths of edges. We use two constraints as follows:

- **C1**: Since $x_{ij} <= d_{ij}$ and $x_{ij} = x_{ji}$ for each edges {*i*, *j*} we can write in Minizinc:
```
constraint
    forall(e in E)(
        X[Edges[e,1], Edges[e,2]] <= Edges[e,3]
        /\
        X[Edges[e,1], Edges[e,2]] = X[Edges[e,2], Edges[e,1]]
    );
```
- **C2**: The feature of the distance matrix is that it is a metric on the set of vertices and so can write:
```
constraint
    forall(i in V, j in V, k in V where i!=j /\ k!=i /\ k!=j)(
        X[i,k] + X[k,j] >= X[i,j]
    );
```

Diagonal elements of distance matrix are zeros, but this feature will satisfy our requirement by default since variables X[i,i] is declared in model only and domain for distances is set {0,...,infinity}.

3.2 MiniZinc model for network reduction

We show how to utilize the MiniZinc model for distance matrix as a base for our network reduction problem (1)-(3). We will extend above used notation:

Parameters (continue)

- q100 – integer coefficient of extension is equal 100*q

Variables (continue)

- Y – binary matrix of size nEdge where Y[k]=1 if k-th edge is in reduced network and Y[k] =0 otherwise,
- Z – matrix of flows of size nEdge × 2 where Z[k,1] is flow from node Edges[k,1] to node Edges[k,2] and Z[k,2] is flow from node Edges[k,2] to node Edges[k,1].

Interpretation of the goal variable total_cost is unchanged. It can be formal to show that this is maximized because our own goal is (3) to minimize the total length of reduced network. We use six constraints as follows:

- **C3**: In reduced network we choose some edges only and so corresponding constraint **C1** must be modified:

```
constraint
    forall(e in E)(
       X[Edges[e,1],Edges[e,2]] <= max(Edges[e,3],(1-Y[e])*infinity)
           /\
       X[Edges[e,1], Edges[e,2]] = X[Edges[e,2], Edges[e,1]]
    );
```

- **C4**: Constraint **C2** above triangulation inequality remains valid:

```
constraint
    forall(i in V, j in V, k in V where i!=j /\ k!=i /\ k!=j)(
        X[i,k] + X[k,j] >= X[i,j]
    );
```

- **C5**: A feasible reduction of edge {i,j} is possible only if exists a node k so that $x_{ij} = x_{ik} + x_{kj}$:

```
constraint
  forall(e in E)  (
    Y[e] = 0 -> exists(k in V diff {Edges[e,1],Edges[e,2]})
       (X[Edges[e,1],Edges[e,2]]=X[Edges[e,1],k]+X[k,Edges[e,2]])
  );
```

- **C6**: The feasible reduction of edge {i,j} is possible if this is valid constraint (2):

```
constraint % feasible extension of minimum i-j path
  forall(e in E)  (
    (Y[e]=1 -> X[Edges[e,1], Edges[e,2]] = Edges[e,3])
        /\
    (Y[e]=0 -> X[Edges[e,1],Edges[e,2]]<= q100*Edges[e,3] div 100)
  );
```

- **C7**: The reduced network is at least spanning tree:

```
constraint
```

sum(e in E) (Y[e]) >= nVertex-1;

- **C8**: The spanning tree is constructed using flows from every (non-root) nodes to root 1:

```
    sum(e in E) (bool2int(Edges[e,1]=1)*Y[e]*Z[e,1])=nVertex-1
    /\
    forall(i in 2..nVertex) (
        sum(e in E) (bool2int(Edges[e,1]=i)*Y[e]*Z[e,1]
            +bool2int(Edges[e,2]=i)*Y[e]*Z[e,2]) =
        sum(e in E) (bool2int(Edges[e,2]=i)*Y[e]*Z[e,1]
            +bool2int(Edges[e,1]=i)*Y[e]*Z[e,2])-1
    );
```

4 ILLUSTRATIVE EXAMPLE

Let us show a small example of transportation network modeled by the weighted graph $G=(V,E,d)$ pictured on figure 1. Assume that passengers will tolerate 1.4-multiple exceed of travel time i.e. q=1.4. We used *gecode* [5] solver library for solving constraint programming. After computing via our model we got a solution, reduced network which is represented as the connected spanning sub-graph $G_q=(V,E_q,d_q)$ with required properties (1)-(3). Dashed edges pictured on figure 2 can be removed from original network.

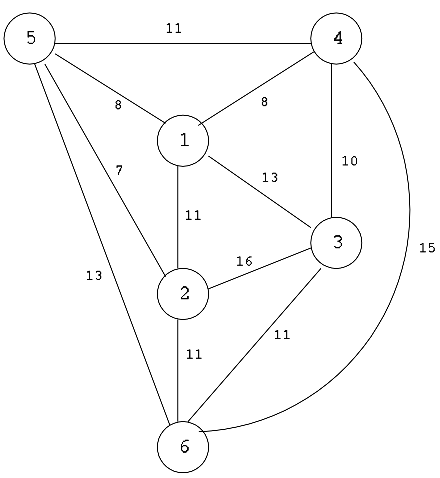

Figure.1: Network before reduction

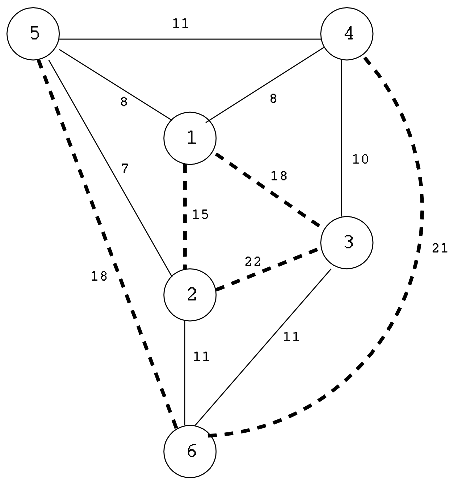

Figure.2: Network after reduction

The total length of network is reduced from 134 to 66 distance units and so we save 50.75% of length of network.

5 CONCLUSION

MiniZinc model does not dictate how to solve the problem. First experiments with solver *gecode* show that we can really solve only small instances with number of vertices 10-20. We observed that rate and time of solution is dependent on choice of parameter *infinity*. The best result we got for

$$infinity = q \,.\, \max\{d(i,j) \mid\ i \in V, j \in V\}+1,$$

where $d(i,j)$ is distance between vertices i and j in graph G.
We hope that solving real instances with 50-80 vertices will be possible after using some solver for parallel search of constraint programming on grids.

ACKNOWLEDGEMENT

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INNOVATIVE CONCEPTS OF MODELING TRANSPORT PROCESSES IN SUPPLY CHAIN MANAGEMENT

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ABSTRACT

The main task of supply chain is to guarantee uninterrupted flow of cargoes, information and payments. These flows make up a system, defined as a set of logistic elements interconnected through transformation processes. The strategy of integrated management comprises all areas of a company, i.e. procurement, distribution, customer service, and it aims at the co-operation, integration and shortening of flow cycles and customer orientation. Have been described the features and main characteristics of modern concepts synchromodal transport and identifies differences in relation to the well-known mulimodal system. The presented analysis of transport service qualities in the context of prospective transport included participants of complex supply chains. The results show that they aim towards improvement of relations, co-operation and partnership in future process-related and strategic solutions.

Keywords: supply chain, future logistics, synchromodal transport, comodlity, transport service quality

1 INTRODUCTION

Modern entrepreneurs determine new strategies and trends aiming at successful business in the face of dynamically changing environment, global competition and clearly defined customer requirements. Major changes are also visible in the efficient organization of processes making use of various modes of transport and service quality.

There are new concepts in the logistics of cargo flows supported by many implementation programs on the domestic and international market. Effective use of transport vehicles, route optimization, grouping of destination points, reduction of redundant packages, skillful use of infrastructure and appropriate investment projects result in competitive advantage and attract customers. Fundamental object is outlining global efforts towards sustainable development by utilizing transport means with optimized solutions and specific advantages of each transport mode.

2 INTEGRATION OF SUPPLY CHAIN THROUGH MULTIMODAL TRANSPORT STRATEGY

The main task of supply chain is to guarantee uninterrupted flow of cargoes, information and payments. These flows make up a system, defined as a set of logistic elements interconnected through transformation processes. The strategy of integrated management comprises all areas of a company, i.e. procurement, distribution, customer service, and it aims at the co-operation, integration and shortening of flow cycles and customer orientation – compare Figure1. These would not be possible without efficiently operating transport, coordinated on various levels: engineering, technology, organization. Various transport modes are used depending on transport needs, affected by: volume of supplies, type of cargo, location of markets, available infrastructure, carriage time, location of resources [11]. The choice is also dependent on costs, safety and promptness of deliveries, recently the environmental impact. The creation of a responsible and sustainable transport policy based on the above aspects was supposed to change significantly the transport structure by increasing the share of other transport systems alternative to road, especially by intermodal configurations.

Figure 1: The circle of process organization in supply chain management.

Conventional combinations of transport modes enable using optimal solutions and advantages of each mode, which should result in agile, unimpeded and flexible carriage in the bimodal, intermodal or multimodal system [9]. Publications on the subject, particularly those in the English language, present a variety of concepts and definitions of multimodal transport.

Combined transport is a form of intermodal transport (included in the multimodal transport). Its characteristic feature is the fact that the major part of carriage is executed between terminals by rail, inland or short-sea shipping, while feeder services are provided by road carriers over strictly specified distances.

Although there are favorable premises for intensive development of multimodal transport (location at major junctions of European transport corridors and growing transit traffic) [7] Polish cargo transport market is dominated by road transport. Combined transport is perceived as a system that does not offer a real alternative to road transport, because technically it is not sufficiently flexible, too slow and unreliable in terms of delivery, and too expensive [2, 6]. This opinion is supported by research on delivery promptness [8]. Its results show that among many difficulties in timely delivering of cargo units by intermodal transport the most frequent delays are caused by the rail operator (as much as sixty five percent of the examined sample, due to lack of proper rolling stock, delays due to previous delays, strikes, insufficient manning, errors in shipment sorting, equipment failures, railway works). Other causes include: delays during cargo preparation and carriage to terminals (about eleven percent), delays caused by terminal operators (three percent) and others (customs, automatic data identification, unidentified – twenty one percent).

3 MULTI-VARIANT TRANSPORT IN CONTEXT OF CO-MODALITY

The processes of cargo flow concentration are accompanied by globally unprecedented in magnitude new logistic forms of organization and management, a prerequisite for time and cost effective control of information and financial glows, and for the satisfaction of demand for cargo quantities generated by globalization. Among the factors necessitating the changes in traditional approach are changing expectations of customers, including their environmental awareness, growing role of general cargo in trade and the location of production centers [5, 12]. The co-modality of supplies, a relatively new term in transport logistics, first appeared in 2006. policy of European Union in this respect indicates the need to optimize the use of each mode of transport as a method for achieving a simple and efficient transport system by replacing competition with the concept of complementarity. Such approach gains importance in European transport and logistics as it is economically attractive in terms of flexibility, accessibility, promptness, multiplication of financial efforts for infrastructure, cost reduction and availability of information in real time. With the objectives defined as above, it may turn out that in a given transport process only one mode of transport can be employed, and that is ‘heavy’ road transport, e.g. in the modular system. The very idea of co-modality does not assume that intermodal transport is necessary and justified. What it assumes is that to strive for the above mentioned objectives, the decision on one or more modes of transport should be considered. However, it is assumed that shifting a part of long distance road transports to other modes will be encouraged in the light of growing congestions on European road network, lengthening travelling time of vehicles and delivery delays. It should be borne in mind, though, that each transport process, according to sustainable development and main guidelines of co-modality of supplies, will be evaluated in respect to eco-logistic solutions, meeting customer expectations and cost reduction. The latter factor still remains the most significant for a majority of companies.

4 SYNCHROMODAL SYSTEM AS A METHOD OF CREATING A MODERN INTELLIGENT TRANSPORT POLICY

Innovative actions aimed at the effective organization of transport processes require that all participants of the supply chain maintain bilateral co-operation, based on mutual trust and partnership, especially long-term relation of trust. The concept of synchromodal transport creates a multimodal transport policy at a higher level of process organization (see Figure 2), based on combinations of co-modal transport with proper scale of individualized solutions.

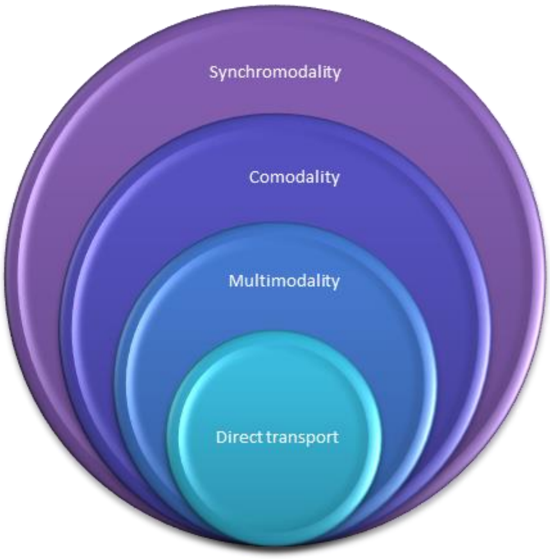

Figure 2: The levels of process organization in transport multi-faceted

Synchromodal transport is an innovative, promising idea of flexible and sustainable utilization of transport resources based on the co-operation of carriers representing various transport modes, adjusted to customer requirements and current transport capacities. Unlike intermodal transport, where cargo is moved in a specific direction, i.e. from a point of shipment to its destination by an initially chosen transport vehicle, synchromodal transport assumes that at any moment one of several options of transport connections are chosen. This means that in real time the best available methods of transport are used [1, 4]. An optimal decision is preceded by detailed recognition of customer preferences, analysis of multi-variant combinations of services and the estimation of possible results. Such approach demands from supply chain participants honest and up-to-date information exchange, for which a properly configured computer platform cannot be overestimated. The key requirement for smooth and dynamic operation of the system is the creation of skeleton networks as a backup of main seaports, logistics centers, container terminals. The system needs a compatible network, efficient operators, appropriate allocation of transmission capacities, effective utilization of infrastructure and suprastructure, and the implementation of intelligent transport systems. General assumptions of innovate concepts characteristics and differences compared to the multimodal transport shows Table 1.

Table 1: Characteristics of multi-variant transport systems models and their interrelations

Type of transport system	Multimodal transport	Synchromodal transport
Main idea to the transport system	Carriage of cargoes by using at least two different modes of transport	Carriage of by using favorable and available modes of transport
Features of the system	There is one contract of carriage obliged, in charge of the delivery of goods is a responsible contractor. Each carriers performs its task subordinated to the needs of transport processes across the supply chain which means reduction or loss of autonomy of the individual modes of transport [Szołtysek, 2009]	Sustainable use of available resources
Handling of cargo	Integrated unit loads, e.g. containers, swap bodies, semitrailers or motor vehicles, special containers; Cargo discretisation, which means that only cargo unit is subject to manipulation	Integrated unit loads; balance between the modes of transport, provision of open access to each transport market and reduction of harmful impact on the environment

Synchromodal transport furthermore implies making optimum use of the factor time: push instead of pull. Containers no longer remain at the deep-sea terminals in anticipation of action on the part of the recipient (pull), but are directly moved by barge or train to the inland terminals in the hinterland in a pro-active fashion (push). The realization of a synchromodal transport system is not that easy. The consolidation of volumes is essential in this respect. Only then frequent connections are possible between all the hubs using all three modalities: rail, inland shipping and road. The result is an optimal sustainable and reliable transport system [3]. In terms of technology, innovative solutions are related to increased capacity of a road vehicle, e.g. by using double loads on the bottoms of trailers and semi-trailers, increasing the maximum vehicle length, or wider use of standard Euro-pallets for cargo unitizing. It is worth noting that of all EU countries there are only two that allow the movement of road trains longer than 18.75 meters: Finland (25.25 m) and Sweden (24.00 m). Regulations on allowable maximum mass of vehicles in road traffic also vary: from 38 tons in Austria, 40 tons in Poland, 50 tons in Holland, to 60 tons in Sweden. Therefore, the best instrument for promoting synchromodality in supply chains will be revised and harmonized transport regulations. Apart from the variety of vehicle parameters, other obstacles for the idea of synchromodality are coordination problems in individual transfer junctions, demurrages, insufficient infrastructure, lack of standardized data exchange, unequal engagement of co-operating parties. Pilot implementation of the innovate concept is currently realize between Rotterdam and Tilburg in the south of the Netherlands. This concept entails the optimal operational alignment of shippers and carriers in their choice of transportation modality and infrastructure. This operational alignment is characterized by 1) the ability to switch freely between modalities and logistics networks whenever desirable and 2) by being able to aggregate and bundle transport loads to enjoy the benefits of economies of scale.

5 QUALITY SERVICES IN A MULTI-FACETED SUPPLY CHAIN – CASE STUDY

Effective organization of transport processes becomes increasingly difficult due to minor role of rail, sea and inland waterway transport in cargo traffic compared to the market share of road transport (see Picture 3).

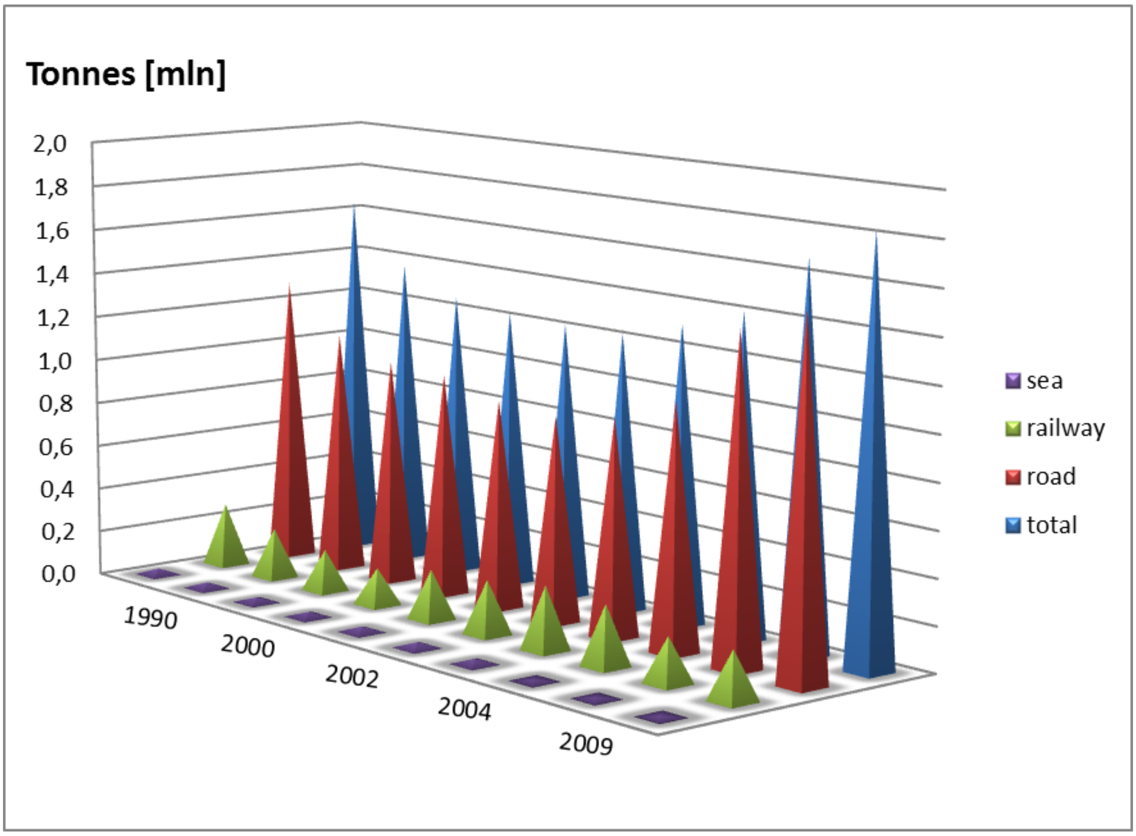

Figure3: The volume of freight transport based on mode of transport

According to analyses of the Railway Transport Office (*UTK*) the fraction of intermodal transport in the first three months of 2011 showed a rising trend compared to the same period a year before. By the end of March the following results were recorded: carriage of 980,000 tons of commodities, overall transport work covered 418 million ton-kilometers, which compared to the previous year meant an increase of railway freight in combined carriage by, respectively, 18.2% and 19.3%. However, it is still a slight fraction in the transport market oscillating at 1.95% of the mass carried and 3.96% of performed carriage work.

Although in the short run frequent and prompt deliveries by road meet customer needs and contribute to the improvement of processes, the use of more vehicles in the available road infrastructure may lead to congestions and reduced average speed of deliveries, with consequent delays and reduced traffic safety. Inclusion amount of cargoes transport in 2010 year, with the context of the average distance traveled by the mode presented Figure 4. It is concluded that the dominant road transport (84.4% of transported cargoes) while performing traffic on the shortest average distance equal to 144 kilometers and the railroads that transported 11.8% of the average distance cargo transport recorded at 225 kilometers.

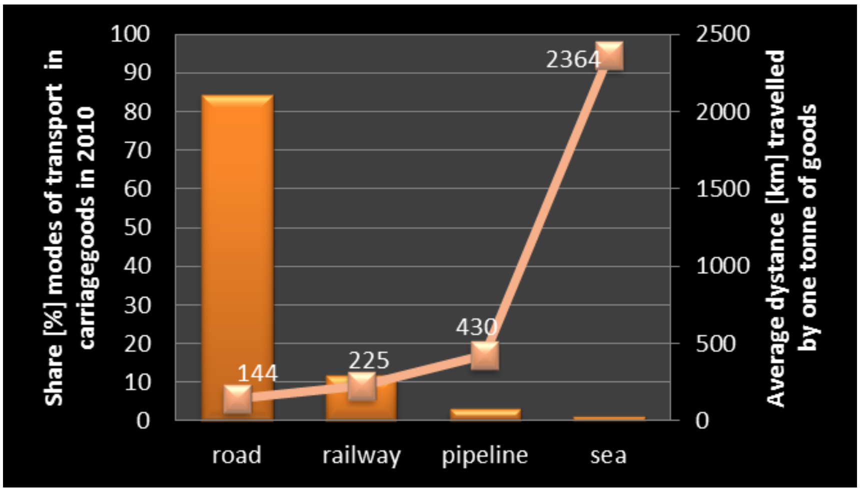

Figure 4: Participations in various modes of freight transport in comparison with average distance a tone of cargo

It should be noted here that the transport service quality depends on the satisfaction of customers from the service, but also their overall assessment they make by balancing positive and negative impressions related to the organization and all services it provides**.** Notably, among reasons for contacting a particular service provider may be the felt intensity of the customer's needs, their financial capacity and the flexibility of service offer of the provider. Taking into account the evaluation of customer satisfaction from services provided, we analyzed a number of features determining the suitability of a given mode or vehicle for fulfilling a transport need.

The examination of the significance of quality features of transport services in the complex supply chain in the context of innovative strategy of synchromodal transport included 613 samples. The companies were selected on purpose, i.e. those actively participating in organized cargo flows. Respondents showed stable opinions, that is their long time presence on the market guaranteed objective opinions. Results from companies operating less than seven years or those with financial liquidity defined as 'low' or 'close to zero' were omitted. Completely filled out questionnaires were delivered by 141 respondents. Transport processes taking place in multi-level supply chains were evaluated using two marking scales. One covered descriptive research based on bipolar interval scale, identifying essential determinants of transport services by the prioritizing of features indicated in the questionnaire [10]. The other accounted for the significance of a feature in terms of dynamic relations between an attribute and attribute significance, comprising such determinants: readiness, continuity, credibility, safety, mobility, promptness, flexibility, reliability. These were analyzed in two areas: direct deliveries – one vehicle used, usually a road truck, and multimodal deliveries with various configurations of available means of transport (at least two different modes). The level of participant supplies satisfaction is shown in Figure 5.

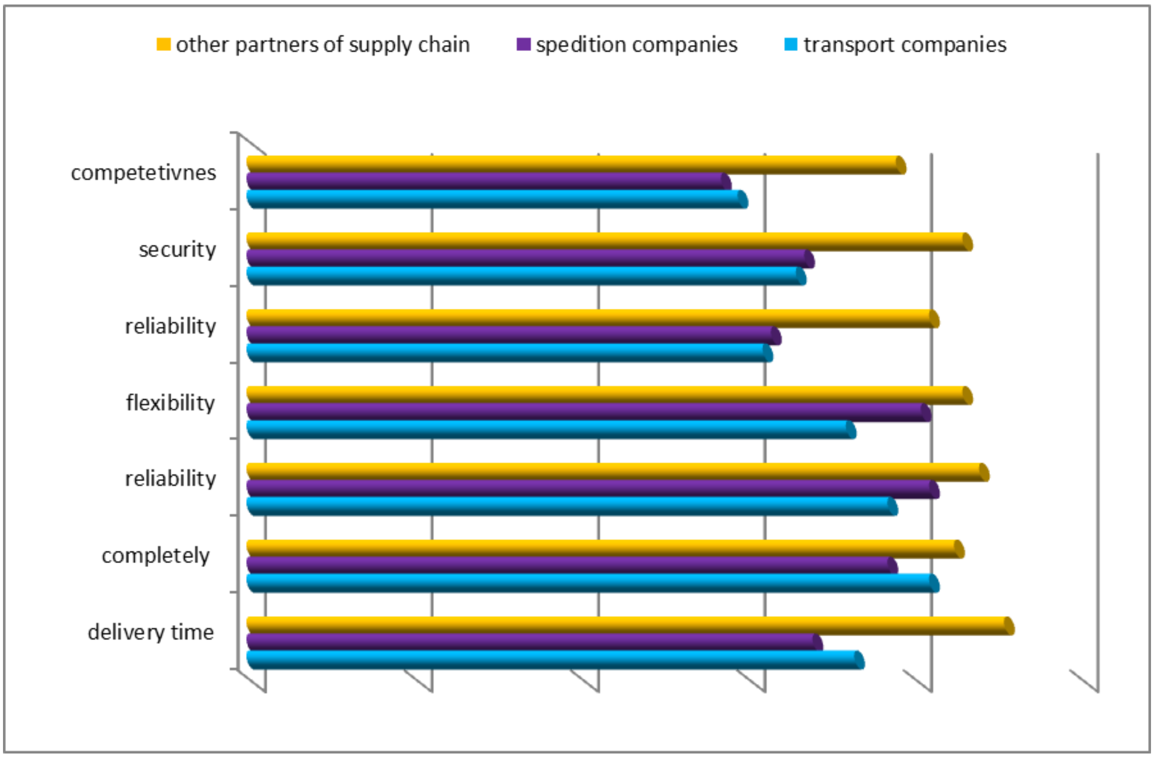

Figure 5: Significance of quality features of transport services provided in direct and combined deliveries

It will be noted that all examined quality features of services provided as direct deliveries or combined transport have attained a significance level higher than 50%. Interestingly, only 25% of respondents representing road transport participants indicated 'mobility' as an essential feature for customer satisfaction, although this mode of transport is most frequently used for *door-to-door* services. Multimodal transport requires from its participants more involvement, service integration and better arrangement of distribution structures – the significance level of the features ranged from 72% (safety and mobility) to 98% (promptness), which may indicate that each individual feature as well as all of them combined play a significant role in the complex transport process.

6 CONCLUSIONS

Innovative concepts of transport process management leading to effective adjustment to market requirements point out directions in which modern companies should develop. Customized offers of integrated and comprehensive services based on mutual trust, co-operation and partnership will be determinants of effective and progressive logistics. The following conclusions can be formulated:

a. Synchromodality is an essential pre-condition for optimally and sustainably organizing transport in the future.
b. Coordination creates efficiency and data exchange is really crucial to raise logistics to a higher level.
c. Customer criteria in that respect are (in varying orders) reliability, efficiency, price, speed and, increasingly, sustainability.
d. Strategic collaboration alone will not suffice. To further streamline logistics in the future, the business community must also simply cooperate at the operational level.

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SLOVENIA AT THE INTERSECTION OF CORRIDORS

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ABSTRACT

The Trans European Transport network (TEN-T) will be in the future divided into core, completed by 2030 and comprehensive network, completed by 2050. In the following years, the international trade flows will take place after new guidelines planned by European Commission. One of the main problems considering Slovenia is infrastructure stagnation in recent years. It is therefore feared that the key TEN-T corridors, which include potentially interesting Mediterranean and the Baltic-Adriatic corridor can partially bypass Slovenia in the future, if Slovenia will not start with infrastructure developments, primarily with second track between Divača and Koper. Main findings show that a future development of Slovenia is under serious question, if corridors will take another way, especially for road, rail and maritime transport. This paper also shows that our neighboring countries Croatia, Italy and Austria are developing faster than Slovenia in terms of logistics infrastructure. The key aspects and consequences in the case that Slovenia will not be placed in TEN-T corridors are presented.

Keywords: Trans-European Transport Network, corridors, investment, infrastructure

1 INTRODUCTION

One of the main goals of European Union from the very beginning after World War II is to design the most competitive, dynamic, knowledge-based economy in the world and in this sense a transport policy is developing. By 2050, the main goal is to develop the most competitive, sustainable and innovative transport system in the world (European Parliament, 2000). Part of the vision is also Trans-European Transport Network (TEN-T) which aims to integrate road, rail and air transport, inland waterways and maritime transport. All these modes of transport are crucial for the smooth functioning of internal markets, mobility of people, goods and economic, social and territorial cohesion of the European Union.

The European Commission is establishing a new rapid transport network where focus will be on some newly created corridors, from where Slovenia, can be eliminated. The main problem is that people, who were responsible for inclusion in these corridors, were referring to our geographical and strategic position, that Slovenia is located in the heart of Europe. Reading Slovenian media, we could get a feeling that European transport is unable to function without inclusion of our country. On the other hand, this was only a political media dictation, where some people wanted to disguise a fact that Slovenia is logistically and economically well behind neighboring and other European countries. Our leading politicians were focused on V. and X. Pan-European corridor and the importance of them, but these corridors are not playing the priority role in the European documents, since everything is nowadays focused on a new Trans-European Transport Network (TEN-T).

Slovenian economic development in the next years and decades also depends on inclusion in Trans-European Transport Network (TEN-T). The intensified talk in Slovenian public about TEN-T inclusion started in the beginning of 2012, triggered mainly by the Luka

Koper, where they raised a concern that inclusion in TEN-T would play a main role for their business development in the future.

The question arises whether the fight for integration into TEN-T is meaningful at all. On the other hand, it is important to know what are Slovenia's major competitive advantages in relation to other countries. Thanks to specific geographical location the main thing that Slovenia can benefit is logistics and also due to our diverse landscape, tourism. Logistics is surely one of the points that can lead Slovenia out of the crisis, but a bright future is not possible without infrastructure investments and the inclusion in new TEN-T corridors, which are presented below. In the following chapters I will try to analyze all the possible consequences that could arise in the case that Slovenia would not be fully included in TEN-T.

2 TRANS EUROPEAN TRANSPORT NETWORK (TEN-T)

The idea of Trans-European Transport Network appeared in 1993 when the Treaty of *Maastricht was signed*. The goal was to establish a new network that would connect road and rail transport, airports and waterways in a single transport network called TEN-T. In 2011 the European Commission adopted a proposal for the restructuring of existing trails and Slovenian position in new maps is not looking good. TEN-T network is composed of two different layers. First one is the so called core network, which should be completed by 2030. Construction of this network will facilitate an approach based on the ten existing corridors that will provide the basis for the coordinated development of infrastructure within the core network. The core network will connect:

- 83 main European ports with rail and road links,
- 37 key airports with rail connections into major cities,
- 15,000 km of railway line upgraded to high speed,
  35 cross border projects to reduce bottlenecks.

The second is the comprehensive network, which should be completed by 2050 and will provide complete coverage of the European Union and access to all regions. The new network will provide safer traffic, less bottlenecks, smooth and faster travel. That is why the European Union in the next financial perspective 2014-2020 will generously help with the financing of core network; the initial cost will amount around 250 billion Euros. The European Union will support the implementation of TEN-T with more financial instruments, including the Cohesion Fund and European Regional Development Fund (European Commission, 2003b). European Investment Bank will help with loans and credit guarantees. Slovenia is also from this viewpoint in a very bad situation, because it can happen that we will not be able to extract as much funding as we had the opportunity until now (European Union, 2011).

2.1 Mediterranean and Baltic-Adriatic corridors

Slovenia is in the draft regulation on guidelines for the development of TEN-T involved in Mediterranean Corridor (Figure 1) whose route runs from Algeciras via Madrid, Barcelona, Lyon, Turin to Milan, crossing Slovenian border in Koper, and continuing through Ljubljana and Maribor to Budapest and then to the Ukrainian border. The Mediterranean corridor route is similar as the V. Pan-European Corridor. Slovenia is for now drawn on the map, but there are certain infrastructure modernization plans, which are doubtful and should be made in a near future, specially the link between Trieste - Divača or the second track Koper-Divača and railway link between our national airport and capital city of Ljubljana.

Larger problem occurs when checking the vitally important corridor linking the Baltic to Adriatic. This corridor should provide an establishment of high-capacity rail lines designed for speeds up to 160 kilometers per hour for passenger transport. It begins at the northern ports of Helsinki and Tallinn, and then it passes through Kaunas to Warsaw. Here it attaches rail connection from Gdansk. The way forward is to Katowice, where, according to two parallel pathways connects Žilina and Bratislava; Brno and Ostrava to Vienna, Austria. From there it carries on past Graz and Klagenfurt to Villach and through Udine drops to the Italian ports of Trieste, Venice and Ravenna.

In last year Luka Koper exposed the problem and with a help of our ministers in European Parliament achieved on Council of Ministers of European Union, that Slovenia is included in this map with a route from Maribor to Koper (Figure 1), but the final confirmation of the revised TEN-T regulation still waits for the view of the European Parliament that should happen in 2013. Nevertheless, for the corridor based on the railway line, six years ago a letter of intentinon was signed by the following countries: Slovakia, Poland, Czech Republic, Austria and Italy. Where was Slovenia then? It looks like it was obvious for the people responsible for transport that Slovenia will be automatically included in above mentioned corridor. (European Commission, 2012a)

Figure 1: Baltic-Adriatic corridor

Source: Luka Koper, 2012

3 TRANSPORT

In the following chapters I will present the effects that may occur in the case Slovenia is going to be excluded from key infrastructure links. Focus is on the effects on population, economy and further development of Slovenia.

3.1 Maritime transport – infrastructure

Luka Koper and infrastructure investment is a long story, going on from the first idea of the third pier. It is a fact that port infrastructure works should start as soon as possible. The key one is, in addition to the third pier, also deepening the entry channel in the port and that i co-financed by the Cohesion Fund. Deeper entry channel would provide arrival of much bigger container ships. All that infrastructure investments should take place as soon as possible, through strategic partners - whether with a consortium of shipping companies, logistic providers, and financial institutions - either through recapitalization and change of business ownership interests in the port (Škrinjar, 2012).

If we place ourselves in a situation that the Baltic-Adriatic corridor is already in a full swing and our Luka Koper is not in itand that the third pier still exists only on paper, then we can ask if the construction of it is necessary. In doing so we have to define how important the third pier is and how much extra traffic can it provide according to situation. Luka Koper is with only two piers already competitive on the European markets, with total exclusion of these corridors; this would mean that maximum growth foreseen by 2040 would be out of reach. Given all together we can easily forget about third pier, because Slovenia we will not need it, especially when things on the second railway track between Divača and Koper will take place with a similar pace then for the last 20 years.

3.2 European traffic flows

The Figure 2 shows which are the most important countries in Europe for Luka Koper. In addition to Slovenian territory, which is more or less filled, representing over 30% of total throughput the most important partner is Austria, which is a serious competitor in Baltic-Adriatic corridor, with 5.6 million tones of goods handled and its 33 percent share represents the most important market for our port. If we take a look on the map (Figure 2) and imagine, from which ports will Austrians continue to transship their cargoes, if Slovenia would be excluded from TEN-T or we would not have an appropriate infrastructure connections? It surely would not be Luka Koper and it would be a huge blow to the only Slovenian port. Similar considerations can be made with other partners, for example Slovakia and Czech Republic. Here is also Germany, but with exclusion of above mentioned corridors and competition of Northern ports we can easily forget about some serious business with them (Čertalič, 2012).

Another look on the map (Figure 1) Baltic-Adriatic corridor, tells us the route goes through all the above mentioned countries, Austria, Slovakia and the Czech Republic, which means that the Luka Koper could quickly lose part of their business partners, who would prefer a quicker and more profitable rail. These countries should prefer the Baltic-Adriatic corridor where rails speeds for cargo transport would reach up till 120 km/h. We could also add the part of the cargo, which would Luka Koper lose from Hungary, especially after entering our southern neighbors Croats in the European Union with Port of Rijeka that will only increase a competition in North Adriatic ports. Furthermore, Croatia is also building a modern rail connection with Budapest.

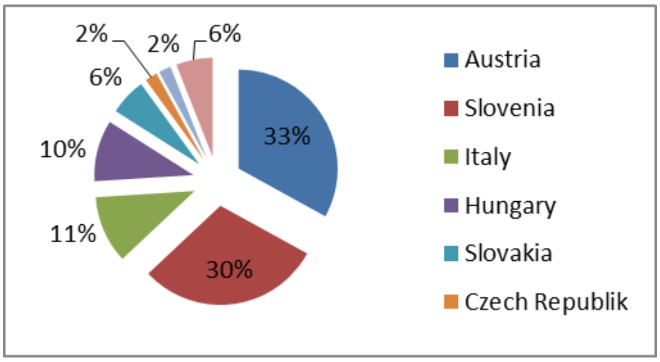

Figure 2: Luka Koper main markets (2011)

Source: Čertalič, 2012

3.3 Luka Koper growth

At the bottom in Figure 3, we can see the growth of port activities in recent years by the amount of freight handled. In 2011 Luka Koper handled 17 million tons of cargo, representing nearly 11% increase over the previous year, dominated by bulk cargoes (24%) and containers (22%). Praise worthy achievement is primarily container traffic, where a milestone was reached in 2011 (Pavlin, 2012). Growth could be even higher, if the economic situation in the world would be better, but all this is a consequence of poor growth and weak production in developed countries in connection with a financial situation in the Euro area.

What about the future? The current capacity of the container terminal is 700,000 TEUs per year. Ex-CEO of Luka Koper, Gregor Veselko believed that they can come up with million cargo containers without the third pier. When or if a third pier will be built, and the first pier extended, additional infrastructure will handle from 2 to 2.5 million TEUs of containers annually (Pavlin, 2012). By 2015 they want to reach 21.4 million tonnes of ship cargo (Figure 3). Ambitious plans go all the way until year 2040. The question arises whether such growth in traffic at the Luka Koper is possible at all or is it an illusion that will not come if they would not appear in one of the key international traffic flows? Without adequate infrastructure in the shortest possible time (the construction of the third pier, and especially the second track to Divača), modernization of railway lines, such scenario could be just a dream (Luka Koper, 2012a).

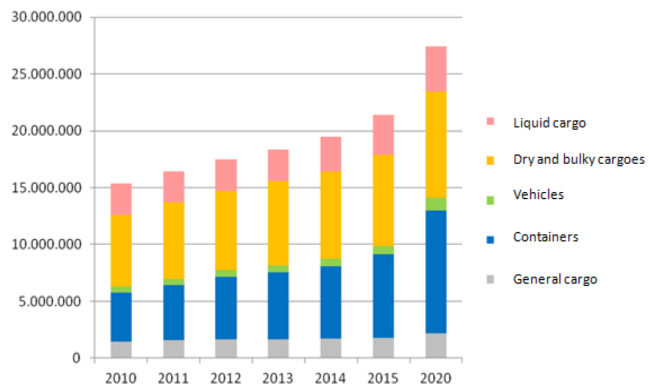

Figure 3: Cargo freight plans until 2020

Source: Čertalič, 2012

3.4 Coastal Karst region development

What would the exclusion of Luka Koper from the Baltic-Adriatic corridor meant for a region? As stated on their website "Luka Koper is a stock company, whose activity affects on the development of Coastal-Karst region, giving it a positive and dynamic economic pulse" (Luka Koper, 2012b). It was nice to see that the city of Koper and coastal economy (and also other parts of the Coastal-Karst region), four decades ago began to develop mainly due to construction and development of Luka Koper.

Regional development will stagnate in the following years, if there won’t be the expected growth, which is connected with infrastructure plans. With stagnation I mean the employment, economic growth and other factors, as a result of it. Not just Luka Koper, but all the companies that are directly and indirectly connected with it will suffer the consequences. In addition Luka Koper would reduce investments in sponsorship, which would have an impact on sports, art and other activities where Luka Koper is investing now.

3.5 Railway transport – Second track Divača Koper

The story of second track Divača-Koper is a well known and is going on for almost 20 years. The main problem is 27 kilometers long route, which should be built according to the original plans until 2015. Despite “ambitious” plans of all governments since 1996, it still exists only on paper; until the building process there is still a long way to go. Interesting is the information that second track line was estimated at 700 million Euros in 2007, but today, its value jumped dramatically and the project is currently estimated at 1.3 billion Euros (Cirman, 2012).

Future of the second track Divača - Koper is under question and this is the main concern of Luka Koper as the current capacity of the track is at the upper limit utilization. Damijan (2012b) showed in his research that according to current trends and the expected economic growth of certain countries, just one track will be enough until year 2018 according to realistic scenario. Given that 60 percent of the cargo from Luka Koper is transshipped by rail, this concern is how justified, because without new infrastructure the expected growth will be smaller or transit will move to Port of Trieste, Port of Rijeka or to Slovenian highways what will cause additional external effects.

In February, Brian Simpson, Chairman of the European Parliament's for transport visited Luka Koper and talked with the leader managers about non-inclusion in the major TEN-T corridor Baltic-Adriatic. They also spoke about the second track, and Simpson believes that starting of a construction would be a sign that Slovenia is serious in building infrastructure and in its integration into the network (Glešič, 2012). More than that a construction has not yet begun, worries a fact that governments have this plan for almost 20 years. A conclusion from all this is that the second track is urgent, regardless of the current financial situation that prevails in Slovenia. At this place I should also mention that 100 years ago, the track between Trieste and Poreč in the length 123 kilometers was build in 8 years, since the decision to start building, until its finish. Also Luka Koper built the first track between Divača and Koper in nearly 3 years (Šuligoj, 2012).

Slovenia’s northern neighbor Austria is an example of a good practice. Despite the current financial situation that prevails in the world it has long-term plans for the rail network and have already started the construction of a much bigger number of lines? It is necessary to consider a broader look at what the infrastructure could bring in the long term, for example 20, 30 years. This is not only for inclusion in the TEN-T, but the start of construction would automatically mean many new jobs in the construction sector, that is, as we know in a very critical phase at the moment. Not to say how the second track Divača - Koper and the rest of the modernization of the railway network would influence on the development of some other activities at the railway itself. It is important that a construction starts in a shortest possible time, because otherwise, Slovenia and Luka Koper will have significantly less potential for further economic growth, because the route will be redirected to other European flows, particularly to our neighboring countries, who invest significantly more than Slovenia.

3.6 Development of activities next to the railway

As mentioned above, we must not forget about additional activities that could be developed in the case that both corridors would go through Slovenia. Development of industry, further development of logistics and transport sector and other service activities that would occur beside the track itself are only couple positive effects.

Just remember how huge an impact of southern railway construction was more than 150 years ago on the development of Slovenian economy and industry, which was developed as an effect of a railway. We also have to mention Austrians, with whom we love to compete. In Brussels they presented the key effects of the railway infrastructure. Only due to the railway construction there will be 4,000 jobs created. After the construction phase and when TEN-T will work with full power, the estimated number is 15,000 new jobs. A similar move in Slovenia would solve problems in the whole construction sector. Along the Baltic-Adriatic corridor was revived as 31,000 new jobs will occur among all countries and Austrian gross domestic product (GDP) is going to increase by 9.5 billion (OBB, 2011). These are only the direct effects of construction and Austria's involvement in the Baltic-Adriatic corridor. On the other side there are also long-term effects that will led to the development of economic activities along railway. New activities would be developed due to increased traffic across our country. For all this effects described above, Slovenia is going to be deprived, because obviously there is no great desire and will to follow Austrians (Damijan, 2012a).

3.7 Road transport – loan repayment

Last year, DARS, Motorway Company in the Republic of *Slovenia*, ended in positive numbers. Net profit is amounted at 24.6 million Euros. These numbers look good, but are double edged due to rented amount of loans. DARS is already hiring new loans to pay off the old ones. Debt at the end of 2011 was 2,9 billion Euros and by the unchanged lending conditions it would lead to 4,1 billion Euros commitment until year 2037 (Stergar, 2012). The following Table 1 shows how much money will DARS have to repay in the next few years, especially 2014 will be the most critical year when the amount is 450 million Euros. What will happen in the future, if we take into consideration that Slovenia would not be included in the key TEN-T corridors?

Table 1: Return of DARS loans

Loan repayment	
Year	Debt in EUR
2013	228 million €
2014	450 million €
2015	271 million €
2016	294 million €

Source: Stergar, 2012

First we should look into the present. The above mentioned explanation indicates that DARS will face some problems in returning loans for year 2013 and even bigger problems for year 2014, when they have to repay 450 million Euros. All this will be impossible with current revenues. According to data published in the Annual Report for 2011 (Figure 4), the revenues are amounted to 336.5 million Euros. Most, nearly 300 million Euros they obtained from tolls.I should also add that DARS, in addition to repayment of loans will have to care about building new sections of roads, the maintenance and management of highways, not to mention third development axis that needs to be finished. At this level of current debt, all these projects will be very difficult.

Type of revenue	2011 (in EUR)	2010 (in EUR)	Index 2011/2010	Structural share for 2011
Revenue under the Agreement on the Performance of Tasks	643,333	668,098	96	0%
Tolls collected, rentals, motorway closures, extraordinary freight transportation and other revenue	330,526,387	313,610,621	105	98%
Revenue from tolls	298,339,794	290,095,679	103	89%
Revenue from leases	7,221,547	6,518,711	111	2%
Revenue from closure and overweight load transportation	1,081,994	2,378,157	45	0%
Revenue from easements	1,753,320	131,767	1,331	1%
Revenue from the lease of optical fibre/telecommunication lines	1,008,136	1,011,992	100	0%
Other sales revenue	724,255	608,469	119	0%
Other operating revenue	20,397,340	12,865,847	159	6%
Financial revenue	3,355,869	2,256,934	149	1%
Other revenue	2,012,882	80,171	2,511	1%
TOTAL	**336,538,471**	**316,615,824**	**106**	**100%**

Figure 4: DARS revenues

Source: Letno poročilo DARS, 2011

Figure 4 shows total revenues of DARS in 2010 and 2011. Already last year, they admitted that the money for the repayment of all loans started melting away and the revenues through tolls are not enough. DARS management decided to seek counsel for debt restructuring. What would happen if the number of trucks and consequently tools would significantly reduced, if Slovenia would be excluded from key infrastructure links? In this case any debt restructuring or raising vignettes price would not help DARS.

What would happen in case that DARS would not be able to repay these loans, because of consequences that Slovenia would not be fully included in TEN-T? All loans that DARS has hired at the European Investment Bank (EIB) are guaranteed by the state of Slovenia, what means that their return is guaranteed by the Ministry of Finance or money from the state budget that flows from our, taxpayers' pockets. There is also a possibility of rescheduling the loan agreement that would mean the extension of the repayment date or hiring a new loan to pay off the old one, but all this can not last forever. It is a fact that DARS, is in the short term period in big troubles, specially the return of loans and raising money through tolls.

3.8 Prices of vignettes/tools

As mentioned above in Figure 4, the total income of the company DARS this year stood at about 336 million Euros and the main source are tolls. Less than half, 45 percent of the money was collected from lighter vehicles, thus the vignette system and the other 55 percent of toll freight (Stergar, 2012). This may concern not only DARS and the Slovenian government, but all the people of our country; in addition, the sales of vignettes in 2012 fell for a 1,25% based according to a year before (STA, 2013a). On the other hand, freight transport, which will, as far Slovenia is not included in important infrastructure links, fell sharply. Transit will instead through Slovenia took place over our neighboring countries. Already in the previous paragraph, we wondered how to repay the loans, which is almost impossible at current revenues. Will the residents of Slovenia in the next few years pay debts accumulated by DARS with the prices of vignettes? Although vignettes have a limited duration, it should be soon introduced electronic toll collection, it is reasonable to ask what will be the price of vignettes in the coming years. The (annual) price vignettes, which now cost 95 Euros, will increase by twice, maybe three times? In 2008, DARS already mentioned, that there should be an annual vignette price 125 Euros (Nared, 2012). What about freight? Thus, the price of transport across the Slovenian network is going to increase significantly, but at the same time if Slovenia would drop out of key connections, it would not help.

Given current projections, toll revenue between 2010 and 2060 will fluctuate between 250 and 350 million Euros. This amount highly depends on traffic flows that will take place across our country (Darja, 2012a). In such circumstances, we can expect increase of vignettes prices, which in turn would mean a drop in sales and a shift of traffic on regional roads that would probably again increase external costs such as traffic jams, accidents, pollution… But again, this leads us nowhere. It seems that DARS operates in a way "hand to mouth". We can also forget about any infrastructure improvements, which are a key for competing services. Increasingly, it seems that once again, the taxpayers are going to solve semi-sunken boat of DARS.

3.9 Logistics companies

Big part of the road transport represents hauliers, who are indirectly dependent on what will happen with Slovenia and inclusion in the TEN-T. Although the Baltic-Adriatic corridor is based primarily on the rail, Slovenia exclusion would mean fewer goods to the Luka Koper. If we assume that 60 percent of goods is transported by rail and the rest by road, would also be part of this significant decline, which would mean the collapse of some Slovenian logistic companies, which are largely dependent on where will European traffic flow take place in the future. If just one major company terminates the operation through Slovenia or diverts their cargo to other ports traffic flows for the Slovenian logistics companies can be fatal. This happened to one of the biggest Slovenian logistic companies, Intereuropa. The news that has heavily shaken them was that Sandi Češko, the owner of Studio Moderna, is moving its central warehouse from Dravograd, Slovenia to Katowice, Poland. Studio Moderna represented, according to unofficial figures, around a fifth of annual income for Interuropa (Kačič, 2012). Not to mention that their stocks have fallen dramatically the very next day after the news. This is a fine example and also warning for companies that depend on freight transport across Slovenian territory and also for the country as a warning what can happen in the next few years, if Slovenia will be excluded from key transport links.

4 INFRASTRUCTURE PLANS OF OUR NEIGBOURING COUNTRIES

The need for infrastructure development is one of the greatest global challenges of our time, but logistics infrastructure projects in Slovenia are in the phase of stagnation for the last couple years. If we just look at the most important ones, for example, how much time has passed since the idea of a second track between Koper and Divača, from the starting concept of the third pier in the Luka Koper? Not to mention the modernization of the railway infrastructure, second track in Gorenjska region and on the Maribor-Šentilj track, electrification of Pragersko - Hodoš, capacity increase at the track Zidani most-Maribor, construction development on third axis of Koroška against Dolenjska regions, reconstruction of Karavanke tunnel and we could go on.

It looks like Slovenia for now does not have any serious intentions to build nationally important logistics infrastructure projects, but a completely different story goes on at our neighboring countries, which are apparently aware that the infrastructure is a key to boosting the economy. So, what are ambitious projects from neighboring countries that represent a serious danger to Slovenian logistics in next couple years?

On the 1st of July 2013, Croatia will join the European Union, which means that all administrative advantages that Slovenia had against our southern neighbors will be "wasted". At the entrance from the logistics point of view, Croatia is already well prepared for all types of transport. The most ambitious project that will become a reality in a near future is planned near city Zagreb, more specifically in the trade zone Dugo Selo. There will be built logistics distribution center under the name Cargo Centar Zagreb. This new cargo center is going to be placed on one million square meters; its value is estimated at around 230 million Euros. The main partners of this project are Luka Rijeka, Croatian railways Cargo and Cargo Center Graz. The facility would provide many new jobs during the construction phase. When the project is going to be completed, there will be an additional thousand employees in the logistics center, at the same time we should not forget the construction of additional facilities, such as gas stations, hotels, restaurants and customs offices that will enable the employment of 3,000 people. Container transport capacity in the Port of Rijeka will be built by Italians and is expected to increase by 2016 to a million containers per year, while Luka Koper traffic is around 700,000 containers per year. At the same time, Chinese are interested in the investments in the port, because they want to make Rijeka their entry point for Southeast and Central Europe. In addition to investments in the port, they are also interested in the modernization of rail links, particularly between Rijeka and the Hungarian border. This is the link Rijeka - Botovo that would through Karlovac and Zagreb significantly shortens the route to Hungary and increase the capacity. Work on the new updated track should be completed by 2026 and the project is estimated at 4.5 billion Euros. However, the route from the port will not base only on rail link, because they also want to build a link road between the western part of the port and Rijeka ring road (Cvelbar, 2012). Croatia is not stagnating neither in aviation, with French help, they will build a bigger passenger terminal at Zagreb Airport, which will further increase the number of passengers at the Zagreb airport at 3 million per year (Koražija, 2012).

Our northern neighbors Austrians mostly invest in railway infrastructure. By successfully lobbying in Brussels and starting many new projects, they have succeeded in securing an important place in the Baltic-Adriatic corridor. They are working on a new southern railway from Vienna to Klagenfurt, where construction work is preceding two key tunnels and rail lines. The first one is so called Koralm tunnel between Graz and Klagenfurt, which is 33 kilometers long and will be built by 2022. On the other hand there is the Semmering tunnel between Vienna and Graz in the length of 27 kilometers, which will be constructed by 2025. At the same time they are also working on railway stations in Graz (where, among other things, there is an important regional Cargo Center Graz) and Salzburg. I should also mention the construction of one of the most modern railway stations in Europe, which is being built on the outskirts of Vienna. According to the size of the project, the goals are being appropriate, as they expect that by 2025 the railway station will enable the flow of 120,000 passengers and 1,000 trains per day! Investment in the entire project with all associated infrastructure and residential buildings is estimated at 4 billion Euros (Wien info, 2012).

In the West, the Italians succeeded despite the lack of money to make rail link between Udine and Treviso, they also have plans to invest in their North Adriatic ports. In the port of Trieste 130 million Euros will be invested in the coming years, mostly to improve the rail links and the construction of a new container terminal and logistics platforms. They have similar plans for other ports Venice and Ravenna. An important part of the infrastructure is also one of the three existing cargo centers in the region, Interporto Padova, which in the comparison to Slovenia, equals the size of all open and covered storage areas in our country. Investments in this center are rising with significant increase in freight volume.

In Hungary, the situation in the country can be equated with the one in Slovenia. The only advantage is that railway link between Budapest and Port of Rijeka is under construction and they have the Cargo Center Budapest.

Regardless of whether all the above infrastructure plans will be fully implemented, it can be concluded that the ideas and designs of Slovenia's three neighbors Croatia, Austria and Italy are more ambitious and have better vision for the future. Slovenia. Neighboring countries are aware that without investment in infrastructure there will not be any progress or economic growth. It is true that today's economic situation is difficult, in the first plan are reforms and savings, but the fact is that in order to boost the economy and maintain global competitiveness it is necessary to invest in strategically important infrastructure logistics projects.

Slovenia is now facing a serious challenge, if we take into consideration that potential corridors might be bypassing Slovenia and that on several strategic locations there are well planned investments in infrastructure. Definitely Slovenia has to redefine its position in the region, due to new, more competitive environment (Božičnik et al., 2012). In the opposite case we will not be able to compete in our region, nor on global market.

5 CONCLUSION

This paper presents some possible effects in case that Slovenia would be excluded from the trans-European transport network, which is going to be a key infrastructure link in Europe by 2050. A loss itself would also leave much deeper consequences, but at this time, we are not aware of them as we should be. Infrastructure, jobs, development and growth of Slovenian logistics companies and all the people who are directly or indirectly connected with Slovenian logistics are just one of them. In 2030, when the corridors will be in full swing and Slovenia going to be just partly involved, we will regret all our decisions that we have not started building second track, third pier and other strategically important infrastructure projects and other upgrades earlier.

Most concerns a fact that there is no great interests in serious infrastructure projects that should be already built in the past, whether from the budget of the Republic of Slovenia, with the help of strategic partners or concession. Despite the harsh austerity measures, which we can see today, investing in infrastructure is the only possible scenario for the progress of the economy and competitive battle of Slovenia on the global market.

All infrastructure investments in the following years probably will not be needed anymore, if Slovenia will drop out of key links. International trade flows in this case would be easily redirected to our neighboring countries even though some people think that Slovenia is the heart of Europe. Due to ambitious infrastructure plans of our northern and southern neighbors our ability to play any important role in the trans-shipment across Europe in near future deteriorated significantly. In recent years we have held all the cards in our hands, which assured that Slovenia could be the key link for Central and Eastern Europe, but we did not take that chance. Jean Eric Paquet from European Commission once said, that investing in strategically important infrastructure projects is actually investing in the future. So, what kind of future do we want?

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AIRPORT COLLABORATIVE DECISION MAKING (A-CDM) INITIATIVE AND OPPORTUNITIES

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ABSTRACT

Airport Colaboratve Decision Making (A-CDM), initiative from Eurocontrol, is a concept to enhance the efficiency and turn-round process at an airport, the so called “missing link” in Air Traffic Management system. Basis for A-CDM is transparent exchange of operational data between airports, air navigation services, airlines, ground handlers and other stakeholders to make operational decisions. Exchange of this data nowadays is often insufficient, late or missing at all. Several large airports in Europe have allready implemented A-CDM and experienced operational benefits in terms of operational efficiency, better use of resources and increased punctuality. On the other hand, many airports are still not aware of A-CDM benefits and what is a risk of non-action. The others have have been struggling with the implementation process. What about smaller regional airports? Investments? There are still many challenges in defining the relevant data, methods for sharing, and common terminology.

Keywords: airport, collaborative decision making, operational efficiency

1 INTRODUCTION

Congestion on airports is already a limiting factor not only at a number of big airports but also on smaller, regional airports, for at least some part of the day. In addition to that, airports nowadays are struggling with many other challenges such as economic, commercial, environmental and/or regulatory.

Central to the success of any airport is its ability to enable aircraft to depart and land in accordance with the schedule. Flights are delayed and cannot be ready to depart at their scheduled times, but this information is not relayed to many of the people who should know. The A-CDM concept is the aviation community’s attempt to manage all flight movements from end-to-end, and requires the involvement of all stakeholders in day-to-day operations, including managing flights and the normal delays associated with airports and airspace. [7]. The core of A-CDM is information sharing between airport partners. Today, real-time information sharing between the Air Traffic Management system and people on the ground at airports happens only at A-CDM airports [3].

2 AIRPORT COLLABORATIVE DECISION MAKING (A-CDM)

Airport CDM is about partners working together more efficiently and transparently in how they work and share data. It allows better decision making, based on more accurate and timely information, with all airport partners having the same operational picture [12].

Airport CDM is more than a European project. In fact the original inspiration for the generic CDM concept came from USA [3]. The development of advanced Air Traffic Flow Management (ATFM) systems in the United States and Europe during the 1980s and 1990s has had an enormous impact on air traffic management (ATM) and airport operations. ATFM has become an essential instrument for reducing the cost of delays to airlines and other airspace users, and for achieving better utilization of airport and ATM resources. On the other hand, ATFM has also been criticized at times for deficiencies that occasionally contribute to slowing down air traffic operations rather than reducing delays. The adoption by the U.S. Federal Aviation Administration (FAA) of a collaborative decision making (CDM) approach to ATFM is one of the most significant events in the history of ATM, in general. It marks a major change in the philosophy under which air traffic control has traditionally been operated. While ATFM and the CDM approach to it affect every part of the airspace, their effects on airport and terminal airspace operations are particularly critical [6].

Collaborative Decision Making in USA is a joint FAA industry initiative designed to improve traffic flow management through interaction and collaboration between airspace users. Through improved communication CDM is intended to reduce the use of ground delay programs and to give users more flexibility in responding to airport arrival constraints The Flight Schedule Monitor (FSM), a primary component of US CDM, is a support tool that collects and displays arrival information, retrieves real-time demand and schedule information, monitors ground delay performance, and provides "what-if" analyses capable of projecting arrival rates, slot availability, and departure delays. The FSM is shared among CDM participants and is updated as schedules change [10]. Using information provided through. Today, recognition is increasing around the globe and CDM representatives in the US are excited by the European concept and how it applies to airports [3].

ATFM systems now play a central role in air traffic management in both the United States and Europe. Similar systems may eventually be developed in other regions of the world. The most important weakness of AFTM was the limited availability of decision-support tools to cope with complexity of the ATFM environment. The CDM program has made significant progress in this respect through the development of the software solutions, which incorporates several powerfull decision-support algorithms and utilities. Still, much remains to be done [6].

3 AIRPORT CDM ELEMENTS

The Airport Collaborative Decision Making concept involves implementation of a set of operational procedures (Figure 1) and automated processes [3]:

- Airport CDM Information Sharing is essential in that it forms the foundation for all the other elements and must be implemented first.
- The Milestones Approach (Turn - Round Process) aims to achieve common situational awareness by tracking the process of a flight from the initial planning to the Take-off.
- Variable Taxi Time is the key to predictability of accurate take off and in-block times especially at complex airports.
- Collaborative Pre-Departure Sequence establishes an off-block sequence taking into account operators' preferences and operational constraints.
- CDM in Adverse Conditions achieves collaborative management of a CDM airport during periods of predicted or unpredicted reductions of capacity.
- Collaborative Management of Flight Updates (CFMU), nowadays called Network Manager, enhances the quality of arrival and departure information exchanges between the CFMU and the CDM Airports.

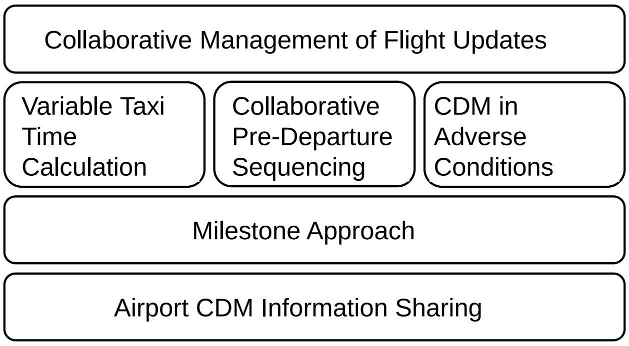

Figure 1: Airport CDM Information Sharing & Milestone Approach

Source [2]

3.1 Information sharing

In real life situations, carefully planned events such as arrival and departure times and gate usage often change. When this happens, such changes need to be communicated effectively through to the numbers of people. This includes air traffic controllers, ground controllers, staff responsible for gate allocation, airline dispatchers, baggage handlers, refuellers, in-flight caterers and security (see Figure 2.). In any of them has the wrong information, then it usually results in a delay in the process. In most (bigger) airports these functions are handled by completely separate companies, which means that sharing accurate information in a timely fashion is a constant challenge [3].

Airport CDM information sharing is the foundation of all other identified Airport CDM applications. The sharing will use the existing infrastructure at airports, but information flows between all partners will be improved by combining data from different sources. Each partner has at some point a piece of information that is more up-to-date and more reliable than the estimates used by other partners; yet all too often this better information is not shared. The real situation can often be very different from the plan and if anything goes wrong on the ground, the deviation is not communicated to the network sufficiently in advance. The type of information needed covers: airline schedules and flight planning information; predictions, status messages and operational planning information (stand, gate, landing time, in-block time, turn-round time); advisories and alarms (e.g. insufficient time to complete turn-round); status of aeronautical aids/systems and weather situation. In this commercial world it can be also tempting to see information as a revenue generator. Others have tried to charge for data, but have found that when they do, the whole CDM process stops. People will always find ways to recharge back, which simply creates a cycle of resentment and mistrust, whereas CDM relies on trust and mutual benefit [3].

3.2 Turn-round process

The Airport CDM Turn-round process links the flight and ground segments, improves current information flows and predicts forthcoming events. Aim is to improve data quality, predictability of departing flights and planning information for all partners, including CFMU (Central Flow Management Unit) [1]. The whole process can be further improved by defining a set of so-called “milestones” (see Figure 2.). These represent the significant events that occur during inbound flights and following turn-round. By monitoring these events and following the procedures and rules, the partners can anticipate problems quickly when there is any deviation from the plan [3].

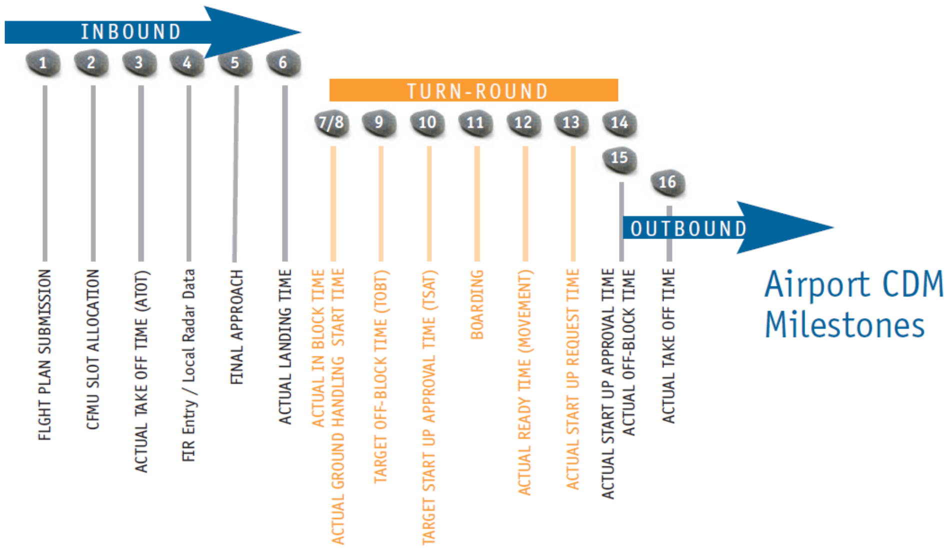

Figure 2: Airport CDM Milestones

Source [3]

3.3 Collaborative management of flight updates

In Europe the job of balancing demand and available capacity of airspace is done by the Central Flow Management Unit (CFMU) (see Figure 3.). But there is currently no link between airborne and ground flight segments and although information from the airports plays a key role in the efficient planning of the CFMU, airports are not truly integrated in the 'gate-to-gate' planning process. The Collaborative Management of Flight Updates aims at further improving the flexibility of aircraft and airport operations and the pre-departure sequence by using Slot's preferences and airport operations constraints into account [1].

Recently, two new ATFM messages have been developed by Eurocontrol to facilitate the "Collaborative Management of Flight Updates": the Flight Update Message (FUM) and the Departure Planning Information (DPI) message. The FUM provides real-time arrival updates to a CDM airport, advising about modifications in the Estimated Time of Arrival. The DPI message provides realistic departure updates to the CFMU from the CDM airport. The intention is that flight updates or changes are communicated as soon as possible, providing the CFMU with up-to-date Estimated Take-Off Times (ETOT). With such estimates, CFMU is able to establish an accurate picture of the departure flow from CDM airports. If more airports provided the CFMU with accurate Target Take Off Times via an automated Departure Planning Information (DPI) message, the CFMU would have dynamic sector counts which would result in enhanced management of the European airspace.

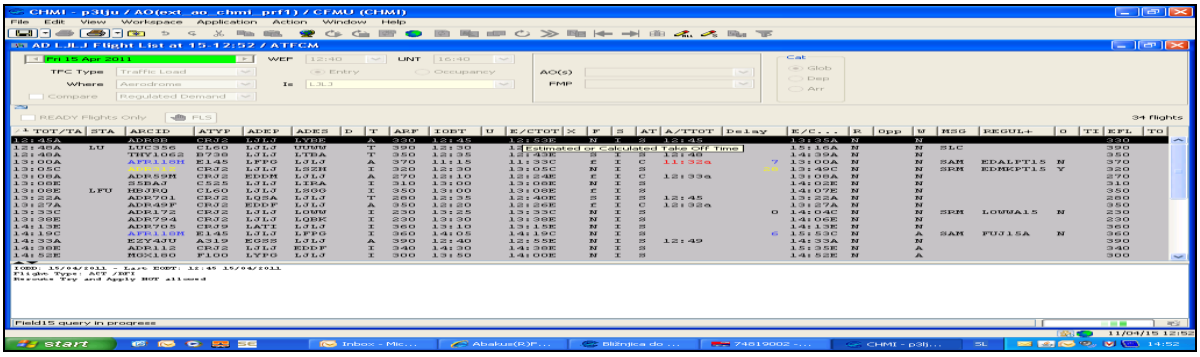

Figure 3: CFMU Ljubljana Flight List for Ljubljana Airport

Source: Aerodrom Ljubljana

3.4 Variable taxi time calculation

The duration of the taxi time is calculated to the required accuracy, based on general and location specific rules. At complex, large airports the layout of runways and parking stands can result in a large difference in taxi time. Smaller, regional airports, except on really rush hours or unexpected events, don't have large differences in taxi time. Variable taxi time calculation aims at improving the airline's adherence to scheduling by introducing and distributing realistic taxi times [1].

3.5 Collaborative pre-departure sequence

The "Collaborative Pre-departure Sequence" is an essential airport CDM application for optimizing the use of apron facilities, stands and gates, while at the same time aircraft and airport operators' requirements and priorities are taken into account in a collaborative process. Accurate estimates of off-block times are necessary for the effectiveness of this application. The collaborative pre-departure sequence aims at enhanced flexibility, increased punctuality and improved slot-adherence, allowing the airport partners to express their preferences [1].

3.6 Adverse conditions

Airports partners have developed various procedures to deal with adverse conditions. The A-CDM in adverse conditions aims at collaborative capacity management during periods of reduced capacity (due to fog, strong winds, snow, etc.). This has a significant impact on turn-round and taxi time. If all other Airport CDM elements are already in place at an airport, special Airport CDM procedures for adverse conditions can be applied [3]. The A-CDM in adverse conditions helps airports minimise the impact of bad weather on operations by disseminating relevant information in anticipation of disruptions and allowing a rapid recovery after disruptions. A-CDM in adverse conditions ensures that de-icing, whether on stand or remote, becomes part of the overall process of handling a flight. The time required for de-icing becomes visible and it can also be accounted for in the calculation of the various target times [1].

4 AIRPORT CDM IMPLEMENTATION

Conventional A-CDM implementation involves identifying existing systems and the functionality that must be bridged to meet the technology requirement; engaging technology suppliers to make the necessary change; and then testing the changed system to ensure they function collaboratively. Eurocontrol has prepared the A-CDM implementation manual guide with an overview of Airport CDM and how it can improve the efficiency, capacity, punctuality and customer satisfaction with step by step implementation (see Figure 4.) including the following [2]:

- Operational Concept Description
- Functional Requirements and Specifications
- Key Performance Indicators
- Generic Memorandum of Understanding / Service Level Agreement
- Implementation Risks
- Generic Procedures

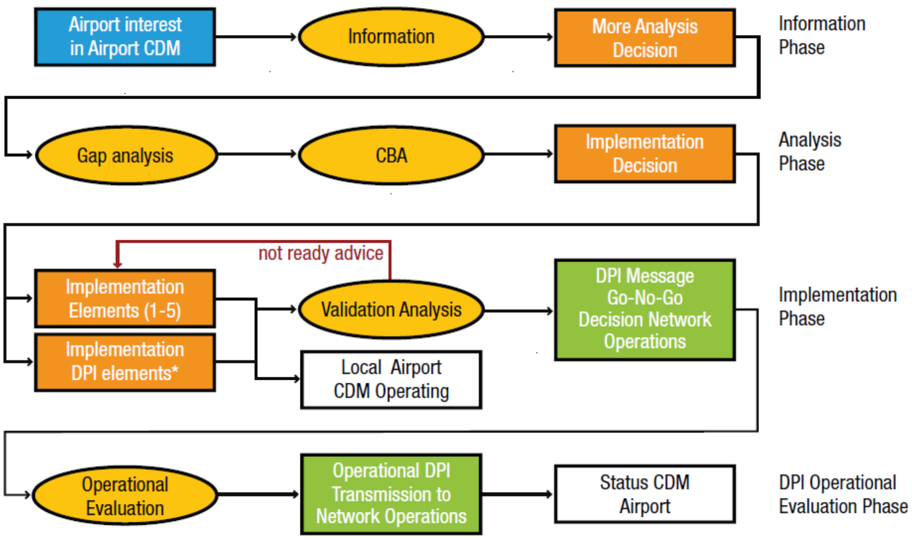

Figure 4: General process for Airport CDM Implementation

Source [2]

In some airports CDM-like procedures are already in place, but using different names and definitions. A gap analysis can identify where additional information or action is needed. That same analysis will also help to define how to tailor existing information and processes without overcomplicating things, as well as how to provide access to what is needed [1].

5 AIRPORT CDM NETWORK AND BENEFITS

Eurocontrol says there is a very strong case for implementing A-CDM. By using more accurate taxi times and sharing data, controllers can optimize the departure sequence for flights [8]. A-CDM has been fully implemented at Munich, Brussels, Paris CDG and Frankfurt Airport. More than twenty European airports are working toward it [12]. Mostly of them, bigger EU airports, with annual passenger figures way above above 5 millions (see Figure 5.).

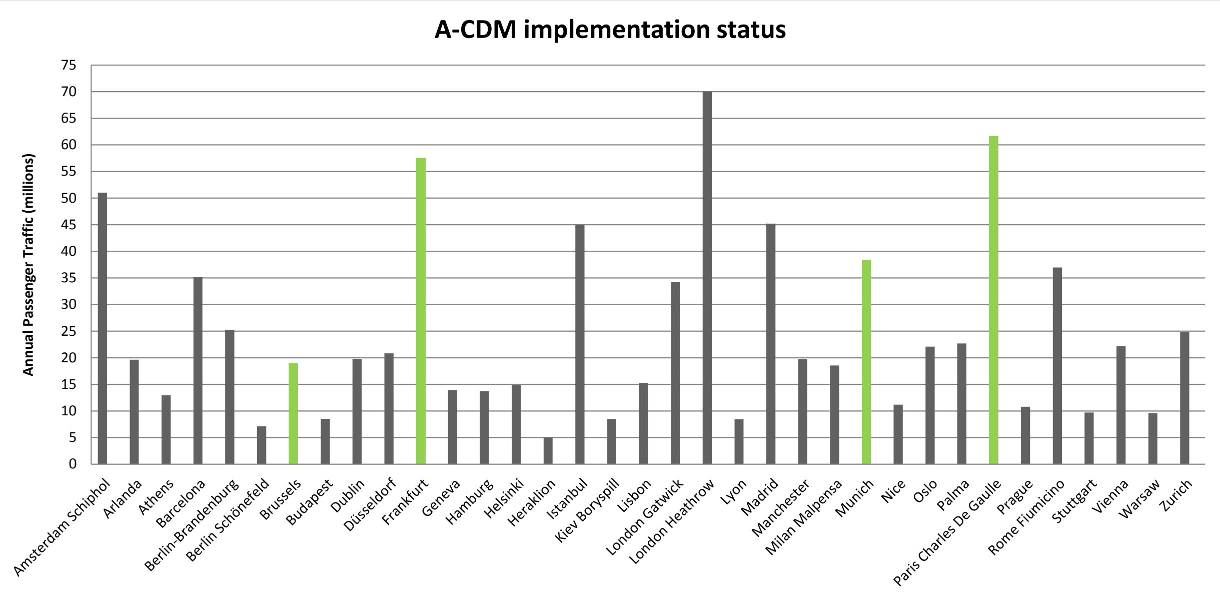

Figure 5: A-CDM implementation status comparision in terms of passenger traffic

Airport Munich was the first airport to introduce A-CDM in june 2007, bringing about a 10 per cent reduction in taxi times and lower emissions [7]. Paris Charles de Gaulle reports savings of 14.5 tonnes of fuel per day, Brussels Airport reports reduced taxi-out time by a quarter. In 2011, Madrid and Palma Mallorca signed a Memorandum of Understanding (MoU) that commits stakeholders to accelerate the activity. Rome/Fiumicino in Italy and Lyon in France are close behind Heathrow and Amsterdam in completing the necessary milestones. Other airports that signed MoUs in 2011 include Manchester, Budapest, Stockholm, Istanbul/Atatürk, Rome Fiumicino, and Lyon [12]. Helsinki: believes that average engine idling times can be reduced by up to three minutes per aircraft during peak times, which equates to an annual reduction of about 5,100 tonnes of CO2 emissions. If 50 major airports saved one minute per taxi time per flight, as Brussels has achieved, A-CDM could save airlines 145,000 tonnes of fuel or 475,000 tonnes of CO2 annualy [4]. Other benefits of CDM are more reliable arrival times, and corresponding departure times, of the same aircraft on its next flight. On the internal side, CDM partners will be able to make much better use of staff and other resources, from aircraft at gates to handling equipment. This can generate cost savings, which are much needed in these challenging times, to all aviation partners. For instance, Munich Airport has reported a cost-benefit ratio of more than 1:10, which for Lufthansa alone represents some €20-30 million [4].

6 CONCLUSION

Releasing an update to their action plan for A-CDM, ACI (Airport Council International) Europe and Eurocontrol stated their ambition to see the process fully implemented at eight new airports in the very near future (was ment by the end of 2012 [9]). This would bring 400 million passengers per year under the influence of A-CDM, which is more than 25 per cent of European passenger traffic. [9].

A-CDM is about individual parties working in a harmonized way to optimize the overall process (rather than just optimizing their tasks). But, systems and information sharing, however, will not be effective without cultural change and an understanding of the bigger picture [13]. Cultural change can be a lengthy process for many airports. In Europe, Airport CDM is regarded as a tool to help deliver capacity, performance and environmental benefits, but implementation has proceeded at a slow pace [9]. Questions remain, why it is apparently so difficult and lengthy to introduce Airport CDM as many organizations have been working towards for a last decade. Some blame so-called “system challenges”, which are being resolved by the introduction of new “cloud” IT technology and web-based applications as well as for connections for handheld devices and personal mobile phones. Another major factor is the operational culture at the airport: stakeholder need to learn to trust, respect and support each other much more, even though they are separate organizations with different business objectives. It takes leadership to achieve this [5].

What can the smaller, regional, airports like Ljubljana Airport, benefits from? For example, Helsinki will be the only Finnish airport to adopt A-CDM in the foreseeable future as Eurocontrol’s detailed studies have determined only those airports with over 50,000 movements a year would benefit from this type of operation [4]. Among the benefits for regional airports are: seeing the bigger picture, mutual trust, cultural change and especially a common vocabulary with clear meanings. At one Eurocontrol seminar different delegates said ETA (Expected Time of Arrival) meant for them: Touchdown (ATC), Engine Shutdown on stand (Airport/Ground handler), In-block time (Ground handler), At stand (Passenger) [3]. Benefits for regional airports are that they can be achieved even at the most basic level, of purely improving the distribution of existing information amongst users and stakeholders, creating common situational awareness, with relatively low investment. Simply by interfacing existing systems to provide better quality data based on common information elements and interactions. Nowadays, also in regional airports related to ATM, information is seen as a “revenue generator” and we are charging the exchange of data to each other, whereas A-CDM relies on trust and mutual benefit. Hopefully A-CDM initiative will help us to resolve some local (individual) understanding about the “bigger picture concept”. But that can be a lengthy process, also in a regional airports and ATM’s.

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OLDER DRIVER'S CHARACTERISTICS REFLECT IN ROAD TRAFFIC SAFETY

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ABSTRACT

Traffic accidents caused by elderly people are increasing. We cannot support a view that the increase of elderly people will direct result in an increase of traffic accidents. The main reason is in their specific mobility habits. To scope the prevention of accidents caused by elderly persons, there is a need to address the issue based upon an analysis of the reduced physical and mental functions of such persons and of the characteristics of their accidents.
More crashes occur in intersections than in most other driving situations.
Research how older driver's characteristics reflect in road traffic safety was made based on old driver's interviews about their mobility habits and police traffic accidents records, analyzing the infrastructure impact in different traffic accidents involving older drivers.

Keywords: Older road user, Traffic safety, Travel characteristics, Road infrastructure, Behavior, Traffic accident

1 INTRODUCTION

Many different studies have shown that elderly drivers are more frequently involved in specific types of accidents (e.g. situations involving more than one vehicle, especially at intersections).[1] Some results concerning the behaviour of different population groups, with respect to age, and safety of elderly participants in road traffic were reported. According to Blockey and Havley, older drivers have more error accidents and this tendency increases with age. An error accident is defined as the failure of planned action to achieve a desired outcome without the intervention of some chance or unforeseeable event.[2] In general, these studies consistently find correlation between crash rates and older driver's traffic safety: accidents are more likely to occur in good weather, during daylight hours, at intersection, while marking turns: their causes are not excessive speed or alcohol. These results show that the problem of older participant in road traffic on over-all safety is not negligible even today, while its importance will rise in future [1].

In general, in urban areas, there are many factors that contribute to the low level of traffic safety. One of them is certainly high number of intersections where drivers are changing their driving direction. This creates many trouble points. Another reason is high amount of information that participants should pay attention to, high number of signals allowing and forbidding something, and at the end there are too many vehicles of different types concentrated in a small area. But the authors of this article believe that the main reason for participation of the elderly in specific types of accidents is their lower psychophysical ability.

[1] Daigneault G., Pierre J., Frigon J., Previous convictions or accident and the risk of subsequent accidents of older drivers, Accident Analysis and Preventions, 34, Elsevier 2002
[2] Ib. 4, p. 260

Nonetheless, there is evidence that older individuals do compensate for their driving limitations by driving less frequently, and when they do drive, driving at lower speeds and during daytime hours.[3] Individuals eventually do decide to stop driving altogether, both because they recognize that they are likelier to cause an accident and because they themselves are likelier to be harmed should they be in an accident, regardless of fault. We need to know whether those older individuals who do continue to drive are riskier on average than other drivers.

2 CHARACTERISTICS AND TRAVEL BEHAVIOUR HABITS OF OLDER TRAFFIC PARTICIPANT'S

The physical and mental functions used at a traffic scene are classified. Eyesight and hearing are used by drivers to recognize their environmental situations. Judgment and reaction are functions for analyzing the recognized situations and reacting to the outcome. In terms of functions directly related to driving, the main factors seem to be eyesight, judgment and reaction. The major index for performance of the functions relative to judgment and reaction is reaction time. Judgment of information in the elderly slows down and becomes more incorrect. The reaction time of old people is 30% longer than that of young people (Yasuo Mori, 1995).

Elderly drivers tend to provoke accidents at intersections. They cannot properly act at intersections where more complex information handling and more appropriate judgment are required than in any other place. In the moment, collection of many environmental information (infrastructure, traffic situation), appropriate decisions, coordinated own movements and carrying out a safe maneuver is necessary. Another breakdown of intersection accidents revealed the fact that the amount of information to be recognized and analyzed for a left turn is greater than in case of other maneuvers. Intersections with unusual shapes could easily cause more pressure to old drivers, since their deteriorated functions face elevated necessities to handle complex information. Mostly, driving speed is reduced and movement "inconvenience". Such behavior the other drivers cause unexpected situation and increases the possibilities of traffic accidents [4,6].

Analyzing the driving characteristics of older driver on ordinary roads, it could be summarized:

- Their driving speed is slower.
- The space left between them and the vehicle in front is greater.
- The running position in the lane is more to the right.
- A tendency to drive in the outer line is common.
- Positioning on the curve section is more unstable.

Uneasy feelings experienced by elderly drivers during driving are "passing oncoming vehicle on a narrow road", changing directions, driving in a fast traffic flow and backward driving. The percentage of the uneasy feeling about passing oncoming vehicles on a narrow road especially increases with age. Heavy traffic volume and visibility of signals and signs are among the most frequent road conditions that cause them driving difficulties. The decline in the abilities of individuals that are important for safe integration into the traffic, it is difficult to control or measure. Often the older participants reduced ability try to substitute with

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3 Baldock et al.,Self regulation of driving and its relationship to driving ability among older adults, Accident analysis and prevention 38, 2006

experiences, but in today's rapid development and changing of infrastructure it is often impossible [5].

In Europe, the older drivers make in average per year between 5000 and 10000 km, for drivers, using just city road network even less.[4] If it is possible, they avoid time of "peak hours". For daily travelling they choose settled routes, mostly provide common travel behavior and repeated routes.

3 TRAFFIC SAFETY FACTS

Most important when discus a road traffic safety of older drivers is relative riskiness, emerge from a model of the probability of observing accidents. It should be assumes that older and younger drivers are equally mixed on the road and that older drivers are at least as likely to cause the accident as are younger drivers. The riskiest older drivers significantly limit how much they drive or choose not to drive at all so as to lower the risk they may cause property damage or injure themselves or others; older drivers do self-regulate [7].

Relative riskiness of older drivers can be defined as:

$$\theta_0 = \frac{\frac{A_0}{M_0}}{\frac{A_y}{M_y}}$$

where A_i is the number of accidents caused by driver type i (younger Y, older O) and M_i is vehicle kilometres travelled of driver type i. Thus relative riskiness measures how much likelier or less likely older drivers are than younger drivers to cause an accident per vehicle kilometre driven. Relative exposure could be defined as:

$$N_o = \frac{M_0}{M_y}$$

Older traffic participants are the second most risk group from the traffic safety point of view. Due to statistical data in Slovenia in period 2010-2011 10,1 traffic fatalities per 100.000 inhabitants is recorded in the age group over 60 years.

Analyzing traffic accident data in period 2010-2011 for Slovenia, statistically it is possible to expose traffic accidents where older people are involved.[5] Some accident data from analyzed period is presented in Table 1, including the participants in traffic accidents older than 60 years with their consequences.

Among those traffic accidents older drivers (over 60) incur responsibility in average for 10,2% of all traffic accidents. Significant is also level of injuries which mainly is higher comparing to other age groups. Between all participant modes involved in traffic accidents, number of car drivers is the highest.

4 www.epp.eurostat.ec.europa.eu
5 http://www.policija.si/index.php/statistika/prometna-varnost

Table 1: Involvement of older drivers in traffic accidents in time period 2010-2011

No. of persons involved			Dead		Serious inujuries		Other injuries		Uninjured	
	60+	% of all	60+	% of all	60+	% of all	60+	% of all	60+	% of all
2010	5.897	9,5	64	19,3	189	15,6	823	6,1	3689	6,5
2011	6.028	9,7	52	16,7	181	15,9	1012	6,4	4431	6,9
all persons involved in accidents										
No. of persons responsible			Dead		Serious inujuries		Other injuries		Uninjured	
	60+	% of all	60+	% of all	60+	% of all	60+	% of all	60+	% of all
2010	4.103	9,9	31	17,5	91	14,1	275	5,9	2292	7,7
2011	3.973	10,5	23	12,4	123	12,3	308	6,2	2751	8,4
persons that caused those accidents										

Source: (www. policija.si/index.php/statistika/prometna-varnost)

In year 2006 on purpose to establish how safe fill older drivers in different types of road intersections, the research was made. In same Slovenian cities (small, middle and large size) the research was repeated. In last year's lot of different novelties were made in road infrastructure. As known, older road participants need more time to get used to those new situations. Taking into account, older drivers for daily migrations use, if it is possible, same always same roads, it was expected there filling of safe is better compare to the questionnaire, made in year 2006.

In questionnaire 300 coincidental chosen traffic participants were included, aged over 60 years of both genders. More than 66% of inquiries participate in traffic every day, 29% few times per week. About 25% already have been involved in traffic accident, 82% of them once, 16% twice, and 2% three times or more. More than 67% of all this accidents happened in intersections. Older traffic participant's opinion about knowing novelties concerning traffic is that 80% are well known, and 20% badly or poorly know them. Compare to results from 2006, their estimation is better. According to different traffic modes of participation, we analyzed again inquiries opinion about "feeling safe" in various types of road intersections (non-lighted, traffic lighted, one-lane roundabout, two-lane roundabout). Most difficulties from the traffic safety point of view for older traffic participants are still in the connection with non-lighted road intersections. Still the most safe they feel in one-lane roundabouts and traffic-lighted intersections and less safe in two-lane roundabouts and turbo-roundabouts. The percent of answers about non-lighted road intersections as unsafe was the same as in year 2006, the largest difference is detected in opinion of roundabouts. Older people compare to year 2006 fill them safer. Still the main reasons of unsafe non-lighted road intersections are priority enforcing, poor visibility, inappropriate traffic signalization, ignoring of regulations and rules especially at the time of traffic jams.

To achieve the characteristics of traffic accidents in which older car drivers are involved in analyzed period, accident data were researched and on-situ investigations were made in two cities: large and middle size.

Input data for research were: date and time of accident, injury level, role of accident participant, age, road type, road stationing, accident cause, accident description, and road and environment condition.

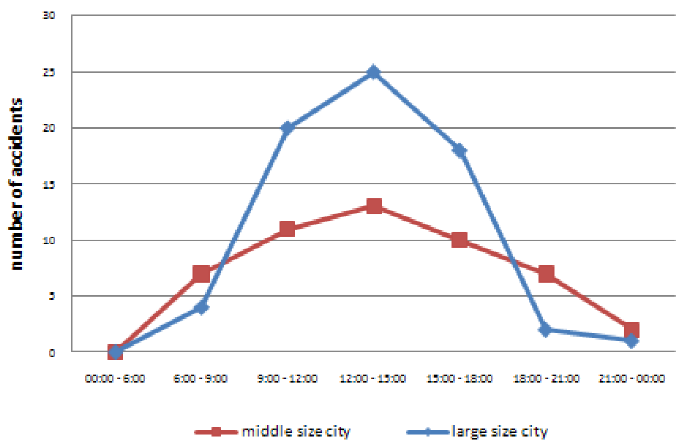

Figure 1: Day-time of accidents in correlation with the number

For all accident spots on-situ the characteristics of road infrastructure elements, signalization, visibility traffic conditions and structure were investigate.

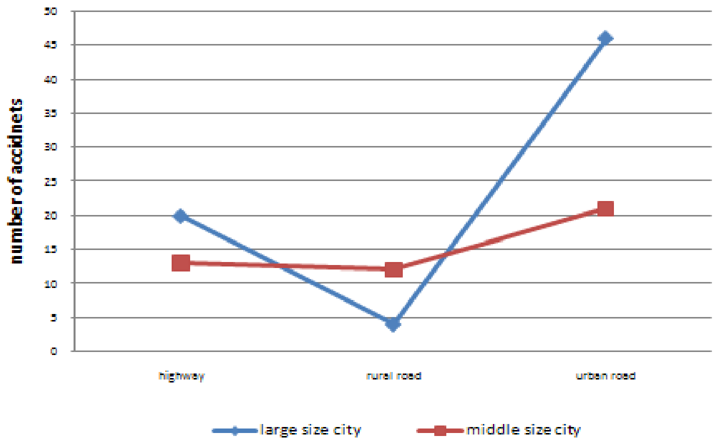

Figure 2: Road type of accidents for large and middle size city in correlation with the number

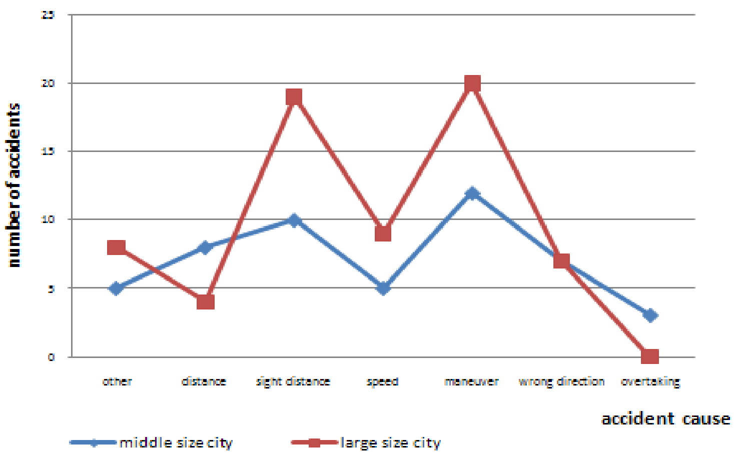

Figure 3: Accident cause in correlation with the number for large and middle city

According to traffic system approach, the focus was on researching the relations between road infrastructure elements and traffic accidents (driver behavior) on pre-crash phase. Main purpose was to find in different accident spots the similarity of infrastructure elements, potentially caused the inappropriate behavior of older drivers. It is found out that most accidents happened in non-lighted intersections in day-time, on traffic peak hours. In middle city, the number of accidents in urban roads is a bit higher than on highways and rural roads. On urban roads the number of accidents in large city is nine times higher than on rural roads and lower on highways than in middle size city. In both cities the main cause for traffic accident is wrong maneuver and sight distance.

Intersections continue to represent crash-prone locations on a transportation network. When approaching intersections, drivers are confronted with a complex driving task that includes observing and responding to traffic control devices, reacting to these devices, reducing speed, executing turns, observing and reacting to pedestrians and cyclists and avoiding conflicts with other vehicles. For older drivers with reduce capability, coordinating that tasks could be a problem compare to other age group of traffic participants.

Figure 4: Accident spot: high speed in main roads – dangerous maneuver of inclusion/exclusion to/from main traffic flow

On-situ investigations in intersections with accidents record – foundings:
Problem in non-lighted intersections:

- Inadequate visibility angle with regard to speed limit in main road.
- Incomprehensible or too many traffic signs.
- Connection to main road in curve.
- Visibility – lighting.

Figure 5: Accident spot: inadequate visibility, high speed in main roads – dangerous maneuver of inclusion to main traffic flow

Problems in multilane intersections:

- High speed in main road - older driver's reaction time is longer, due to reduced motorical abilities the maneuver of inclusion to the main road or turning left to minor road became dangerous (specially in peak hours when traffic density is high).
- Infrastructure, signalization and guidance of cyclists and pedestrians in intersection area.

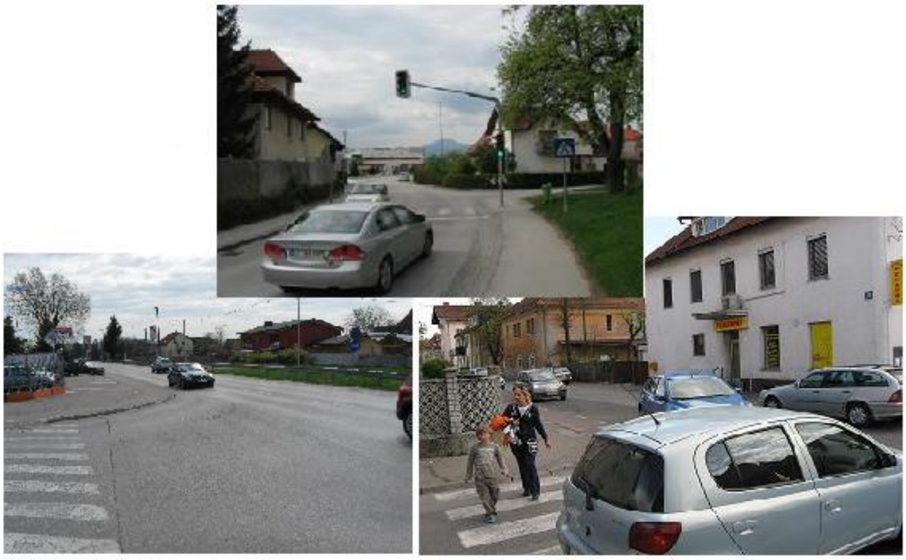

Figure 6: Accident spots: inadequate visibility angle, connection to main road in curve (combine with high speed in main road)

Safe system aims to reduce the number of crashes, and should the crash occur, reduce the severity of injury through the management of safer users, safer roads and roadsides and safer vehicles.

Safer users: comply with speed limits, comply with road rules, using in-care safe equipment, not to be affected by alcohol and drugs.

Safer roads and roadsides: speed limits to match infrastructure, roads and roadsides designed to highest safety standard practicable.

Safer vehicle: vehicle manufactured featuring high standard safety features.

The methodology used to investigate traffic safety as system raze simplification of traffic safety problems and the naïve conclusions that approximately 90% of all crashes attribute to driver "error" and improving driver behavior will result traffic safety improvement. The simplistic presentation of traffic safety disregards the dynamic interaction between the road environment, vehicle and road user. Such approach result non-optimized solutions. Development progress in traffic safety approaches is chain-of-event approach and the understanding that each traffic accident is consequence of "accident process", caused by connecting coincidental factors in the system. Breaking a single link in chain could prevent an accident.

In traffic safety system matrix, that is the most important correlation. For older driver complicated traffic situation that requires quick reaction present even travelling outside the standard route, being faced with high demand and, consequently to feel unsafe. In the moment, collection of many environmental information (infrastructure, traffic situation), appropriate decisions, coordinated own movements and carrying out a safe maneuver is necessary.

4 CONCLUSIONS

According the fact, the population aging increase with years, to ensure traffic safety initiatives for older road users must be included into the road safety plan. This action plan based on a safe system approach that calls for programs aimed at road, vehicle and users. Safety improvements are implemented through revised design standards for roads and roadsides for construction and maintenance activities. The information from accident spots and crash analysis applies the countermeasures to locations, particularly intersections, with similar characteristics.

Further research on older drivers safety in Slovenia will base on Haddon matrix, analyzing the environmental factors in pre-crash phase, in additional in depth research the impact of road design and layout elements, speed limits and pedestrian/cyclist facilities will be made.

Additional in situ research will be made in different environmental conditions to consider various impacts to traffic safety.

Using statistical methods and T distribution (because of small data sample), the correlation between traffic safety and road elements will be evidenced.

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ECONOMIC INFLUENCES OF GENERAL AND BUSINESS AVIATION ON THE DUBROVNIK AIRPORT MANAGEMENT

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ABSTRACT

Civil aviation today touches nearly every aspect of our lives, and its success will, to a great degree, shape our society and its economy over the next decades. This paper will analyze the impact of general and business aviation traffic on the Dubrovnik Airport. The primary goal will be to define economic influences on airport management. There will be statistics about the movement of general and business aviation at the airport, to define key parameters and detailed explanation of their movements. Special attention will be paid to the direct and indirect impacts of general and business aviation on the airports and their surrounding areas.

Keywords: Impact, case study, general aviation, business aviation, airport management

1 INTRODUCTION

Dubrovnik Airport is situated on the southern part of Croatian, 13 km southeast of Dubrovnik. With a turnover of 1,500,000 passengers a year, this airport is the second largest in Croatia [11]. It is assumed that the gravitational area of the airport covers a circle radius of 200 km. It includes the area of Dubrovnik – Neretva County (HR), region of Herzegovina (BiH), Trebinje area (BiH) and Herceg Novi area (MNE). Total area is inhabited by 380,000 residents. For the development of this airport it's especially important Dubrovnik – Neretva County, because of touristic potential.

To establish a high quality tourist services is very important to have good transport infrastructure and transport facilities. Dubrovnik area is very attractive tourist destination, but one of the preconditions for the realization of the tourism development strategy is appropriate transport infrastructure, transport facilities and organized transport processes which are consistencies with the tourist requirements and demands for quality services. [2]

Business aviation is defined as all kind of aviation other than military and commercial aircraft liners. It provides more than a billion dollars of business activities, providing employments for more than one billion people, economic growth for thousands of cities and business entities all over the world [1]. There are more than 400,000 business aviation aircrafts in the world [6]. These aircrafts range from light two – seater training planes to transcontinental private jets. It is important to point out that more than two thirds of general aviation flight hours are achieved in business purposes. The goal of general aviation aviation is to provide efficiency, practicality and attainability [1]. To estimate the potential of general aviation air traffic demands it is necessary to analyze economy impact, of general aviation at total economy impact of Dubrovnik Airport.

2 TRAFFIC ANALYSIS ON DUBROVNIK AIRPORT

2.1 Passenger traffic and number of operations

In 2012 Dubrovnik Airport recorded 1,480,549 passengers in 16,216 aircraft operations. Compared to 2011 this is 10% increase of total passenger traffic. Increase of international passenger was even more significant with growth of 13% comparing with year before. This is the largest turnover in the fifty-year history of Dubrovnik Airport what makes 2012 the record year.According to the number of passengers, Croatia Airlines is on the first place with 408,399 passengers (26% of total passenger traffic at Airport), followed by Easy Jet (10%) and Monarch (5%). Among other carriers Lufthansa, British Airways and Austrian Airlines stand out with 4% share. All other carriers participate with less than 3%. Compared to 2011 number of flights has increased for 1% in 2012. Most of the flights were scheduled flights (67%) while charter and general aviation flights participated with 13% and 20%. In 2012 there was an increase of low-cost airlines passengers. Their share in total number of scheduled flight passengers increased from 23% in 2011 to 28% in 2012. [11]

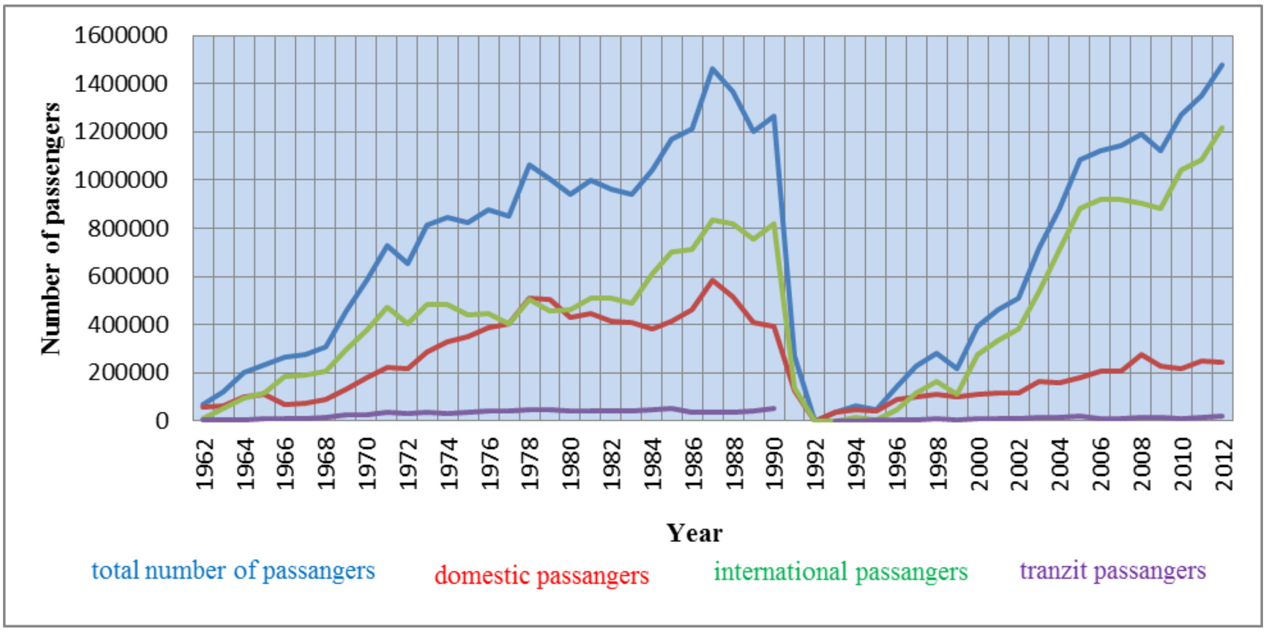

Chart 1: Number of passengers for the time period 1962 – 2012

Source: Statistical data Dubrovnik Airport

In 2012 Dubrovnik Airport has provided services to one of leading European and World private aviation company, Netjets. Successful collaboration is achieved with Flight & Ground Support providers Universal Aviation, JetEx, Jeppesen and Euro Jet Intercontinental.In the last few years, Dubrovnik Airport constantly records the growing number of airlines. During 2011 airport services were used by 53 airlines, in 2012 by 57 airlines, while at 2013 more than 60 airlines are expected [11].

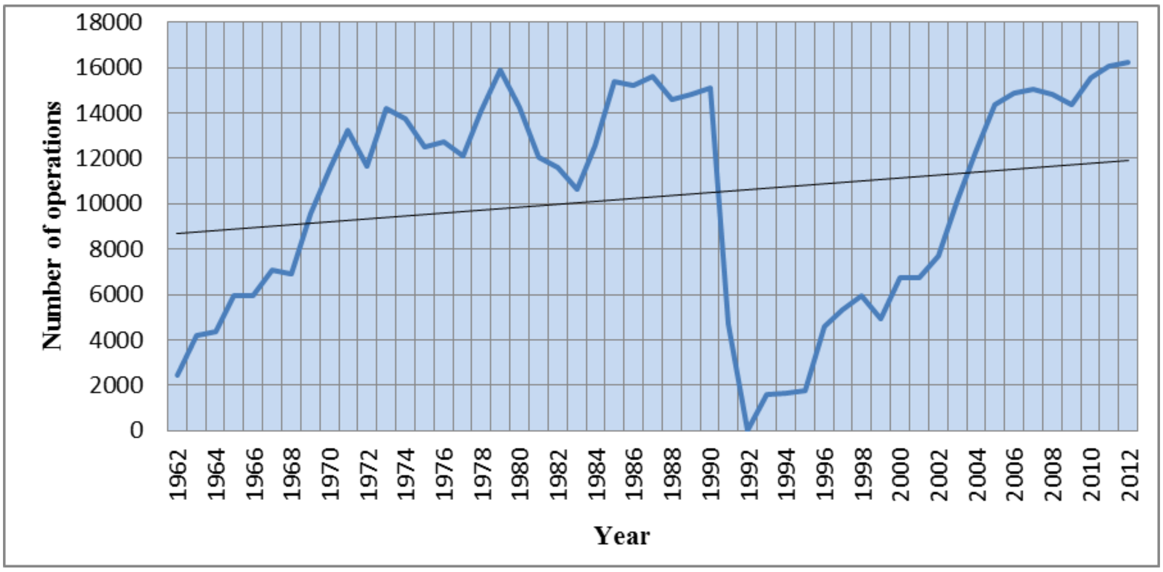

Chart 2: Number of operations for the time period 1962 – 2012

Source: Statistical data Dubrovnik Airport

2.2 Analysis of general aviation at Dubrovnik Airport for the period from 2008 to 2012 with emphasis on business aviation

Dubrovnik Airport annually handles approximately 6,000 general aviation passengers and has an average of about 3,400 operations related to general aviation. Compared with year 2012 when 4,382 passengers were served, in 2004 total 6,900 passengers passed through. The reason for this fall could rely partly to the economic situation that happened as a consequence of the global economic crisis. [1]

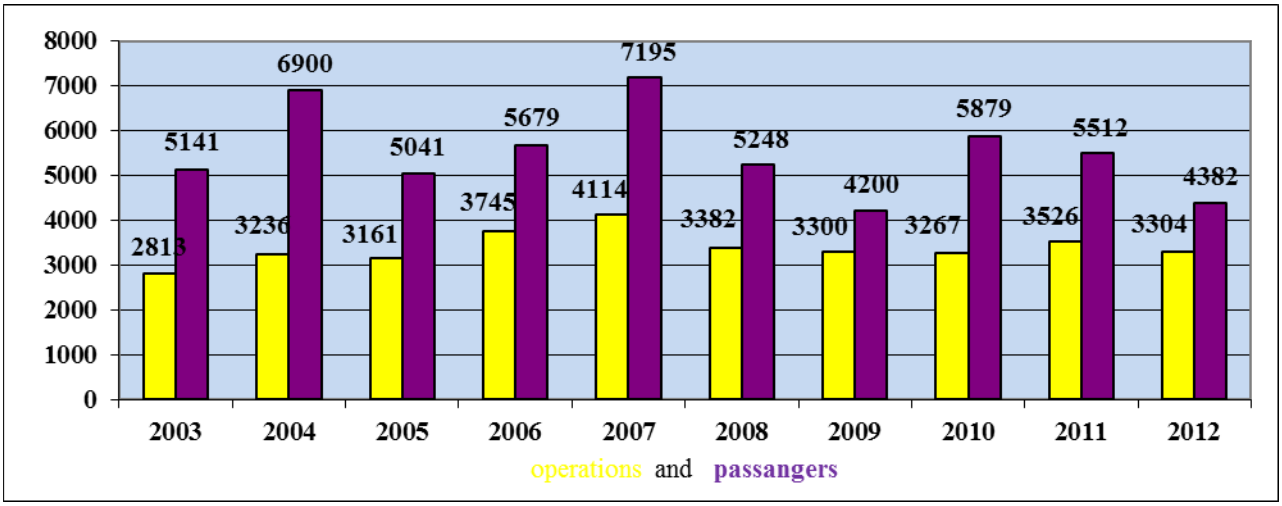

Chart 3: The total number of operations and passengers in business and general aviation at the Dubrovnik Airport for the time period 2003-2012

Source: Statistical data Dubrovnik Airport

Accelerated development of general aviation which includes business aviation traffic at the Dubrovnik Airport as well, begins in year 2003, when the number of operations started to increase rapidly. In these operations total number of 5,141 passengers was recorded with maximum of 9,900 in 2004. As a consequence of the economic crisis in 2009 the number of passengers declined to 4,200. The 95% of all flights that concern business aviation at the Dubrovnik airport is achieved during touristic season. The rest of the flights are related to transit (technical landing) and training flights. This analysis gives us an overview of the operations by the type of plane and number of passengers for the business aviation and other general aviation in the period from 2003 to 2012. [1]

Dubrovnik Airport annually serves over 1,400,000 passengers. There are about 16,000 landing and takeoff operations. The 21% of the total number of operations applies to general and business aviation (2,400 in international traffic and about 900 on domestic flights).

Table 1 show the comparison of business aviation traffic during the tourist season (June, July and August) since 2008 to 2012 year. The table also shows number of passengers in domestic and international arrival and departure. The total number of arrivals and departures on domestic flights for the last three years is 579 arrivals and 494 departures. In parallel with international traffic, where is achieved 3,967 arrivals and 4,279 departures.

These data demonstrate the importance of international business aviation traffic at the Dubrovnik Airport. The reason for such large difference between domestic and international arrival/departures is increased interest in Dubrovnik and the surrounding area as a tourist destination. Economic crisis that hit the Republic of Croatia had a direct impact on local traffic and is cited as the major cause of falling turnover.

Table 1: Comparison of business aviation operations in the domestic and international traffic at Dubrovnik Airport

The number of operations on domestic flights					The number of operations in international traffic				
0-2.25t	2.25 - 5.7 t	5.7 - 10t	10 - 50 t	50 <t	0-2.25t	2.25 - 5.7 t	5.7 - 10 t	11 - 50t	51 < t
2008.									
Domestic passengers arrivals / departures			24/24	June		International passengers arrivals / departures			414/300
48	11	8	13	0	83	72	50	118	8
Domestic pax arr/ dep			54/52	July		International pax arr/ dep			361/425
85	24	28	17	0	133	88	114	183	8
Domestic pax arr/ dep			68/59	August		International pax arr/ dep			508/605
87	27	23	13	0	179	122	165	218	0
2009.									
Domestic pax arr/ dep			17/44	June		International pax arr/ dep			293/254
48	14	3	5	0	84	64	80	186	0
Domestic pax arr/ dep			54/58	July		International pax arr/ dep			194/134
80	17	14	13	0	107	93	103	201	0
Domestic pax arr/ dep			49/38	August		International pax arr/ dep			410/363
56	15	7	6	0	132	98	145	189	0
2010.									
Domestic pax arr/ dep			103/42	June		International pax arr/ dep			696/907
62	18	13	12	0	80	43	70	126	0
Domestic pax arr/ dep			114/76	July		International pax arr/ dep			456/467
120	31	16	20	0	98	86	109	176	0
Domestic pax arr/ dep			42/53	August		International pax arr/ dep			459/604
110	45	33	21	0	116	91	118	212	6
2011									
Domestic pax arr/ dep			18/17	June		International pax arr/ dep			206/229
54	24	15	13	88	50	75	132	0	
Domestic pax arr/ dep			78/102	July		International pax arr/ dep			564/608
116	33	19	20	102	91	110	174	0	
Domestic pax arr/ dep			49/40	August		International pax arr/ dep			478/492
116	48	39	26	123	103	127	217	0	

2012									
Domestic pax arr/ dep			36/40	June		International pax arr/ dep			264/199
70	28	20	24	97	63	84	137	0	
Domestic pax arr/ dep			86/82	July		International pax arr/ dep			503/369
79	18	13	14	107	94	105	205	0	
Domestic pax arr/ dep			53/42	August		International pax arr/ dep			341/404
71	19	15	13	135	98	143	187	0	

Source: Statistical data Dubrovnik Airport

3 ECONOMIC INFLUENCES OF GENERAL AND BUSINESS AVIATION

Research conducted by the London Business School in mid-'90 found that companies which have been using business jet aircraft achieved 11.3% better results than the average companies [5]. Another study performed by the Arthur Andersen firm showed that among the 766 best companies on the European market own the business jet [5]. Business aircraft allow the user greater flexibility than aircraft in scheduled air services mainly because they fly on their own schedule at those airports that are close to the final destination of passengers. One of the main advantages of these aircraft are considerable savings in travel time. One can say that the job "stops" when flying aircraft on scheduled routes. Conversely, flight with business jet is some kind of office in the sky which allows smooth functioning of business, meetings or reports to clients and colleagues while flying. Business aviation is a now very important instrument on the side of big corporations that lead their business in a highly competitive environment where time is a decisive factor in the successful business completion or loss.

Table 2: Number of operations for 20 most common general aviation aircraft at Dubrovnik Airport according to maximum takeoff weight (MTOW)

2009		**2010**	
Maximum take off weight	**Operations**	**Maximum take off weight**	**Operations**
0-2250 KG	314	0-2250 KG	201
2250-5700 KG	120	2250-5700 KG	81
5700 KG-10 T	120	5700 KG-10 T	189
10 T-25 T	158	10 T-25 T	190
25 T - 50 T	45	25 T - 50 T	97
> 50 T	0	> 50 T	0
TOTAL	757	TOTAL	758
2011		**2012**	
Maximum take off weight	**Operations**	**Maximum take off weight**	**Operations**
0-2250 KG	161	0-2250 KG	125
2250-5700 KG	67	2250-5700 KG	81
5700 KG-10 T	138	5700 KG-10 T	131
10 T-25 T	170	10 T-25 T	192
25 T - 50 T	186	25 T - 50 T	144
> 50 T	0	> 50 T	7
TOTAL	722	TOTAL	680

Source: Statistical data Dubrovnik Airport

Table two shows the number of operations for the 20 most common general aviation aircraft types to according to maximum takeoff weight (MTOW). As noted in the table operations of aircraft with maximum weight less than 2.25 T is decreasing while in the same time number of operations performed by aircraft from 10 T to 25 T and 25 T to 50 T is increasing. Although in last four years aircraft heavier than 50 T still hasn't been recorded among the top 20 general aviation aircraft at the Dubrovnik Airport. From operational point of view, such a small number of these aircraft doesn't make greater demands for the airport. On the other hand, from an economic point of view, represent a significant contribution.

Table 3: Aircraft handling services according to Dubrovnik Airport Tariff Regulations

Basic services	**Count**	**Extra services**	**Count**
The fee for the landing and take-off	MTOW	Parking	MTOW
Traffic service	NUM	VIP service	PAX
Technical service	NUM	Transfer of pax and crew	KM
Using the operating area	NUM	De- icing of aircraft	NUM
Passanger tax	PAX	Other services	NUM
Using the infrastructure for traveler	PAX		
The fee for service of protection	PAX		
Fees for people with disabilities	PAX		

Source: Dubrovnik Airport Tariff Regulations

Primary business activity of each airport is aircraft handling. Handling fee is calculated by tariff regulations issued by Airport Authority [5]. These regulations are open for the public and can be found on the airport official website. Handling fee is formed for each particular handling before the departure flight and includes charges for the number of handling services (landing, takeoff, loading and unloading of passengers and goods, the use of airport infrastructure, etc.). Other services which may or may not be the part of aircraft handling, but are included in handling fee are: aircraft parking, land transport for crew and passengers, aircraft cleaning, etc [6]. Table three shows basic and extra services which are included in handling fee with corresponded measuring unit.

As already noted general aviation participates approximately with 21% of operations and 0.3% passenger turnarounds in total traffic of Dubrovnik Airport. However, these two numbers are not sufficient to clearly determine the impact of business aviation on airport revenue or management. The reason is big difference between the type of aircraft, number of passengers and used services on general aviation flights opposed to those on the conventional aviation flights. For example, if we take the number of conventional flight, number of passengers and weight of the aircraft, we get that average weight of the aircraft is from 68 T to 83 T, and the average number of passengers from 104 to 108. Average turnaround time for conventional carriers is relatively short (40 min) and except from in exceptional cases (long delays, errors, bad weather, etc.) there is no additional services. In the same time average turnaround time for business plane carriers is usually over one hour. Table four shows example of handling fee made in accordance with tariff regulations for the A319 aircraft with 105 passengers (cabin occupancy 80%).

Table 4: Calculated handling fee for the aircraft A319 (flight with an average number of passengers)

Services	Count	Price in EUR	Total
The fee for the landing and take-off	64	12,70	812,80
Traffic service	1	386,00	386,00
Technical service	1	578,00	578,00
Using the operating area	1	90,40	90,40
Passanger tax	105	11,00	1155,00
Using the infrastructure for traveler	105	1,00	105,00
The fee for service of protection	105	2,00	210,00
Fees for people with disabilities	105	0,25	26,25
Total:			3363,45 EUR

Source: Dubrovnik Airport Tariff Regulations

Unlike conventional carriers, on business aviation flights there are significant fewer passengers (two passengers per flight) [11]. Because of this the impact on airport passenger traffic is negligible. Also, there is major deference in composition of the aircraft fleet; maximum weight of the aircraft varies between several tons to several hundred tons. Nevertheless, the most significant difference is that the business carriers use significantly more additional services. First, business jets usually park aircraft for few days. This is important because it has significant impact on the apron capacity. Also, business carriers prefer for land transport of crew and passenger airport ground transportation. According to the profile of business jet passengers, business carrier very often books VIP service for its passengers. This is service which conventional carriers very rarely use. For all these reasons, the average handling fee for business aviation aircraft is divided into several categories, depending on the weight of aircraft itself (Table five). Chart four shows share of general aviation in total calculated theoretic revenue (calculated according to tariff regulation) at Dubrovnik Airport.

Table 5: Average handling fees for general aviation aircraft according to MTOW

Maximum take off weight	Average price (EUR)
0-2250 KG	53
2250-5700 KG	160
5700 KG-10 T	333
10 T-25 T	1333
25 T - 50 T	2000
> 50 T	4400

Source: Statistical data Dubrovnik Airport

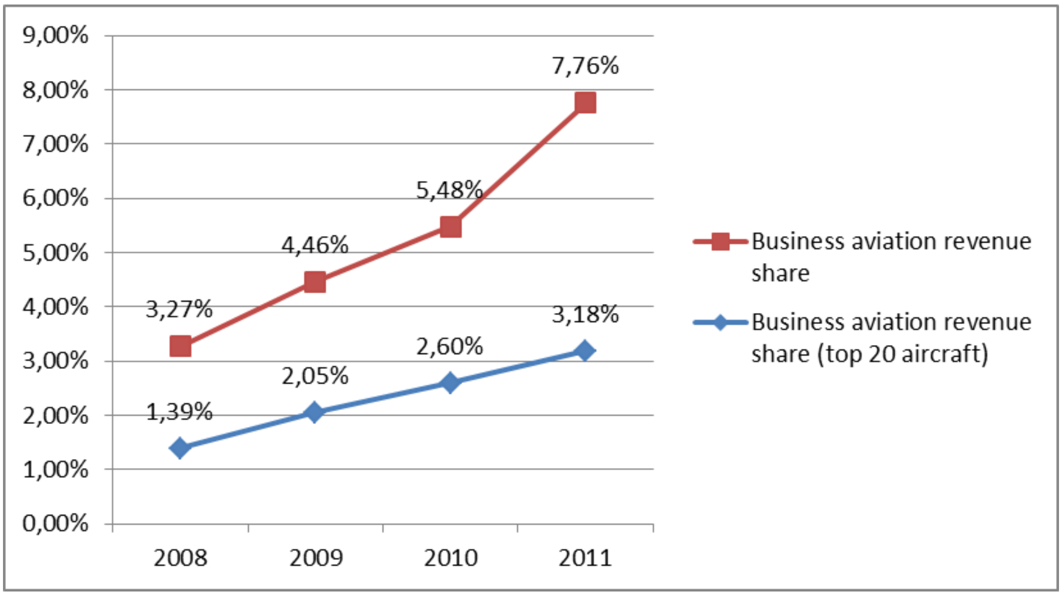

Chart 4: Calculated (theoretic) share of business aviation in total Dubrovnik Airport revenue for the time period 2008-2011

Source: Statistical data Dubrovnik Airport

4 CONCLUSION

Dubrovnik Airport like any other Mediterranean airport has problems with significant differences in traffic demands through the year. Between summer and winter traffic there are major differences; summer demands are to ten times higher. Reason for that is small local community which does not generate significant traffic. Meanwhile at summer tourist travelers generate several times higher traffic. The difference between busiest month in the year and month with lowest traffic in average is five to one.

The development of business aviation and other segments of general aviation depend primarily on capital investments in the Dubrovnik Airport gravitational area. Benefits for development of this aviation at Dubrovnik Airport are runway capacity, the available number of parking spaces for business aviation aircraft, technical support and navigation aids.

The use of business aviation allows new business connections to be made quickly and efficiently, which accelerates the process of investment and the conduct of business relationships. Business aviation contributes direct, indirect and induced impact on Dubrovnik Airport revenues. Traffic generated by this aviation is important to Dubrovnik Airport because of 21% share in total number of operations regardless small share of 0.3% in passenger turnarounds. This is because handling and other fees mostly depends on aircraft maximum takeoff weight and number of operations. Also, business aviation companies and clients use number of additional services that are not preferred by conventional airlines. Thank to this average fee for handling business plane is very close to average aircraft handling fee at Dubrovnik Airport.

Although business aviation promotes high-end tourism in this part of Croatia the impact of it goes beyond numbers. For many communities at the Dubrovnik area it is opportunity to connect important clients to urban centers of Europe.

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THE SPECIFICS OF THE MARKET SEGMENTATION IN THE SEAPORT MARKETING

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ABSTRACT

As a service organization seaports have used the undifferentiated marketing approach to the market for a long time. Modern processes of privatization, deregulation and globalization abolish monopolies and impose the need for market segmentation rather than aggregation. Extracting market segments is very useful in finding opportunities for growth. However, many ports use this tool in their strategic planning very modestly. The starting point in the consideration of market segmentation in this paper is to establish two general levels of segmentation: a) the level of mass marketing, and b) micromarketing. Three main approaches in detecting market segments and measuring differences between them are considered in this paper. These approaches are the a priori, post hoc, and combined, the so-called hybrid model. Based on the research of the Adriatic, Aegean and Black Sea seaports, in this paper are defined target users in the maritime logistics chain, as well as the possible basis of market segmentation in order to develop more efficient positioning strategies of the investigated seaports.

Keywords: Seaport, B2B marketing, segmentation, positioning, strategy, customers, seaport actors, marketing mix

1 INTRODUCTION

Modern ports are characterized by specific proprietary relationships, efficient processes of transhipment, information support to the management processes, developed concept of a corporative culture, along with expanded range of port services and functions, sustainability and reliability. The aim is to ensure better conditions for the promotion of new infrastructure investments and various industries sustainable within port systems. Port management worldwide invests great efforts for the sake of maximizing profit, maintaining or increasing market share, but in the conditions of very dominant competition and pure survival. There is an evident narrow specialization coming exclusively from the request for rationality, efficiency and effectiveness in management, as well as productivity of work and applied technology. Private capital share in the infrastructure development in addition to delivery of services at terminals, have expanded the basic concept of port services, altogether imposing a crucial question: "Who are the subjects that make a final decision with respect to the choice of a concrete port, and which crucial factors of competitiveness determine that choice?"

Over last years, the problem of competitiveness of maritime ports has been drawing attention in scientific and professional circles. Many concepts have been applied with the aim of a comprehensive approach of a trend of including ports into logistic chains of delivery value. In conditions of global economy, port management faces with the challenge of sustainable development of maritime ports. In addition, it is necessary to explore as many aspects of this development as possible: economic, technological, ecological, engagement of wider community into port development and alike. It is of prime importance to pay attention to the marketing aspects of mission which is carried out by maritime ports on a daily basis, focusing above all on the needs, requirements and preferences of the users. The strategies of market segmentation, the choice of a target market (segments), differentiation of offer, positioning and repositioning, present the aim of modern target marketing in maritime ports management.

Positioning is defined as a management process within an organization aimed at developing the positioning strategy at the organizational level, in order to make the organization different in the mind of target segments compared to other product/service providers in the market. Therefore, positioning is considered as the key component of the process of strategic marketing planning, aligned with the aims of the organization, inner resources and external chances from the market [9, p. 29]. Having in mind the character of the consumers and activities, it may be stated that ports are characterized by the principles of B2B marketing. In this view, the basic steps in positioning on the business market, applied to the ports are as follows: a) identification of groups of business consumers with similar needs and behaviour in the usage of port services and their allocation on market segments, b) assessment of power and capability of a seaport with regard to the needs of segments and competition situation, evaluation of a future attractiveness and final choice of segments to be targeted, c) determining the position of the seaport, and d) development of 7P marketing programme, its efficient communication and delivery to the targeted market which will enable to achieve a distinctive image and position on the market [7, p. 106].

The subject of research in this paper is definition of a strategy, selection and application of appropriate ways and bases for a successful segmentation of the markets of the Adriatic, Aegean and Black Sea ports. Namely, these ports belong to the geographically separated areas, but in view of competitiveness, they make a part of the same gravitational market. On the basis of the results of needs analysis of the users of these ports, macro and micro segmentations are sorted out.

2 BASES OF MARKET SEGMENTATION

A basic presumption in developing market segmentation strategy in maritime ports marketing is discovering heterogeneity, but also the homogeneity of needs and wants of the individual groups of consumers. This concept appeared in literature in 1956 [15, pp. 3-8], whereas today market segmentation is considered to be among very important marketing concepts. Each consumer may be potentially separated market, having unique needs. However, having in mind the level of investment in the construction of port capacity, it is reasonable that realization of a rentable business is a basic financial aim of the port, and that it is unreal to expect from the ports to create marketing mix for each consumer individually. According to research, less than 5% of business plans contain useful information obtained by market segmentation [20, p. 198].

Starting point for considering market segmentation is a determination of two general levels of segmentation: a) when there is no segmentation at all, implying a mass marketing level, and b) micromarketing, with four possible levels, i.e. levels of segments, niches, local areas, and individuals [10, p. 240]. The choice of real option for strategy of market segmentation is a very complex question, having in mind the fact that ports operate on an international level. The level of segments implies larger groups of port services consumers. The level of niches relates to consumers with very specific demands. The level of local areas is very practical for ports as it relates to geographically identifiable groups of consumers with peculiar needs and requirements. The level of individual consumers of the port services is becoming more and more popular, therefore, the port management needs marketing knowledge in order to answer the challenges of globalization and technical and technological progress.

The strategy of market segmentation is not only attributive to the traditional markets of business and final consumption but also to the markets of various services. In general, the marketing segmentation in the maritime ports marketing resembles the segmentation of business services market to which the principles of a strategic and international marketing apply. Key support to the segmentation strategy is the process of market research providing general information about consumers (e.g. geographic and demographic data and alike). Thanks to the application of this very important marketing discipline, attitudes, opinions, expected benefits from services and other criteria explaining the ways and behaviour of the service consumers have become dominant over time. There are three main approaches in discovering market segments and measuring difference between them. These are a priori and post hoc approach, and the combination of the two, the so-called, hybrid model [7, p. 110].

A priori is a classic approach taking as a basis for segmentation easily distinguishable segment features, after which collection of additional data is to be undertaken. *Post hoc* is based on the market research and is opposite to the classic principle. The number of segments and sizes are not identified in advance and the features according to which the segmentation is done are not exclusively simple, they are rather based on the real needs and preferences of the consumers. Enforcement of this approach starts from the real behaviour of a consumer. What follows, then, is identification of similarities and differences between consumers, and ends with forming out groups of consumers based on as homogenous as possible features of segmentation. The third approach is defined as a hybrid model, as it is first carried out *a priori*. After basis is formed in such a manner, the process of segmentation based on a *post hoc* approach is being carried out.

Market segmentation is a phase process, regardless of the approach it takes. Phases in this process are: a) qualitative research, b) quantitative research, c) analysis, d) confirmation of validity, and e) profilization [11, p. 414]. The aim of the qualitative research is to, by applying interview techniques on the focused groups, examination interview or repertory grid techniques, establish consumers' motivation, attitudes and behaviour. Quantitative research uses sampling and statistical techniques aimed at measuring and ranking attitudes, awareness, consumers' wants, etc. In the analysis phase, data collected by means of qualitative and/or quantitative research undergo one of the specific analyses, for example, factor, cluster, etc. Confirmation of validity is a step before the very profilization of the groups of consumers and represents the phase in which it is verified whether the segments obtained in the analysis are real, and whether it necessary to undertake additional research and analysis. In the profilization phase, the identified groups of consumers are described and they are assigned the name associated with the common characteristics. For example, there may exist buyers „organizers”, „explorers”, „good”, „bad, etc.

In general, maritime market is characterized by the existence of various numbers of participants and their interests. First of all, this is the case with the ports, customers, supporting industries, government authorities, international regulative bodies, etc. Of the most complicated challenges of port management is defining relevant market and segments which are measurable, available, profitable, different and operative [10, p. 262]. This task is not under the jurisdiction of employees in marketing and/or the market research sector, but it should be rather incorporated in business politics and equally important on business levels.

Literature offers scarce resources in which the processes of market research, segmentations and choice of targeted market for the needs of making marketing decisions in maritime ports are adequately and directly tackled. McGinnis's research is indirectly related to ports, being realized for the purpose of developing segments on the cargo market based on the shippers' attitudes, and having direct implications on the marketing activities of carriers in maritime transport [12, pp. 58-68]. Chin-Shan suggests market segmentation in the field of activities of international distributive centres. Key emphasis in the segmentation is on the needs of shippers, forwarding agents, charterers, importers and exporters. In addition, it comes as a conclusion that customers take the safety of cargo as the most important attribute of services offered by distributive centres, followed by: service of cargo tracking, inside transport and customs. These service attributes are used for the classification of customers of the international distributive centres into three segments: a) the customers oriented toward cargo consolidation and storage b) the customers oriented toward cargo related services, and c) the users oriented toward supporting services [5, pp. 49-60].

Market segmentation in the seaport marketing, apart form the indirect, is also carried out in a straightforward manner, primarily in the view of analysis of the port hinterland in the geographic and wider economic sense. Market research has been conducted so as determine size (in the geographic sense) and strength (according to the economic indicators) of the hinterland. Certain authors detected a relation between port and hinterland in a way that the port's position on the market is not exclusively determined by coastal conditions, but also a developed hinterland [19, p. 84]. By definition, the market explored in the seaport marketing is a concrete region providing regular and fixed resources of goods/cargo, as well as the cargoes is much more economical to transport across the region connected to that port [18, p. 1264]. This market is defined according to the node points (e.g. economic centres in the hinterland), according to networks (channels), objects of transport (e.g. economic centre for energy, material, information and alike). There are three ways of segmentation in the seaport marketing [18, p. 1264]: a) division of the market according to the geographic range (reach), b) division according to the cargo, and c) division according to the consideration of comprehensive factors such as Wilson's and other models.

In the first case, primarily by means of administrative-divisional and economic-regional criterion, geographical comprehensiveness of the market is intuitively determined, whereas the basic drawback is the fact that not much space is left for further segmentation within such a defined market. However, such a method in segmentation is useful for macro analyses and prognoses and anticipating movement on the port services market.

In the second case, it is much simpler to calculate and collect data on the cargo, but it is difficult to reflect the situation on the total cargo transport without falling into the track of one-sidedness, that is, the analysis of certain types of cargo. The third way is recognized as the most rational one, given that in the course of market segmentation, all relevant variables are taken into account.

3 THE DEFINITION AND TYPES OF SEAPORT SERVICE USERS

Ports provide a wide range of services, daily enriched by new, primarily added-value services, then tourist and hospitality industry services, rental of port areas etc. External environment, technological influences and customers' requirements are changing the traditional port role in the logistics chain. Port and support businesses operate in the conditions of globalization, containerization and technological progress, leading towards new partnership forms, increased concession part in port service providing, different public policies of ports, development of new strategies in search for growth and development and similar.

All the above stated have been influencing the reorganization of the ports, thus several concepts featuring modern ports can be systematized, as follows [14, p. 2]: a) ports as elements in value delivery chain, b) port co-opetition, c) globalization of port operations, d) introduction of private capital into operational business at container terminals, e) regionalization of ports, f) *intra-port competition* concept, g) management models and modern port organization, and h) reducing barriers for entering port business. These concepts reflect the change of port business milieu. The process of separation of big market players, their vertical integration, changed (reduced) role of port authorities in port management, as well as the appearance of port providers change the standard relation between the supply and demand in the market of port services. There are more and more companies within the value delivery chain (3PL providers) performing outsourcing in managing assets, transport, foreign trade operations, marketing and similar. In the maritime market, there are 4PL providers offering an integrated, best quality logistics service along the entire supply chain [2, pp. 511-14].

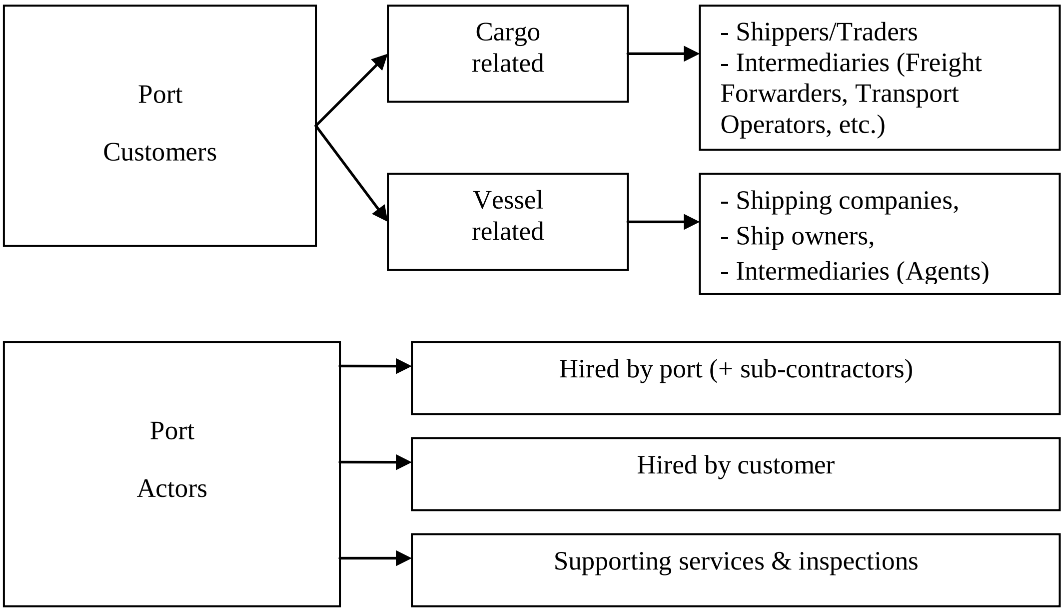

Figure 1: Seaport users' classification

Source: [17, p. 7]

In examining users on the way of the goods from the producer to the consumers, in all transport branches, it is exactly known from whom, to whom and in what way certain quantity of goods is being directed; service is a non-material product and its quality is not known in advance by the user [3, pp. 289-293]. Therefore, in maritime transport organization, the type of goods, transport ways, freight, port, agency and shipping services are clearly defined. In the dynamic conditions of maritime market, with the variety of combinations of goods, users and services, the process of defining target port service users is very complex.

In the period 1996-1999, during the examination of small and medium-sized ports, the general concept of port users, buyers and actors was defined. Port users were classified according to their position in the port system, as well as their role and significance in the logistics chain. Generally, there are two categories [17, p.7]:

- The port Customers, i.e. those who bring business into the port. These can be further distinguished into:
    - vessel-related (shipowners and charterers),
    - cargo-related (exporters, importers and freight intermediaries),

- The port Actors, i.e. those who execute the work in the port adding value to the „port product”. These may be:
  - hired by the port owner (or its subcontractors), i.e. terminal operators, stevedores,
  - hired by the Customer, such as customs brokers, ships' chandlers, surveyors,
  - involved in supporting activities and inspections, e.g. customs, immigration.

In this paper, all users presented in Figure 1 are classed as target ones, while the examination of Adriatic, Aegean and Black Sea port users was mainly reffering to vessel-related and cargo-related customers, as well as port actors, specifically those hired by customers, such as brokers and agencies.

4 MARKET SEGMENTATION IN THE CASE OF ADRIATIC, AEGEAN AND BLACK SEA PORTS

The demand for seaport, shipowner, agency and other services in maritime is of a derivative character. Namely, the demand for specific cargo challenges the demand for other services thus being generated, in order to transfer the goods from one destination to the other. It is fairly difficult to determine who is the decision maker on selecting the port of loading/discharging, who in the delivery chain holds the strongest negotiating power, and, finally, who is the one towards whom the port needs to develop a target marketing concept.

Aiming to understand the market segmentation in the seaport marketing, it is necessary to emphasize several significant differences between business markets and final consumption market, as follows [6, p. 3-4]: a) in the case of business market, the geographical area to cover is significantly larger, b) most of the sales are by their scope bigger than those in the consumption market, c) there are less (several) potential buyers compared to the final consumption market, d) the decision-making process is much more complex in the case of business market, and e) business market organizations are closer to their clients.

Kotler et al. suggest an approach upon which the main variables for business consumption market segmentation are: a) demography (industry, size of enterprise, location), b) operative variables (technology, status of users, ability of consumers), c) approaches to procurement, d) situational factors, and f) personal characteristics [11, p. 409]. Here is started from general principles in business market segmentation, with taking into consideration three approaches in determining the segmentation basis: a) basis selection without rules, b) two-phase, and c) multi-phase approach [7, p. 113]. Emphasizing the importance of business market segmentation in market analysis, selection of target markets and marketing management, Bonoma and Shapiro have developed a multi-phase approach [1, p. 104-10]. Considering the examples of leading world companies, the emphasized segmentation bases are demographical and operative variables, approach to procurement, situational factors and personal characteristics. Out of all the above stated, especially applicable in the seaport marketing are demographical and operative variables, situational factors and personal characteristics.

4.1 Target users of port services

Target users of port services, i.e. market participants having the final word in the port selection in competitive conditions are: shippers, consignees, shipping companies, terminal operators, port authorities and state (government) agencies. Cahoon and Noteboom, from the marketing angle, consider the participants in the maritime logistics chain having the decisive influence in port selection depending on the importance of CIF/CFR and FOB clauses in contracts on international trade [4, p. 4-7]. Namely, in the case of mega organizations, such as leading companies transporting containerized cargo, they have their own unit for organizing cargo traffic and paying all obligations resulting from the transport. In this case, target users are the seller (shipper) and the buyer (consignee). They, in return, organize the sea transport through their shipper, considered the target user, which is often being the case in traditional ports.

The dynamics of events in maritime market imposes the need for individual analysis of each port user. Strategic approach in business is based on careful appraisal of the scope and structure of the goods requiring sea transport and gravitating towards the hinterland of a certain port. On one side, it is necessary to examine the needs of both current and prospective cargo owners, by analyzing their characteristics, as well as the dynamics of needs for transport by sea. Simultaneously, there is a research conducted on the shipowners and/or charterers' preferences. Thus, the process of developing a port positioning strategy is preceded by a comprehensive analysis of clients, primarily users paying for the services, in order to continue with the segmentation and selection of target market segments.

4.2 Example of market segmentation basis

In the research conducted by the author during 2012, aimed at the market segmentation and development of a strategy for container ports (P1 - Bar, P2 - Durres, P3 - Constanza, P4 - Koper, P5 - Piraeus, P6 - Ploce, P7 - Rijeka, P8 - Thessaloniki) positioning the following methodology was applied:

- Firstly, all service users of analyzed ports were identified,
- Then, a focus group was formed; port customers forming the first one (10), while port actors made the second group (10). All were asked to state basic data on the company, previous experience in using the services, strategies, as well as to evaluate the importance of certain qualitative and quantitative business variables of investigated ports on the scale of 1-10,

7. The results gained were possible basis for micro and macro segmentation, which could make specific segments upon which it was necessary to develop future steps in the positioning strategy for these ports in the market.

Table 1: Possible basis of market segmentation in the seaport marketing

Variables	Examples of possible features
a) Basis of macro segmentation	
1. Users characteristics	
Type of users	seaport customers, seaport actors
Sizes	small, medium, large, sales volume, number of employees, etc.
Geographic location	national, regional, international, global
The frequency of using the seaport services	non-users, occasional users, low users, frequent users
The complexity of making decision about the using seaport services	centralized, decentralized
2. Types of seaport services	
Cargo handling without warehousing	importers, exporters
Warehousing	importers, distributional centers
3. Marketing channel characteristics	

direct sales	owners of the cargo (shippers)
indirect sales	agencies, freight forwarders
4. Characteristics of the cargo	
Types of the cargo	general, bulk, liquid, gaseous and special (hazardous, valuable and perishable)
The composition of the cargo	homogeneous, heterogeneous
The method of packaging	boxes, envelopes, bales, bags, pallets, containers
Cargo transportation direction	import, export, transit
b) Basis of micro segmentation	
The key seaport choice criteria	quality, prompt service, security and safety, port tariffs, continuity of services production processes, the possibility of further inland transportation of the cargo, etc.
Personal characteristics of the participants who decide about choice of the seaport	demographic, decision making styles, attitudes towards risk, etc.
Innovativeness of the seaport user	an innovator and follower

Source: Primary research results

The two-phase approach to segmentation in business markets is carried out in two steps, i.e. through macrosegmentation and microsegmentation [8, p. 110]. Macrosegmentation divides the total market upon the users' characteristics, types of port services, features of marketing sales channels and cargo characteristics. In case of eight analyzed ports geographically gravitating towards a single market, criteria of the users' size and frequency in using services is specially emphasized. Therefore, special mixed marketing programmes are prepared for big, sophisticated and loyal users, as well as specific programmes for potential and new ones. From the marketing point of view, it is very important to separate the programmes according to the type, considering that various programmes can be offered to cargo owners, ship owners, agents, shippers and other.

Table 2: Numerical values of weighting coefficients for researched seaports' operation criteria

Criteria	Sub-criteria	Weighting coefficients (W)		
		$W_{Customers}$	W_{Actors}	W_{avg}
Quantitative criteria	Number of berths	7,90	7,86	7,88
	Total berth length	8,20	8,14	8,17
	Max. water dept	8,80	8,43	8,61
	Daily operations	8,50	7,71	8,11
Qualitative criteria	Railway connection	9,40	9,43	9,41
	Road connection	9,30	9,14	9,22
	Barge services	7,50	7,86	7,68
	Shuttle services	7,60	6,86	7,23
	Free zone	7,90	7,86	7,88
	Value-added logistics services	8,20	7,57	7,89
	Distribution centers	8,10	8,57	8,34
	Quality management system	8,20	8,43	8,31
	Integrated marketing communications	8,40	8,29	8,34
	Ship supplies	8,30	8,43	8,36
	Container control	9,00	8,71	8,86

	Container leasing	7,80	8,43	8,11

Source: Primary research results

Microsegmentation is done in case that macrosegmentation does not provide adequate results, and is based on behavior characteristics of the purchase center and its members [13, p. 263-271]. In examining the market, feedback has been provided on the satisfaction/unsatisfaction of users regarding provided service programmes of researched ports. This way, it is possible to form segments valuing the quality of port services, tariff, continuity in service providing and similar. For example, in this research, users evaluated certain quantitative and qualitative parameters of port businesses in the way presented in Table 2.

It can be concluded that port customers appreciate certain quantitative criteria more than port actors do, which is specific for maximum aquatorium depth and daily operation. We have pretty similar evaluations for the parameter of connection with hinterland. Not rarely the personal characteristics of the users are taken as significant segmentation criteria in making decisions on choosing certain logistics direction, or of the port compared to competition. These can be managers at certain maritime management levels, experts in the area of logistics, marketing, finance, technology etc.

5 CONCLUSIONS

Ports and terminals, transport and other businesses in maritime industry in general, represent the basics of global production, consumption and distribution. The current situation in seaport business operations has been featured by the need for creation and implementation of a range of marketing strategies for increased turnover, attraction and keeping of shipping lines and cargo flows as target users. In the competitive environment, marketing offers a wide range of solutions for achieving and maintenance of competitive advantage. Many implemented marketing ideas and activities in seaports thus far has been contributing to the achievement of a unique goal – to be superior to competition and, being such, to be selected by the users.

Contrary to mass marketing, modern target marketing reflects the need for development of segmentation, targeting and organization positioning in the minds of target users. Market segmentation is located in the centre of marketing strategy, since it enables the revealing of strengths and advantages of competition, and better chances of the ports implementing it. Market segmentation is a phrasal process, regardless of whether the *a priori* or *post hoc* approach is used, or their combination, the so-called hybrid model.

In dynamic conditions of maritime market, with so many combinations of various users and services, it is extremely complex to identify the target users of port services, in this paper classed as port customers and port actors. The paper, using the two-phase segmentation approach, has determined macro and micro segments, emphasizing that the obtained segments evaluated individual business criteria, which can be used for the development of all other target marketing strategies, especially positioning and repositioning. Furthermore, this paper can be useful to marketing managers in Adriatic, Aegean and Black Sea ports.

It is necessary to occasionally follow the changes in the segments for the purpose of dynamics in internal and external environment. It is important to emphasize that the choice of any of the three segmentation approaches, there are bases that may be necessary, but not sufficient, condition for a successful market segmentation. This would mean that the segmentation procedure, conditionally speaking, ends when, passing certain levels, user groups have been defined, i.e. segments reacting homogenously to marketing variables of a seaport.

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DEFINING THE NUMBER OF POSTAL UNITS IN THE SERBIAN NETWORK

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ABSTRACT

The public postal operators in developing countries should define the model for proper postal network design and access. The access to the postal network represents a set of different elements that interact with each other. They have a common aim of providing continuous, of high quality, reliable and sustainable universal postal service. There are different approaches in defining the components and criteria for establishing the system of access to the postal network of the public operator. In this paper we present a new, general, method created to generate fuzzy rules from numerical data, well known as Wang-Mendel's method. The authors apply method on real data collected from Serbian municipalities and finally compare current number of permanent postal units and the results obtained by fuzzy model.

Keywords: Network access, Postal units, Fuzzy logic, Wang-Mendel's method

1 INTRODUCTION

The universal postal service is a service of general interest and represents a set of postal services which are performed continuously on the territory of any country, within the prescribed quality, at affordable prices and under the same conditions for all users, without any discrimination [6]. The universal postal service is being developed in line with technological and economic development and the needs of users.

The providing of the universal postal service depends on properly designed postal network and locations of access points. Access points include the admission points, including mailboxes intended for the population, either in public places or in the premises of the universal postal service provider, where postal items can be handed in by the users of postal services [5].

Worldwide experience suggests different approaches in defining the components and criteria for establishing the system of access to the postal network of the public operator. As can be noticed, different countries have different approaches to access to the postal network, established in relation with criterion as a density, minimum number of post offices, distribution, etc. In accordance with these criteria, for example, in Australia were established 4000 post offices, of which 2500 in the rural area. In Denmark, there must be at least one post office offering full service in a settlement with more than 5000 people. Post offices in cities with the population of 2500 to 5000 inhabitants should not be closed unless there is some other service. Post offices in rural areas should not be closed unless the postman can provide the service or the distance to the next nearest post office does not exceed 10 km, measured in a straight line.

Following mentioned criteria, in Germany, postal network consists of 12000 post offices. Settlements with more than 2000 people must have at least one post office, or be the center of the overall plan. Public postal operator has pledged to set up a stationary post in settlements of over 2000 people, and that it is not posted on a higher distance than 2km in settlements with more than 4000 inhabitants. In Hungary, settlements with more than 600 people must have a permanent post office, except that in settlements of 600 to 1000 people a mobile building can be set, if permitted to do so by local authorities. In cities, the distance of post office from users must not be greater than 3km, but for every 20 000 residents there should be a permanent post office. In Japan and Norway, one post office in each municipality was established.

This paper considers the postal network of public postal operator in Serbia, as a representative of the postal operators in region. The current trend of public postal operator and regulatory body in Serbia is to optimize the access points, universal postal service and public postal network. One possible way to achieve this goal is to minimize the number of permanent postal units of postal network. This process would reduce costs of postal operator, as well as the total number of employees.

In this paper a new approach to optimize the public postal network is proposed. The authors use well known Wang-Mendel’s (WM’s) method which consists of five steps. Step 1 divides the input and output spaces of the given numerical data into fuzzy regions. Step 2 generates fuzzy rules from the given data. Step 3 assigns a degree of each of the generated rules for the purpose of resolving conflicts among generated rules. Step 4 creates a combined fuzzy rule base based on both the generated rules and linguistic rules of human expert. Finally, Step 5 determines a mapping from input space to output space based on combined fuzzy rule base using defuzzifying procedure.

The proposed model is general and with slightly modifications can be implemented in numerous scenarios of determining requested number of postal units. The main advantage of described model is in the fact that experts’ opinion and experience are embedded. This is a reason why we decided to use WM’s method which combines the importance of numerical information and experts’ knowledge. The authors of the paper use a case study of municipalities’ characteristics in Serbia for numerical evaluation and testing, but the model can be applied on any postal network worldwide.

After comparing current number of permanent postal units and the results obtained by fuzzy model, it is observed that the proposed model is very useful in order to optimize the number of access points in public postal network.

The paper is organized as follows. The Section 2 gives the model for determining the number of permanent postal units. In the following Section results and discussion are presented. The last Section 4 is devoted to concluding remarks.

2 MODEL FOR DETERMINING THE NUMBER OF PERMANENT POSTAL UNITS IN THE PUBLIC POSTAL OPERATORS’ NETWORK

The issue of access to public postal operator’s network is of great importance. There is no transparent methodology for the definition of particular criteria values (density of access points, minimum number of post offices, distribution/allocation of post offices on urban and rural network and other).

In the next time period, the Serbian postal operator is planning reorganization of the postal network. Since this is extremely important activity, which influence on total costs and number of employees, it is necessary to adopt some models in order to determine the number of requested permanent postal units in urban settlements.

The authors of [8] defined following criteria for urban settlements:

In every settlement with more than 1000 inhabitants (and municipality) should be provided with at least one permanent unit of postal network;

In settlements with more than 20 000 inhabitants, there has to be at least one permanent unit of postal network on every 20 000 inhabitants.

2.1 Fuzzy approach

For most real-world control and design network problems, the information concerning modeling, tuning, evaluation, realization, etc. can be classified into two classes: numerical information obtained from some kind of measurements and linguistic information obtained from human experts. Fuzzy logic provides a formal methodology for representing, and implementing a human's heuristic knowledge. Up to know fuzzy logic have been applied on numerous problems related to transportation, optimization and design [7, 9, 11, 13, 18].

In this paper we propose a general method, known as Wang Mendel's method for combining both numerical and linguistic information into a common framework – a fuzzy rule base and apply it to the problem of determination of required number of permanent units in public postal operator's network.

Generally, WM's rule generation method is used to derive fuzzy rule base. This method could be combined with some other methods, such as: Genetic algorithms [2, 4], Swarm optimization algorithm [1, 17], Simulated annealing [16], etc. Giving the literature review of the fuzzy systems in the transportation fields, author of [12] represented several papers with WM's method application. Teodorović [12] emphasized that WM's method represents a nonlinear mapping, with the possibility to approximate any real continuous function to arbitrary accuracy. Wang [15] extended WM's method to enhance the practicality. The author presented the approach for ranking the importance of input variables and proposed an algorithm for solving pattern recognition problems. Authors of [3] emphasized that WM's rule generation method is the one of the earliest algorithms, but with one disadvantage. This method selects the rules with the maximum degree, without taking into consideration other conflicting rules. The authors compared three methods, and the main conclusion of the paper is that the weighted mean method has the best robustness and error-tolerance, consequently this approach is suitable for extracting rules from the real data with noise. The results obtained by Yanar and Akyurek [16] indicated that WM's method provides better starting configuration for simulated annealing compared to fuzzy C-means clustering method.

According to the authors' knowledge, there is no paper dealing with WM's method in designing postal network or determining requested number of postal units.

In this paper, the input variables of proposed, fuzzy, model are:

the total number of settlements with a population between 1000 and 20 000 (labeled as x_1)

the total number of inhabitants in settlements with a population of over 20 000 (labeled as x_2).

As output variable of fuzzy model the authors of the paper adopt the number of permanent postal units in each settlement (denoted as y). The data for the variables x_1, x_2 and y (from Table 1) were collected from whole territory of the Republic of Serbia.

The values for input variable and output variable can be seen from Table 1. As it can be noticed each set of desired input-output data is given in the form of:

$\{(x_1^{(1)}, x_2^{(1)}; y^{(1)}), (x_1^{(2)}, x_2^{(2)}; y^{(2)}), \ldots, (x_1^{(40)}, x_2^{(40)}; y^{(40)})\}$.

Table 1: Values for input and output variables

Municipality	$x_1^{(i)}$	$x_2^{(i)}$	$y^{(i)}$
1	8	0	8
2	5	156280	13
3	13	26549	14
4	10	25526	11
…	…	…	…
39	14	47485	16
40	18	75743	22

A sample of 40 municipalities from Table 1 is formed randomly with respect to all of the analyzed municipalities in the Republic of Serbia.

The first step in WM's method divides the input and output spaces into fuzzy regions. Assume that the domain intervals of x_1, x_2 and y are [x_1-, x_1+], [x_2-, x_2+] and [y-, y+], respectively. We divide each domain interval into 2N+1 regions (N may vary from variable to variable) and assign each region a fuzzy membership function (Table 2).

Table 2: Domain intervals for x_1, x_2 and y

Variable	Domain
x_1	[0, 30]
x_2	[0, 200]
Y	[1, 25]

On following figures we show both input variables and output variable. The shape of each membership function is triangular. Of course, other divisions the domain regions and other shapes of membership functions are possible.

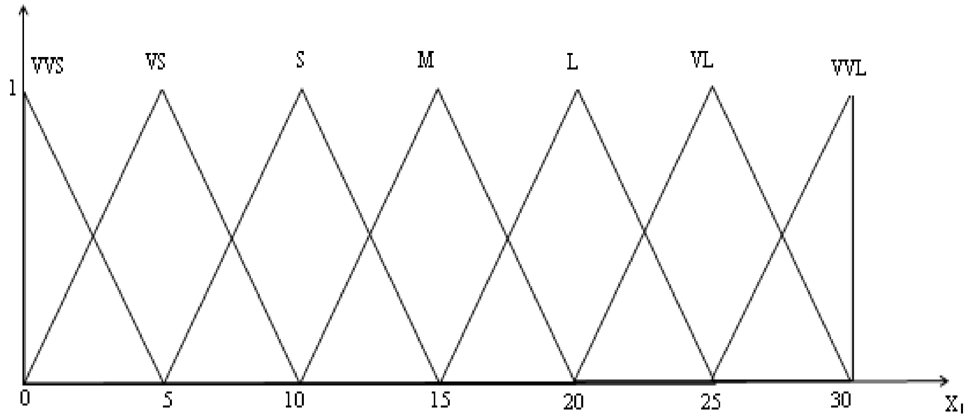

Figure 1: Input variable x_1 (the total number of settlements with a population between 1000 and 20000)

The membership functions of following fuzzy sets are shown on Figure 1: very, very small number of settlements with a population between 1000 and 20 000 (VVS), very small number of settlements with a population between 1000 and 20 000 (VS), small number of settlements with a population between 1000 and 20 000 (S), middle number of settlements with a population between 1000 and 20 000 (M), large number of settlements with a population between 1000 and 20 000 (L), very large number of settlements with a population between 1000 and 20 000 (VL), and very, very large number of settlements with a population between 1000 and 20 000 (VVL).

The domain of the second input variable x2 is covered by the following fuzzy sets (Figure 2).

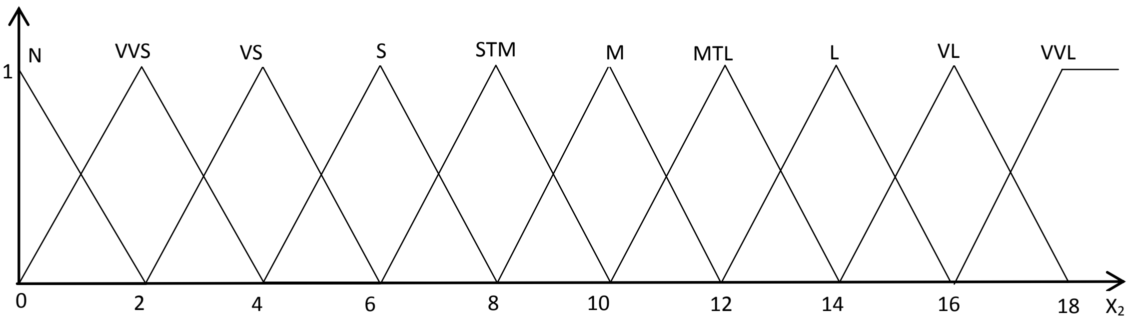

Figure 2: Input variable x_2 (the total number of inhabitants in settlements with a population of over 20 000) measured in thousands

Figure 2 shows the membership functions of following fuzzy set: no settlements with over 20 000 inhabitants (**N**), very, very small number of inhabitants in settlements with a population of over 20 000 (**VVS**), very small number of inhabitants in settlements with a population of over 20 000 (**VS**), small number of inhabitants in settlements with a population of over 20 000 (**S**), small to medium number of inhabitants in settlements with a population of over 20 000 (**STM**), medium number of inhabitants in settlements with a population of over 20 000 (**M**), medium to large number of inhabitants in settlements with a population of over 20 000 (**MTL**), large number of inhabitants in settlements with a population of over 20 000 (**L**), very large number of inhabitants in settlements with a population of over 20 000 (**VL**), very, very large number of inhabitants in settlements with a population of over 20 000 (**VVL**).

The domain of the output variable *y* is covered by the following fuzzy sets (Figure 3).

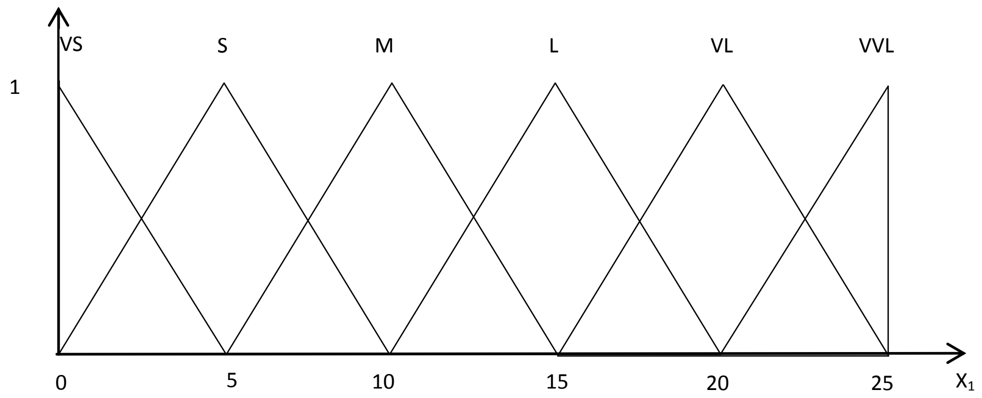

Figure 3: Output variable *y* (the number of permanent postal units in each settlement)

The domain of output variable is divided into six intervals (N = 6). Figure 3. presents membership functions of following fuzzy sets: very small number of permanent units (**VS**), small number of permanent units (**S**), medium number of permanent units (**M**), large number of permanent units (**L**), very large number of permanent units (**VL**) and very, very large number of permanent units (**VVL**).

The second step of proposed model is to generate fuzzy rules from given data pairs. We, first, determine the degrees of given input-output pairs ($x_1^{(i)}$, $x_2^{(i)}$; $y^{(i)}$) in different regions. For example $x_1^{(20)} = 24$ in Figure 1 has degree 5/6 in **VL**, and degree 1/6 in **L** and zero degrees in all other regions. Second, we assign a given $x_1^{(i)}$, $x_2^{(i)}$ or $y^{(i)}$ to the region with maximum degree. Finally, we obtain one rule from one pair of desired input-output data, e.g.

($x_1^{(1)}$, $x_2^{(1)}$; $y^{(1)}$) =›[$x_1^{(1)}$(0.833 in **VL**, max), $x_2^{(1)}$ (1 in **N**, max);

$y^{(1)}$ (0.7 in **M**, max)] => Rule 1.
IF x_1 is **VL** and x_2 is **N**, THEN y is **M**

After this procedure we made 40 fuzzy rules, the one for each input-output pair of data. The part of these rules is shown in Table 3.

Table 3: Rules based on input-output pairs of data

Input-output pair	Rule		
$x_1^{(1)}, x_2^{(1)}; y^{(1)}$	1: If x_1 is **S**	and x_2 is **N**	then y is **M**
$x_1^{(2)}, x_2^{(2)}; y^{(2)}$	2: If x_1 is **VS**	and x_2 is **VL**	then y is **L**
$x_1^{(3)}, x_2^{(3)}; y^{(3)}$	3: If x1 is **M**	and x_2 is **VVS**	then y is **L**
$x_1^{(4)}, x_2^{(4)}; y^{(4)}$	4: If x_1 is **S**	and x_2 is **VVS**	then y is **M**
…	…	…	…
$x_1^{(39)}, x_2^{(39)}; y^{(39)}$	39: If x_1 is **M**	and x_2 is **VS**	then y is **L**
$x_1^{(40)}, x_2^{(40)}; y^{(40)}$	40: If x_1 is **L**	and x_2 is **STM**	then y is **VL**

Next step is to eliminate same or conflict rules i.e. rules that have same IF part but a different THEN part. One way to resolve this conflict is to assign a degree to each rule generated from data pairs, and accept only the rule from a conflict group that has maximum degree. In our case study we don't have any conflict rules, so we just remove same rules from existing rule base. In this way the number of rules is greatly reduced (total number of rules is 17).

Most often, available pairs of input-output data are not sufficient to "cover" all the different situations that can happen in a particular system. Fuzzy rule base is more complete if the number of different input-output data pairs is bigger. In order to obtain better results fuzzy rule base may be amended with additional fuzzy rules generated by an expert. The final fuzzy rule base in the case of determining the required number of permanent postal units per municipalities in Serbia is shown in Table 4. Fuzzy rules generated by the experts are underlined.

Table 4: Final fuzzy rule base

X_2	**N**	VS	S	M	$\underline{\text{L}}$	$\underline{\text{VL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$
	VVS	$\underline{\text{S}}$	$\underline{\text{S}}$	M	L	$\underline{\text{VL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$
	VS	VS	S	$\underline{\text{M}}$	L	$\underline{\text{VL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$
	S	$\underline{\text{S}}$	M	$\underline{\text{L}}$	$\underline{\text{VL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$
	STM	S	$\underline{\text{M}}$	$\underline{\text{L}}$	$\underline{\text{VL}}$	VL	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$
	M	S	$\underline{\text{M}}$	$\underline{\text{L}}$	$\underline{\text{VL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$
	MTL	$\underline{\text{M}}$	$\underline{\text{M}}$	$\underline{\text{L}}$	$\underline{\text{VL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$
	L	S	M	$\underline{\text{VL}}$	$\underline{\text{VL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$
	VL	M	L	$\underline{\text{VL}}$	$\underline{\text{VL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$
	VVL	$\underline{\text{M}}$	$\underline{\text{L}}$	$\underline{\text{VL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$	$\underline{\text{VVL}}$
		VVS	**VS**	**S**	**M**	**L**	**VL**	**VVL**
		X_1						

3 RESULTS AND DISCUSSION

3.1 General information

The Republic of Serbia occupies the territory of 88 361km2. According to the last census [10] Serbia had an estimated population of 7 576 837 inhabitants, distributed in 6167 settlements.

Of the total population in Serbia, more than 42% live in urban areas, i.e. towns with above 20 000 inhabitants. The Republic of Serbia has 52 populated areas (settlements) with over 20 000 citizens. Figure 4 shows the map of counted cities and municipalities in Serbia.

Figure 4: Cities and municipalities in Serbia

3.2 Obtained results

After applying Matlab software and fuzzy logic toolbox the required numbers of permanent postal units per municipalities in Serbia are obtained. These results are shown in Table 5.

Table 5: Values for input and output variables by Wang-Mendel method

Municipality	$x_1^{(i)}$	$x_2^{(i)}$	$y^{(i)}$
1	8	0	8
2	5	156280	13
3	13	23314	13
4	10	24568	10

…	…	…	…
39	14	52693	15
40	18	33837	22

The authors compare current number of permanent postal units per municipality with results obtained by fuzzy logic model. These results are shown in following Table 6. The first column presents observed municipalities. The second column presents current number of permanent postal units per municipality. The third column shows results obtained by WM's method.

Table 6: Comparison of obtained results

Municipality	Current number of permanent postal units per municipality	Number of permanent postal units by WM'S
1	8	8
2	13	13
3	14	13
4	11	10
…	…	…
39	16	15
40	22	22

From Table 6 and Figures 5 and 6 it can be seen that the developed WM's method is able to find the exact number of permanent postal unit for 34 cases, and for 6 cases the model make some deviations from existing number. In 5 of 6 cases, our fuzzy logic model gave the number of required permanent unit less than current number for one unit. This fact is very encouraging for the further implementation of this model. The obtained results indicate that the proposed model can be used in some future restructuring the postal system, in which certainly one of the main targets will be the reduction of the number of permanent units per municipalities.

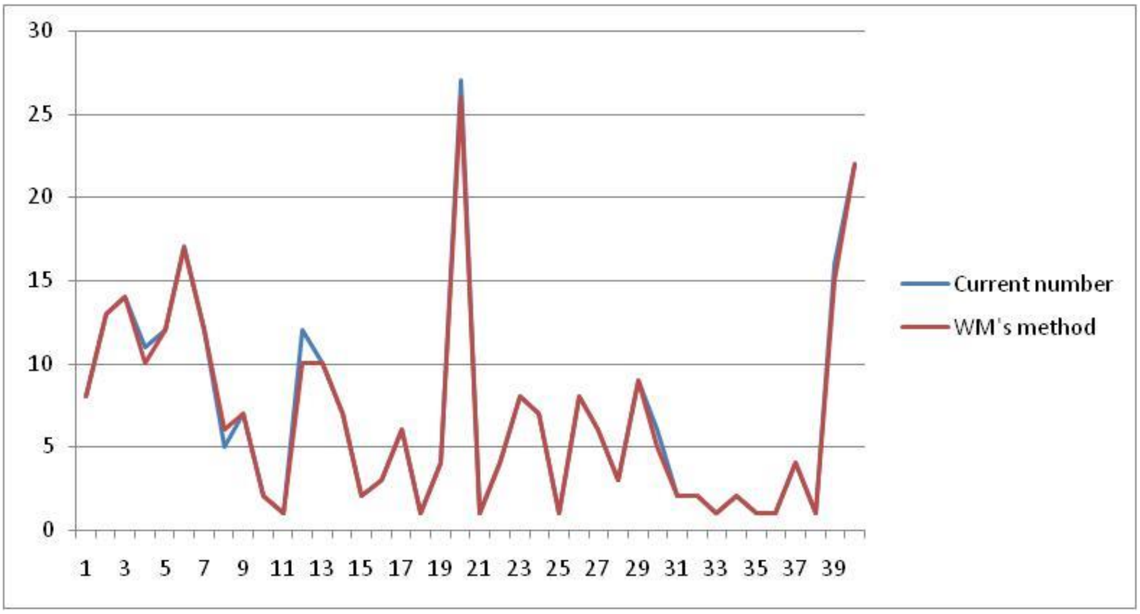

Figure 5: Comparison of the results

The WM's method gives good results because of the fact that when we created fuzzy rule database, we involved the experts with PhD and master's degrees in the postal traffic.

4 CONCLUSIONS

The postal network capacity is a unique, strategic advantage of any post, because it allows access to the service on the internal market, and at the same time, supports the pursuit of expansion and global integration.

The universal postal service network has to meet the requirements of users' access, i.e. to effectively cover the entire territory for which it is organized. That is exactly the reason why we develop new approach for the access to the postal network of the public operator which relies on fuzzy logic and WM's method.

We apply proposed model on real data collected from Serbian municipalities. The obtained results, i.e. number of permanent postal units per municipalities in Republic of Serbia, show that presented model is able to obtain very precise data. In 85% cases our fuzzy logic model gave the same number of required permanent units as current number in Serbian municipalities. This fact is very encouraging for the further implementation of this model.

From this point of view, described model is suitable for application to other, similar, problems related to optimization of the postal network. The further research in this area should take into account more parameters into analysis, such as the demands for services and costs.

ACKNOWLEDGMENT

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COTROLLING AND MANAGING COSTS IN A ROAD TRANSPORT COMPANY

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ABSTRACT

Fierce competition in the road transport sector of the transport industry forces companies to adopt a new approach to their organization and to their way of conducting operations. In addition to consistent quality, clients who use transport services demand lower freight rates. Transport services providers are faced with growing operating costs, which have caused many companies to cease operations, also due to payment default. A company should therefore strive to have detailed knowledge of all its operation costs and to build a lasting system of stability and quality in its operations. This paper introduces a uniform cost management system in road transport, which allows a company to implement appropriate organizational measures with the goal of remaining competitive, without compromising its operations.

Keywords: Road transport, transport company, controlling and managing costs in road freight transport.

1 INTRODUCTION

Despite the State's efforts to divert as much freight traffic as possible to the railways, road transportation represents a relevant economic sector, which addresses the needs of the Slovenian export-oriented economy in terms of quality. The conjuncture period that lasted up until mid-2008 resulted in massive growth of the sector. Due to increased demand, there has been an increase in freight rates. Consequently, transport companies updated and expanded their vehicle capacity. The positive economic climate allowed for all the structural problems that were present in the transport industry to be pushed into the background. Transport companies failed to act in unison in their dialogue with the State, as they were represented by a multitude of interest groups. Financing growth solely through borrowing, systemic financial indiscipline and unfair competition are just some of the problems that caused the transport sector to fall to its lowest level since independence, when the economic crisis started in 2009.

The mentality of growth changed the mentality of survival. Those transport companies, which had not previously built a system of cost management and cost control found it difficult to keep up with the changing demands of the economy and the transport industry. If companies are not familiar with their own cost structure, virtually any freight rate is acceptable in the short term. A cost management and control system does not ensure the survival of a company in itself, but mainly enables the company to take the appropriate decisions and to implement organizational measures in a timely manner. The objective of an effective system is to reduce the total cost, while increasing the quality of services.

1.1 Definition of the Problem

Changed economic conditions in 2009 led to decreased demand for transport services by approximately thirty percent and a steep drop in freight rates. For most companies, borrowing was based solely on annual growth and high freight rates. The companies that were not aware of their own costs did not have a realistic picture of what reductions in freight rates on a global scale meant for a company's operations. An efficient cost management and control system enables clear view of all fixed and variable costs, the relationship between them and, in particular, the measures that a company must take to be competitive and profitable at the same time.

1.2 Purpose and Scope of the Paper

The purpose of this paper is to combine the findings in expert literature and practical experience to provide a contribution on the subject of improving the controlling of logistics costs in transport companies. This paper aims to introduce a unified system of cost managing and control in a transport company, which will enable the adoption of effective and timely organizational measures with the goal of enabling a company to remain competitive, without compromising its own operations.

1.3 Existing Research on the Subject

Upon examining the existing literature, it can be concluded that, while there is some research that addresses the topic of costs in a transport company and the method of pricing, we could not detect any research and recommendations that would offer a systematic approach to cost management and control at the company level.

2 TRANSPORT COMPANIES' OPERATIONS IN ROAD TRANSPORT

In this chapter, we highlight the main factors that affect the operations of Slovenian transport companies. In most cases, the factors will be interdependent, as poor economic conditions mean fewer goods and less demand for transport services and the resulting increased competition and lower freight rates. In such conditions, the only companies that can survive at those that have large transport capacity and an elaborate cost management system. Given the importance of this topic, costs in the transport sector are examined more closely in the third chapter.

2.1 Economic Developments and Trade in Goods

Given the small size of the market and the fact that Slovenia is export-oriented, transport companies are heavily dependent on economic developments in other countries, especially Italy, France, Germany, Austria and the countries of the Western Balkans. Fluctuations in the volume of goods transported by road are otherwise normal, due to various seasonal factors. A drop in volume can usually be detected in the first quarter of each year. When observing the current trends of goods transported (Chart 1 - 2), we can detect a drop that can be expected and that coincides with the negative economic developments in the EU. Trucks registered in Slovenia carried 17 million tons of goods in the third quarter of 2012, performed 3.6 billion tonne-kilometers and travelled almost 246 million kilometers by loaded vehicles. In comparison with the third quarter of 2011, this is 19% fewer goods carried, 6% fewer tonne-kilometres performed and almost 6% fewer kilometres travelled by loaded vehicles.

Compared with third quarter of 2011, 24% fewer goods were carried in national transport than in the same period last year; there were also fewer tonne-kilometers performed and kilometers travelled by loaded vehicles (by 20% and by almost 15%). In International transport, 1% fewer goods were carried; there were also 3% fewer tonne-kilometers performed and 3% fewer kilometers travelled by loaded vehicles (http://www.stat.si/novica_prikazi.aspx?id=5253).

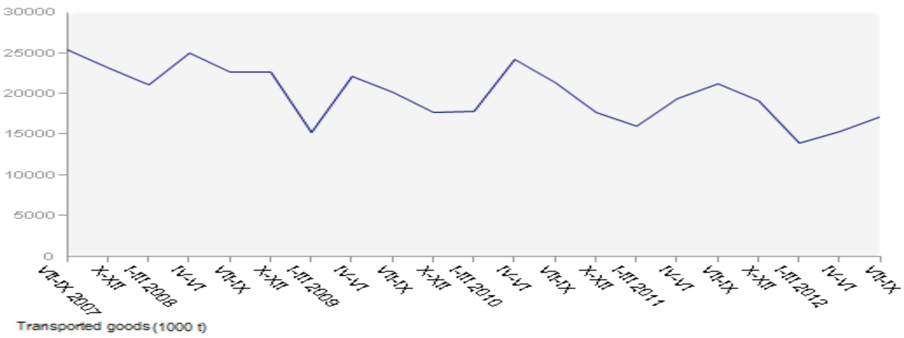

Chart 1: Goods carried by road, Slovenia, 3rd quarter 2007 – 3rd quarter 2012

Source: SURS (www.stat.si/novica_prikazi.aspx?id=5253)

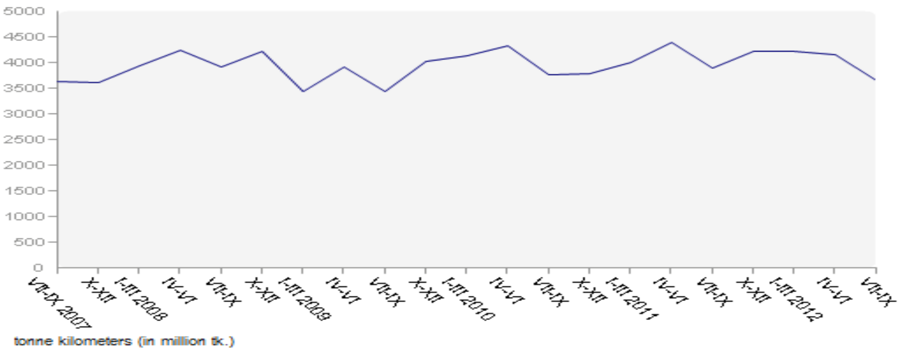

Chart 2: Tonne-kilometres performed in road goods transport, Slovenia, 3rd quarter 2007 - 3rd quarter 2012

Source: SURS (www.stat.si/novica_prikazi.aspx?id=5253)

Chart 3 shows transport prices before and after the economic crisis for the entire European Union, according to Eurostat data.

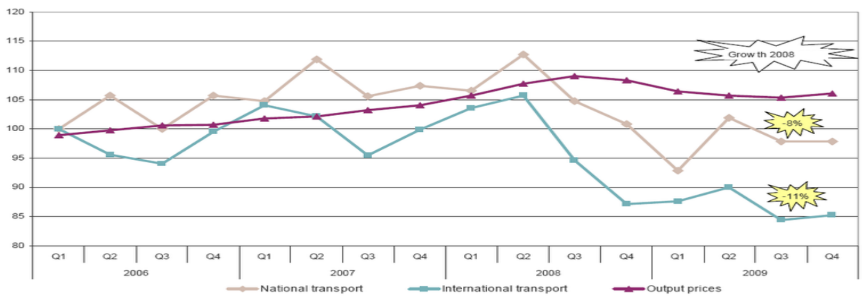

Chart 3: Evolution of hire or reward road freight transport (in tkm) and output prices for freight, 2006 – 2009 in EU

Source: Eurostat (http://epp.eurostat.ec.europa.eu/statistics)

The decline in economic activity has led to lower freight rates, which were partially increased only in the end of the last quarter of 2009 due to growth in Germany and France. Reduction percentage data in freight rates can vary for each country, due to differences in economic situation.

The trade in goods between two countries has a major impact on the transport business. Intensive bilateral trade between two countries (the ratio of imports and exports of approx. 1:1) usually has a balancing effect on freight rates, mainly due to economies of scale and systemic planning of transport services. In this case, the freight rate in one direction equals to the return freight rate. The opposite effect is achieved when the flow of trade is less than or disproportionate (if the ratio of exports and imports is 1,5:0,5). This is approximately the same proportion used to determine in practice the freight rates for one-way or return journeys.

2.2 Economies of Scale

Due to various factors such as competition, increased costs and lower freight rates, the structure and number of transport companies have changed. While there were many small transport companies just twenty years ago, the current situation has changed. In 2008, the Chamber of Craft and Small Business of Slovenia had around 12,600 members in the transport business and in 2011, their number was already reduced by half (Lovšin, P.). Due to harsh conditions in the transport industry, economies of scale became the logical option for companies who want to ensure their own survival. Economies of scale is an economics term that refers to the additional cost savings when large-scale manufacturing enables cost reductions in the implementation of services. As already mentioned, it indirectly helps a company to make a profit, while creating a more open and competitive market for consumers, in terms of a wider choice and higher quality of services at lower prices. The use of economies of scale is particularly suitable for large companies and in industries with high capital costs where costs can be distributed across a large number of production units. (www.poslovnisvet.si)

3 DEFINING COSTS IN A TRANSPORT COMPANY

This chapter deals with the impact of cost rationalization on the profits of a transport company. We continue by defining costs in the transport sector, the issue of variable costs and the specifics cost distribution.

3.1 The Impact of Cost Reductions on a Transport Company’s Profits

The transport sector has a large proportion expenses or costs in its revenue structure. Costs rarely fall below ninety percent of total sales. In practice, this means that the profitability of a transport company ranges between 0.00% and 10.0% of total sales. Profitability, which can be influenced by rationalizing costs, is therefore more important than the amount of revenue. Table 1 shows that increased sales by a monetary unit (hereinafter m.u.) does not result in increased profits by a m.u. In the case where the limit on pre-tax profits for a transport company is 2% (sales revenue minus cost), the company received only 0.02 m.u. of pre-tax profits from each m.u. sold. Each m.u. saved in the company's operations does not automatically mean an increase in sales, but it does mean increased profits. Cost reduction has a much greater impact than increased sales volume, as by reducing the price of the product, an increase in sales is to be expected (Stock; Lambert, 2001, p. 18).

Table 1: Impact of cost reduction on profit

If net profit in sales is 2.0%:2,0 %:				
Savings from:		Relevant increase in sales:		
m.u.	0.02		**m.u.**	1.00
	2.00			100.00
	200.00			10,000.00
	2,000.00			100,000.00
	20,000.00			1,000,000.00
	200,000.00			10,000,000.00
	2,000,000.00			100,000,000.00

Source: (Stock; Lambert, 2001, p. 18)

3.2 The Distribution of Costs in a Transport Company

A transportation service incurs a number of costs, such as labor, fuel, maintenance, terminal, roadway, administrative and others. This costs mix can be arbitrarily divided into those costs that vary with services or volume (variable costs) and those that do not (fixed costs). Of course, all costs are variable if a long enough time period and a great enough volume are considered. For purposes of transport pricing, however, it is useful to consider costs that are constatntconstant over the "normal" operating volume of the carrier as fixed. All other costs are treated as variable. Specifically, fixed costs are those for roadway acquisition and maintenance, terminal facilities, transport equipment, and carrier administration. Variable costs usually include line-haul costs such as fuel and labor, equipment maintenance, handling and pickup and delivery (Ballou, 1999, p. 153). Experts in the profession recommend considering the fixed and variable costs, which are listed in Figure 4 (www.intertransport.si):

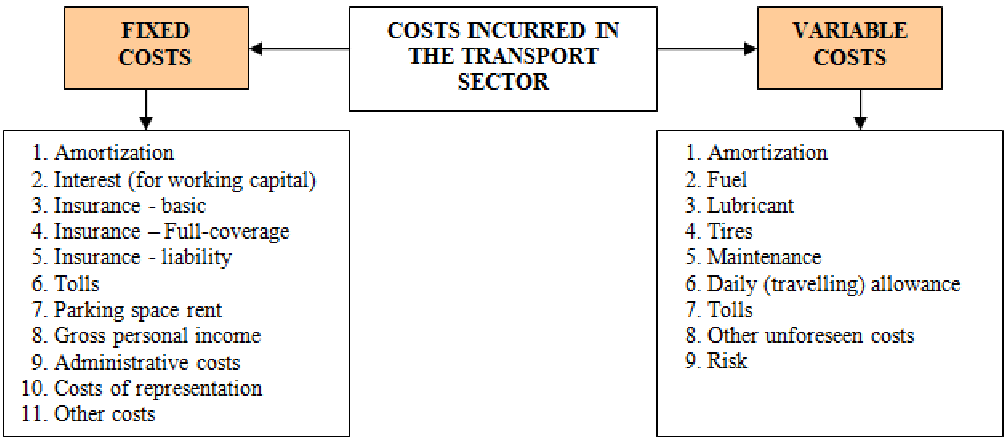

Figure 4: Costs in the Transport Sector

Source: Adapted from Intertransport

In theory, there are several types of fixed and variable costs. As already mentioned, fixed costs are incurred due to a fixed input and remain the same as long as the price and quantity of the fixed input remain unaffected. They are divided into (Križman; Rajter, p. 54):

- absolute fixed costs, which remain the same as a whole,
- relative fixed costs, which are incurred, if we increase the fixed inputs (e.g. the purchase of new machines, renting new premises ...).

Variable costs are costs paid to variable inputs. There are three types of variable costs (Križman; Rajter, p. 57):

- proportional variable or relatively variable costs, which as a whole increase in proportion to the volume of business; on average, they remain unchanged.
- degressive variable costs, which as a whole and on average increase more slowly than the volume of operations.
- progressive variable costs, which increase faster than the volume of business.

Transport companies incur many variable costs in their operations. In practice, they constitute between 70 to 80 percent of the total operating costs. Variable costs are not a problem, as long as they fall into the degressive or proportional categories. The problem arises when we find that variable costs are growing faster than the volume of business. To better illustrate the issue of progressive variable costs, the table below shows an example of progressive variable costs incurred in the manufacture of products.

Table 2: Progressive variable costs

Production volume (Q)	Total variable costs = TVC in €	Average variable costs = AVC in €
0	0	-
100	2.500	25
200	6.000	3
300	10.500	35
400	18.000	45
500	29.000	58

Source: Adapted from Križman; Rajter, p. 58-59

Progressive variable costs are shown in point a) of Figure 5. They usually occur within a company when the company is nearing the limits of its capacities. Typically, this is when salary costs go up (overtime), material consumption may be increased due to lower efficiency and the cause can also lie in poor organization of work.

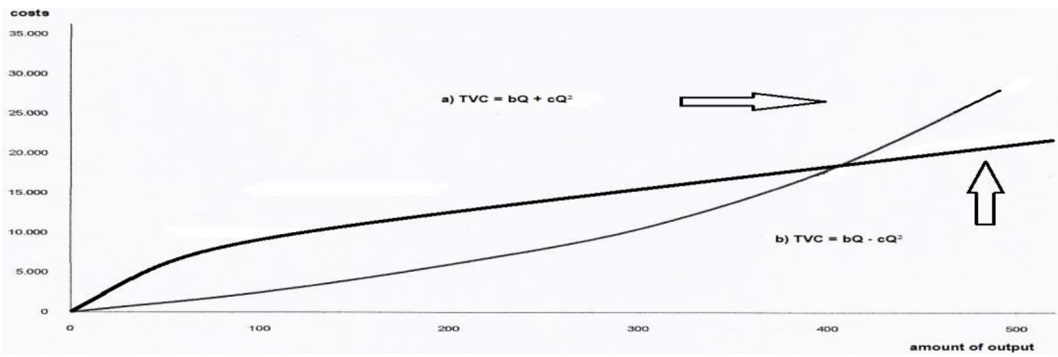

Figure 5: Degressive and progressive variable costs

Source: Adapted from Križman; Rajter, p. 58-59

In any case, it is necessary to find and eliminate the causes of such increase in variable costs. Degressive variable, which are the opposite of progressive variable costs are shown in point b). These occur when there is more efficient use of material and when there are improvements that result in a more rational use of energy and labor. Degressive variable costs as a whole and on average grow more slowly than the volume of business (Križman; Rajter, p. 58-59). The company's goal should be to reduce operating costs in a way that the quality of the product or service remains at least the same. It is precisely when dealing with variable costs in a transport company that we detect a lot of hidden reserves that can be found solely by implementing an effective cost management and control system.

3.3 The Issue of Cost Distribution in a Transport Company

A cost management and control system cannot be established until we have a clear cost distribution strategy. Most of the differences can be found in amortization. In reviewing Slovenian and foreign literature on the subject, both Slovenian and foreign authors count amortization as a cost, even when calculating their own price and not only in their balance sheet items and income statement. The only difference is in the distribution of costs. Hočevar (p. 5), for example, distributes the cost of amortization based on the assumption that drivers cover 6000 km per month locally and 10,000 km per month abroad. The Economic Interest Group Intertransport takes into account a time component in calculating amortization costs. The basic premise is a division based on data that must be both statistical (time spent on kilometers driven) and accounting (with broken down recorded cash flows). This is certainly acceptable as according to the SAS (Slovenian Accounting Standards), amortization as a fixed cost is calculated based on the use of an asset over a period of time. Otherwise, there is a variety of methods that can be used for the systematic allocation of the amortization amount of an asset over its useful life (SRS 1, c, 1-1.18):

- uniform line amortization method,
- the diminishing balance method and
- the units of production method.

The amortization method applied reflects the estimated pattern of economic benefits from the tangible fixed assets. If the pattern cannot be determined with a degree of certainty, the uniform line amortization method is applied. The residual value is normally only taken into account for important items, also taking into account the cost of disposal of the tangible fixed asset; if disposal costs exceed the estimated residual value, the residual value is not taken into account in the amortization. The residual value should be checked at least at the end of each financial year. Amortization calculated for each accounting period is recognized as a cost (SRS c) 1-1.18). According to the fifth paragraph of Article 33 of the Law on Corporate Income Tax (ZDDPO-2), the amortization is calculated individually. The maximum annual amortization rate under the provisions of the first paragraph of this article is 20% for equipment, vehicles and machinery.

4 COST MANAGEMENT AND CONTROL IN A TRANSPORT COMPANY

In this chapter, we introduce a cost management and control system that allows a transport company to adopt the most appropriate decisions. The aim of the system is not only to reduce costs, but also to provide better quality transport services, which should ensure, in a final analysis, effective:

- organization of transport services,
- selling of transport services,
- procurement of resources,
- planning and control of the resources used.

The process of building such system is presented in detail in Figure 6 and is divided into the following steps:

1. **Definition of costs**. In the first phase, it is necessary to define all operating costs and divide them into fixed and variable costs.
2. **Annual review of the costs**. Based on past data, we prepare an annual review of the costs. The review includes several consecutive years, based on data from Table 2. Costs are then deducted from revenues from sales. The result is divided by the revenues from sales to obtain a percentage of profit before tax and compared with previous years.
3. **Monthly review of the costs**. Based on current annual data, we prepare a monthly review of the costs, based on the data from Table 2. Costs are then deducted from revenues from sales. The result is divided by the revenues from sales to obtain a percentage of profit before tax and compared with previous months. To obtain a true picture, some costs must be a lump sum: tires, oil, insurance, administrative costs and shared services.
4. **Building a cost distribution system**. A cost distribution system is important because of the distribution of fixed and variable costs by each vehicle and by individual carriage. In case of regular or recurring carriages, the bulk of variable costs should be calculated under fixed costs.
5. In the distribution of costs **by vehicle,** variable costs and some specific fixed costs are allocated directly to a particular vehicle. Only the cost of shared services is divided by the number of vehicles in order to obtain an average value, which is assigned to each vehicle. Thus, when doing **the analysis**, we are comparing the cost of each vehicle in terms of:
   - maintenance
   - fuel consumption and
   - other costs.

   We then subtract the costs from the revenue generated by a vehicle. The result is divided by the revenue of the vehicle to obtain profitability per vehicle on an annual and monthly basis.

6. The distribution of costs by **individual carriage** is more complicated, since in theory and in practice, different cost allocation systems are used (Chapter 3.3.). In the system presented in this chapter, all fixed costs are distributed along the time component (daily consumption). Variable costs are distributed on the basis of a single event (toll payments, terminals, etc.) and on the basis of kilometers traveled per individual carriage (fuel, oil, etc.). The criterion in the cost of fuel is the average consumption determined by an individual company on the basis of cost analysis by vehicles (point 5). The **objective of the analysis** is to determine how profitable each individual carriage is and whether there are factors disrupting the business process of the transport company. The disrupting factors arise in different business functions within a company (purchasing, sales, service organization) and should be eliminated. In this step, the company can answer the following questions during the analysis:
   - Do the prices of our transport services enable us to cover operating costs?
   - Do the prices of our transport services enable us to turn a profit and ensure the long-term development of the company?

- Are our transport services organized in a way that takes into account the shortest possible time of execution of each service?
- Do we only purchase resources that are essential for our operations?
- Are we paying a reasonable price for these essential resources?
- Are our capacities fully utilized given the current volume of our business?
- Do we have the right cost control information systems in place?

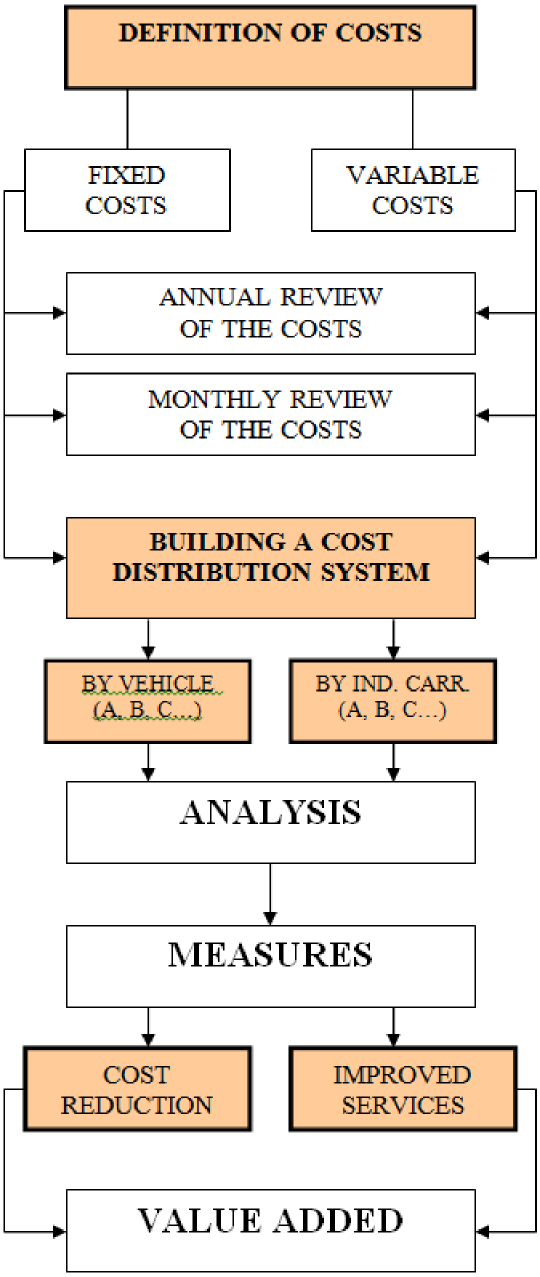

Figure 6: Cost management and control system

Source: Authors

7. The measures that follow are designed to reduce the total cost of operations and to implement quality transport services. The overall goal is increased added value, which allows the company's long-term survival in the cost-intensive transport sector.

Intertransport is correct in concluding that in order to run a successful business in the road transport sector, the responsibility does not lie only with the drivers, but also with the organizers of the transport services. However, without a proper cost control and management system, which takes into account the steps and measures described above, it is difficult to figure out which business function within the company is inefficient.

5 CONCLUSION

Road freight transport has many advantages over other types of transport. It has smaller transportation capacities, but its accessibility is the one great advantage that allows the long-term survival of a business. However, carriers are confronted with major problems in their daily operations, which reveal themselves in their worst form during an economic crisis. Lower freight rates, unfair competition and especially high costs are the factors that most affect the current operations of transport companies. In order for a company to operate successfully, it should therefore be familiar with all its costs. The goal is to build a customized cost management and control system that enables the company to perform a high quality analysis of its operations. Based on the analysis, which is based on past and present data, the company can adopt the necessary measures to ensure better organization, lower costs and higher quality of service.

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MODEL OF ENVIRONMENT - FRIENDLY AIRCRAFT HANDLING – CASE STUDY: ZAGREB AIRPORT

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ABSTRACT

In the era of increased awareness surrounding global warming and the importance of renewable energy, airports are affected by the rising costs of fossil fuels, as well as by the demands for the reduction of greenhouse gases emission. This paper reports the effort to determine the benefits of replacing gasoline and diesel-fueled internal combustion engine ground support equipment (ICE GSE) with electric ground support equipment (eGSE). The model of environment-friendly aircraft handling will be based on the examination of cost-effectiveness and reduction of greenhouse gases in the case of replacing fossil-fueled GSE with cleaner, more efficient electric-powered alternatives. In comparison with the current procedures of Ground Handling, the authors choose Zagreb Airport Ltd. as the representative airport for building Case Study and Airbus A319/A320 as the reference aircraft for calculation of greenhouse gases emission during handling process. The calculation method will be based on real time duration of processes performed by each piece of GSE during aircraft handling procedure. The usage of the model will be tested on aircraft handling for two airline business models: network and low cost. This research will show for the first time the relation between environmentally friendly procedures and vehicles, costs and increase in effectiveness during Aircraft Ground Handling.

Keywords: electric ground handling equipment, environment, aircraft emission, airport

1 INTRODUCTION

The aviation industry has the highest growth rate of all modes of transport and it could have serious implications for the environment in terms of pollution at local and global levels, and also in relation to land use planning, which means building new passenger terminals and runways. It is well known that aviation is a critical part of most economies worldwide, providing for the movement of people and goods throughout the world, enabling economic growth. It is known that aviation has impact in several environmental areas like: noise, air pollution, water, soil, and in this scientific paper the focus will be on air pollution. Air transport's contribution to climate change represents 2% of human-induced CO_2 emissions (12% of all transport sources) with airport activities share up to 5% of total aviation emissions. In the European Union, greenhouse gas emissions from aviation increased by 87% between 1990 and 2006 and over the past 40 years fuel efficiency improved by 70%; from 2001 – 2008 by 16%. There are many subjects which influence air pollution in the air traffic segment and they can be divided into several categories defined by the sources:

- aircraft through the burning of fuels such as Jet-A or Avgas

- aircraft ground movements
- ground airport vehicles (airside)
- transport used by passengers and staff to access airports,
- emissions generated by the production of energy used in airport buildings,
- the construction of airport infrastructure

2 REACTION OF ALL AVIATION STAKEHOLDERS ON REDUCING AIR POLLUTION

As Croatia will become 28th member of EU on July 1st 2013, it is mandatory to prepare all environmental obligations which will follow EU targets, better known as EU 20-20-20 Targets. It means that there should be a 20% reduction in EU greenhouse gas emissions from the 1990 levels; a rise in the share of EU energy consumption produced from renewable resources to 20%; and a 20% improvement in the EU's energy efficiency. In the following paragraphs there will be shown the best practices worldwide in achieving emission reduction goals divided by each stakeholder:

- **Government and aviation organizations** published lots of documents which precisely covered laws and methods how to reduce emissions. The main documents in this area are: ICAO Annex 16 and ICAO Doc 9889 "Airport Air Quality Manual", European Commission Documents, National directives and legislation, and Advisory Council for Aeronautics Research in Europe (ACARE) documents.
- **Aircraft manufacturers** – from the point of aircraft manufacture the two strongest manufactures in the market can be used: Airbus and Boeing. In the next few sentences their improvements will be shown: Airbus 380 has the lowest emissions of any large commercial aircraft 75g of CO2 per passenger km; Airbus 350 XWB is 86% below the current CAEP6 carbon monoxide (CO) limit and 35 % below the current mono-nitrogen oxide (NOx) limit. Boeing on the other side with a new Boeing 787 Dreamliner has a 20% reduction in fuel and CO2 emissions and 28% below 2008 industry limits for NOx (in comparison to Boeing 767); Boeing 737 MAX has a 13% reduction in fuel and Carbon dioxide and 50% below CEAP/6 limits for NOX (in comparison to Next Generation 737).
- ***Airlines reaction*** - using available GPU instead of APU results in fuel savings and less emissions– this saves about 19 million liters of jet fuel and eliminates more than 45 million kg of CO_2 emissions annually; engine wash: keeping aircraft engine components cleaner - engines operate more efficiently and save more than 27 million liters of jet fuel per year, as well as 68 million kg of CO_2; Single-Engine Taxi - using only one engine during taxi, when safe and operationally feasible it saves nearly 11 million liters of jet fuel and about 27 million kg of CO_2 emissions annually; replacing 19,000 catering carts with newer models made of lighter materials saves nearly 7,5 million liters of jet fuel annually. Also, a few years ago the airlines have started testing the usage of alternative fuel, and the first commercial flight using biokerosene was on October 6th 2011 with Boeing 757-200 operated by Thomson Airways, which carried 232 passengers from Birmingham Airport, UK to Arrecife, using a sustainable biofuels blend in one engine.
- ***Reaction of airports*** – airports have started to implement energy-efficient architecture, investing in energy-efficient technology and optimizing energy which they currently use; using Fixed Ground Power - aircraft parking positions with air bridges equipped with fixed GPU's result saving more CO_2 (aircraft APU can be

switched off); alternative power sources – the airports across Europe invest in renewable energy facilities such as biomass, geo-thermal power, solar power and even wind turbines; Ground Handling Vehicles - GH companies convert their vehicle fleets to electric, hybrid, hydrogen or LPG technology (e.g. High-speed Tow Tractors: transport aircraft between terminals and maintenance hangars, saving more than 15 million liters of jet fuel and reducing CO_2 emissions by 40 million kg annually); Airport Public Access - States/Counties/Cities/Airports invest in better public transport links to an airport (the encouraged use of bus, train or metro). The airports have started to compete in reducing emissions through Airport Carbon Accreditation Program which was launched in 2009. This program has four levels (mapping, reduction, optimization, neutrality) and 64 airports in Europe are accredited in this program.

- ***Reaction of Air Traffic Control*** – the implementation of CDM (Collaborative decision making) and CEM (Collaborative Environmental Management), in addition with CDA (Continuous Descent Arrival) and CCO (Continuous Climb Operation) at airports, results in the decrease of congestion during landings and takeoffs, on runways and taxiways, which results in the reduction of fuel, emissions and noise. Airports Council International Europe is working together with Eurocontol on the implementation of CDM on 40 airports which will have a benefit in estimated result savings over 475.000 tones of CO_2.

3 ROLE OF AIRPORT GROUND HANDLING IN REDUCING EMISSIONS AND FUEL SAVINGS

Each airport in line with its traffic increscent has a significant amount of activities during aircraft handling on the apron. Around the aircraft there are many vehicles and equipment which are specialized for some handling servicing activities, and also those vehicles and equipment were mostly powered by diesel or petrol fuel. From the point of view of the airport it is very important to follow and analyze the emissions from handling vehicles on a monthly or yearly basis, and also to work actively on the implementation of environmentally friendly equipment because it is already a major question of the airport future sustainable development. For that reason many airports are strategically focusing on the change of their apron ground handling equipment from gasoline or diesel to electric powered. In table 1 it is shown which equipment is currently used for aircraft handling, and in addition to that it shows the possibilities to change the existing conventional powered equipment with electric powered alternative.

Table 1: Insight into the ground handling equipment and its power sources

Ground Support Equipment			Power	
Acronym	Description of equipment	Purpose of use	Diesel/Gasoline	Electric
AC	Air conditioning unit	Aircraft	✓	✗
AS	Air starting unit	Aircraft	✓	✗
BULK	Bulk train	Baggage / cargo	✓	✓
CAT	Catering truck	Passengers	✓	✓
CB	Conveyor belt	Baggage / cargo	✓	✓
CLEAN	Cleaning truck	Passengers	✓	✓
FUEL	Fuel hydrant dispenser or tanker	Aircraft	✓	✗
GPU	Ground power unit	Aircraft	✓	✗
LD	CL lower deck cargo loader	Baggage / cargo	✓	✓
LV	Lavatory vehicle	Passengers	✓	✓

BUS	Bus for transfer passengers to aircraft	Passengers	✓	✓
PS	Passenger stairs	Passengers	✓	✓
TOW	Tow tractor	Aircraft	✓	✓
ULD	ULD train	Baggage / cargo	✓	✓
WV	Potable water vehicle	Passengers	✓	✓

Source: Authors research based on official Ground Handling Equipment Websites

For the better understanding of the equipment around aircraft for ground handling purpose, Figure 1 shows the position of all the equipment which can be used for handling Airbus A319/A320 aircraft. Each acronym marked on equipment on Figure 1 is described in Table 1.

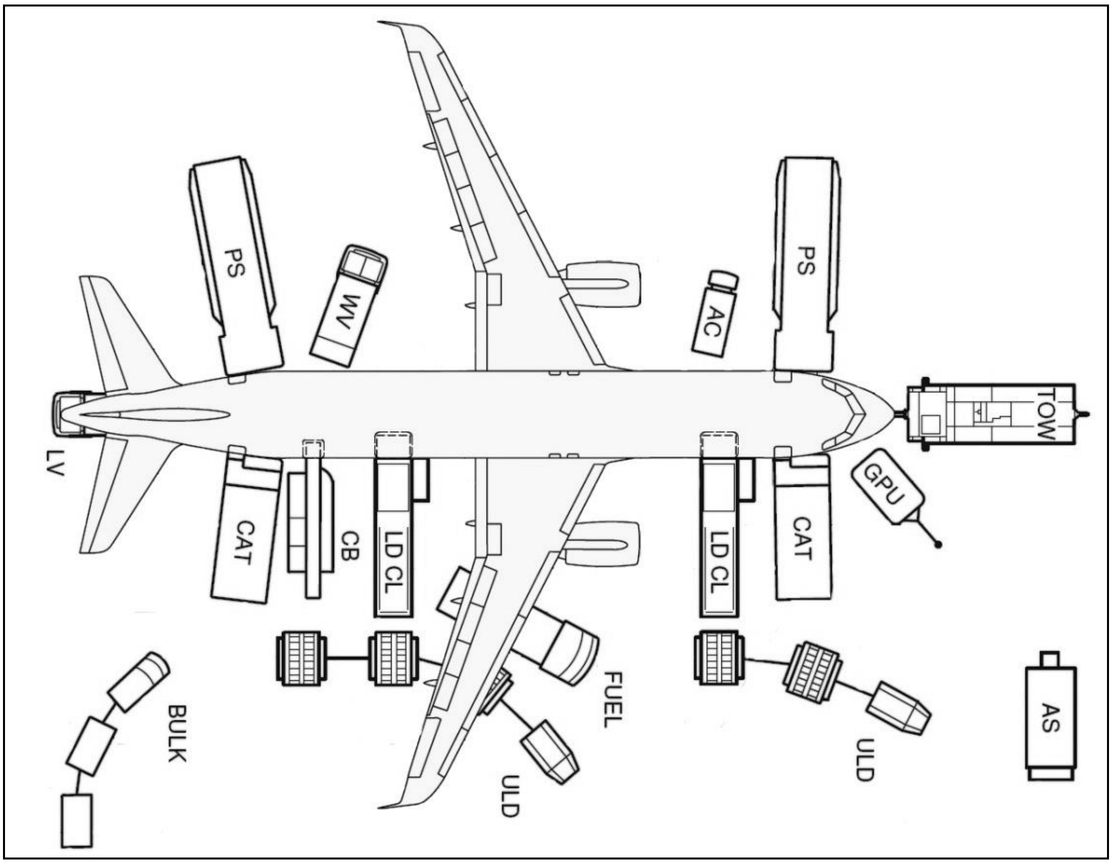

Figure 1: Standard position of Ground handling equipment for Airbus A319/A320

Source: Airbus aircraft characteristics airport and maintenance planning – manual

4 ENVIRONMENTAL AND FINANCIAL COMPARISON BETWEEN DIESEL/GASOLINE VS. ELECTRICAL GROUND HANDLING EQUIPMENT AT ZAGREB AIRPORT

For making the precise calculation and benchmark between diesel/gas and electrical equipment, it is necessary to measure time of activity for each equipment around aircraft, and as this scientific paper will also make a calculation for two different airline business models, such as traditional network carrier and low cost model, Figure 2 shows the difference in aircraft handling time divided by equipment. Table 2 shows the list of ground support equipment at Zagreb Airport considered in the Model of environmentally friendly aircraft handling. Fuel consumptions, as well as technical specifications concerning gasoline and diesel-fueled internal combustion engine ground support equipment (ICE GSE) were provided by Zagreb Airport. Technical specifications and information concerning electric ground support equipment (eGSE), selected to replace fossil-fueled GSE, were provided by eGSE manufacturers. eGSE is chosen to have the same capacities as ICE GSE, except in the case of replacing buses used to transfer passengers to the airport. COBUS 2500e, chosen to replace COBUS 3000, has a passenger capacity half the size of COBUS 3000. When calculating economical and environmental benefits due to fuel replacement, COBUS 2500e is considered to cover double distance of COBUS 3000 to transfer as many passengers as COBUS 3000.

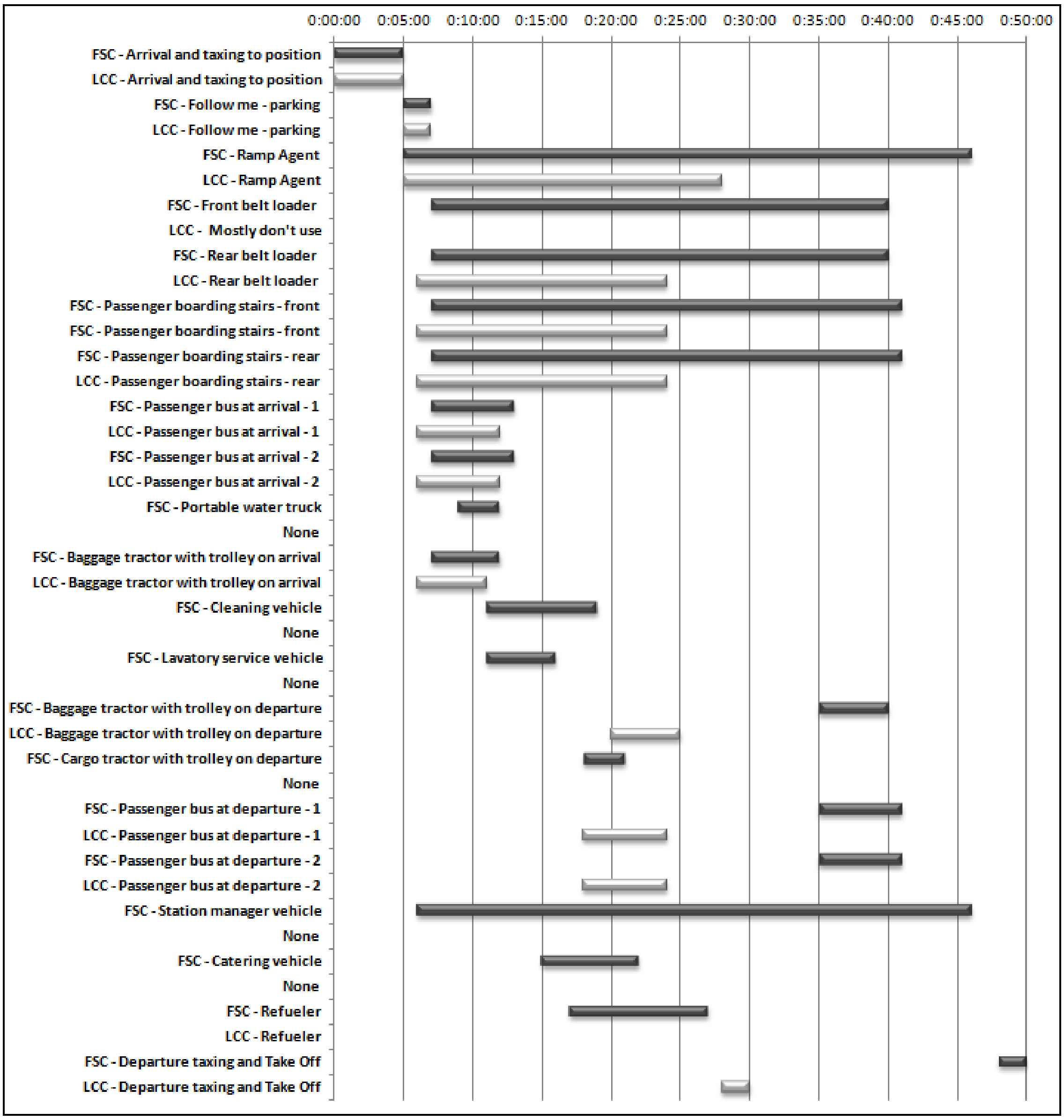

Figure 2: Comparison between aircraft handling time for Network (*FSC*) and Low cost (*LCC*) business model

Source: Average data measured by several handling operations at Zagreb Airport

From Figure 2 it can be easily seen that due to economic reasons and business strategy of Low cost airlines in comparison with Network carriers (FSC – Full Service Carriers), low cost airlines have aircraft block time of 25-30 minutes while Network Carriers have 45 minutes. That short block time on low cost strategy is mainly because their business is based on higher aircraft utilization, using very basic equipment (stewardess clean the aircraft by themselves, refueling is usually made at a low cost base airport, the loading area is in advance determined due to weight and balance reasons). As low cost airlines do not use all the equipment that Network Carriers do, and by analyzing the list of available electric powered equipment it can be said that the airports on which low cost airlines do not make refueling it is possible to create green apron with only electrical powered equipment and zero emissions.

Table 2: List of GSE considered in the Model of environmentally friendly aircraft handling

GSE Type	ICT GSE	Fuel	Fuel consump. [l/h]	Characteris.	eGSE	Fuel	Battery capac. [kWh]	Motor: contin. power [kW]	Characteristics
	Mulag Diesel Convoyer Belt Orbiter 9D	**Diesel**	0,94	Max. height front (mm): 4800 Distributed load (kg/m): 150 Max. individual unit weight (kg): 400	Mulag Orbiter 9E	**Elect.**	40	12	Max. height front(mm): 4930 Distributed load (kg/m): 135 Max. individual unit weight (kg): 400
	Hunert 427-03 D	**Diesel**	2,51	Load capacity per step (kg): 150 Platform height: Max: 5800 mm Min: 2450 mm	JBT UES-2	**Elect.**	40	13	Load capacity per step (kg): 228 Platform height: Max: 5730 mm Min: 2450 mm
	Mulag Comet V-1	**Diesel**	2,63	Drawbar pull (kN): 20	Mulag Comet 3E	**Elect.**	49,6	20	Drawbar pull (kN): 20
	Schrader (Chassis: Iveco ML75)	**Diesel**	2,41		CLT200E - Electric Lav Truck	**Elect.**	40	30	
	Schrader (Chassis: Iveco ML75)	**Diesel**	2,05		CWT300E - Electric Water Truck	**Elect.**	40	30	
			Fuel consump. l/km]						
	VW Transpor.	**Gasol.**	0,2627	Payload capacity : 900 kg	Mercedes Vito E-Cell	**Elect.**	36	60	Payload capacity : 900 kg
	MAN Catering Truck	**Diesel**	0,2147		Smith Newton – Refrigerated Box	**Elect.**	84	120	
	VW Polo 1.6 TDI	**Diesel**	0,034	Max. Speed (km/h): 170 Acceleration 0-100 (sec): 14 Dimensions (cm): 397 x 168,2 x 148,5	Mitshubishi i MiEV	**Elect.**	16	49	Max. Speed (km/h): 130 Acceleration 0-100 (sec): 15,9 Dimensions (cm): 347,5 x 147,5 x 161,0
	COBUS 3000	**Diesel**	0,665	Passenger capacity : Up to 112 passengers and up to 14 seated	COBUS 2500e	**Elect.**	150	134	Passenger capacity : Up to 66 passengers and up to 24 seated

Source: Authors collected data via direct communication with manufactures and sales agents

Since GSE used in aircraft handling operations in the network business model differs from GSE used in low cost business model, as well as the durations of participation of each piece of equipment, separate calculations for these two models have been made. When calculating economic benefits and carbon dioxide reduction due to fuel replacement, the data from Table 3 have been used.

Table 3: Fuel prices and carbon dioxide emissions

Fuel	Type	Fuel price [EUR]	Tailpipe carbon dioxide emission [kg]	Carbon dioxide emission from electricity generation[kg]
Diesel	INA Eurodizel BS	1,2832	2,6817	0
Gasoline	INA Eurosuper 95 BS	1,3782	2,3533	0
Electricity	Low (night) tariff	0,0593	0	0,305

Source: Official prices from INA http://www.ina.hr/ and HEP http://www.hep.hr/

4.1 Economic benefits of fuel replacement

The economic benefits resulted from fuel replacement have been calculated in the case of one aircraft Airbus A319/A320 handling operation, as well as in the case of several operations performed on a single battery charge for network and low cost business model. When calculating power consumptions of belt loaders, passenger boarding stairs, baggage and cargo tractors, potable water trucks and lavatory service vehicles, eGSE was considered to work with rated power for the whole duration of participation in aircraft handling operation. When calculating power consumptions of cleaning and catering vehicles, buses, station manager, ramp agent and "Follow me" vehicles, the distances covered in handling operation were taken into consideration.

Table 4: Economic benefits of fuel replacement in one aircraft Airbus A319/A320 handling operation – network business model

Qty	GSE Type	Duration of participation in one aircraft handling procedure [min]	Fuel consump. [l]	Fuel cost [EUR]	Electrical power consump. [kwh]	Electrical power cost [EUR]	Savings due to fuel replacement [EUR]
2	Belt loader	16,50	0,517	0,663	6,600	0,391	**0,272**
2	Passenger boarding stairs	10,20	0,853	1,095	4,420	0,262	**0,833**
1	Baggage tractor	10,00	0,438	0,562	3,333	0,198	**0,365**
1	Cargo tractor	8,00	0,351	0,450	2,667	0,158	**0,292**
1	Potable water truck	3,00	0,103	0,132	1,500	0,089	**0,043**
1	Lavatory service vehicles	5,00	0,201	0,258	2,500	0,148	**0,109**
		Distance covered in one aircraft handling procedure [km]					
1	Station manager	0,80	0,027	0,035	0,108	0,006	**0,028**
1	Ramp Agent	2,20	0,075	0,096	0,297	0,018	**0,078**
1	"Follow me" vehicle	1,40	0,048	0,061	0,189	0,011	**0,050**
2	Bus	1,40	1,064	1,365	5,600	0,332	**1,033**
1	Cleaning vehicle	0,75	0,263	0,362	0,208	0,012	**0,350**
1	Catering vehicle	0,50	0,215	0,275	0,261	0,015	**0,260**

The economic benefits of fuel replacement in one aircraft Airbus A319/A320 handling operation in the case of network business model can be seen in table 4. Saving due to fuel replacement in the case of network business model is 3,71 EUR per aircraft handling operation. Zagreb Airport has approximately sixteen network carrier handling operations with aircraft Airbus A319/A320 daily. Savings due to fuel replacement are 59,36 EUR daily and 21.666,40 EUR annually.

Table 5: Economic benefits of fuel replacement in aircraft Airbus A319/A320 handling operations performed on a single battery charge – network business model

		eGSE			ICE GSE	
Qty	GSE Type	Time operating on a single battery charge [h]	Number of ground handling operations performed on a single battery charge	Electrical power consumption [kWh]	Fuel consump. [l]	Savings due to fuel replacement [EUR]
2	Belt loader	3,33	12	80,00	6,27	**3,30**
2	Passenger boarding stairs	3,08	18	80,00	15,45	**15,08**
1	Baggage tractor	2,48	15	49,60	6,52	**5,43**
1	Cargo tractor	2,48	19	49,60	6,52	**5,43**
1	Potable water truck	1,33	27	40,00	2,73	**1,13**
1	Lavatory service vehicles	1,33	16	40,00	3,21	**1,75**
		Distance covered on a single battery charge [km]				
1	Station manager	118,52	148	16,00	4,03	**4,22**
1	Ramp Agent	118,52	54	16,00	4,03	**4,22**
1	"Follow me" vehicle	118,52	85	16,00	4,03	**4,22**
2	Bus	150,00	54	300,00	57,00	**55,35**
1	Cleaning vehicle	130,00	173	36,00	45,53	**60,61**
1	Catering vehicle	160,00	322	84,00	69,12	**83,72**

The economic benefits of fuel replacement in aircraft handling operations performed on a single battery charge in the case of network business model can be seen in Table 5. The number of ground handling operations performed on a single battery charge differs for every piece of ground support equipment, as it depends on battery capacity, motor power, duration of participation and distance covered in one aircraft Airbus A319/A320 handling operation.

Table 6: Economic benefits of fuel replacement in one aircraft handling operation – low cost business model

			ICE GSE		eGSE		
Qty.	GSE Type	Duration of participation in one aircraft handling procedure [min]	Fuel consumpt. [l]	Fuel cost [EUR]	Electrical power consumption [kwh]	Electrical power cost [EUR]	Savings due to fuel replacement [EUR]
1	Belt loader	16,20	0,254	0,326	3,240	0,192	0,134
2	Passenger boarding stairs	5,40	0,452	0,580	2,340	0,139	0,441
1	Baggage tractor	10,00	0,438	0,562	3,333	0,198	0,365
		Distance covered in one aircraft handling procedure [km]					
1	Ramp Agent	2,20	0,075	0,096	0,297	0,018	0,078
1	"Follow me" vehicle	1,40	0,048	0,061	0,189	0,011	0,050
2	Bus	1,40	1,064	1,365	5,600	0,332	1,033

Source: Calculation was made by authors based on manufacture data

The economic benefits of fuel replacement in one aircraft handling operation in the case of low cost business model can be seen in Table 6. Saving due to fuel replacement in the case of low cost business model is 1,80 EUR per aircraft handling operation. Zagreb Airport has approximately three low cost airlines with aircraft Airbus A319/A320 handling operations daily. Savings due to fuel replacement are 5,40 EUR daily and 1.971 EUR annually.

Table 7: Economic benefits of fuel replacement in aircraft handling operations performed on a single battery charge – low cost business model

		eGSE			ICE GSE	
Qty.	GSE Type	Time operating on a single battery charge charge [h]	Number of ground handling operations performed on a single battery charge	Electrical power consumption [kWh]	Fuel consumpt. [l]	Savings due to fuel replacement [EUR]
1	Belt loader	3,33	12	40,00	3,13	1,65
2	Passenger boarding stairs	3,08	34	80,00	15,45	15,08
1	Baggage tractor	2,48	15	49,60	6,52	5,43
		Distance covered on a single battery charge [km]				
1	Ramp Agent	118,52	54	16,00	4,03	4,22
1	"Follow me" vehicle	118,52	85	16,00	4,03	4,22
2	Bus	150,00	54	300,00	57,00	55,35

Source: Calculation was made by authors based on manufacture data

The economic benefits of fuel replacement in aircraft handling operations performed on a single battery charge in the case of low cost business model can be seen in Table 7. The results indicate that the higher the consumption of fossil fuels is, the greater savings due to replacement there will be. Such results are expected since diesel and gasoline have much higher prices than electricity. The calculated daily savings due to fuel replacement in the case of sixteen network carrier and three low cost carrier aircraft Airbus A319/A320 handling operations are 38,79 EUR. The calculated annual savings rise up to 23.637,40 EUR.

4.2 Environmental benefits of fuel replacement

The environmental benefits due to the replacement of fossil fuels with electricity, as well as the economic benefits, have been calculated in the case of network and also in the case of low cost business models. Table 8 shows the reduction of carbon dioxide emission due to fuel replacement in aircraft handling operations performed on a single battery charge in the case of network business model, and Table 9 shows the reduction in the case of low cost business model. The results indicate that not all of the replacements of fossil-fueled ICT GSE with eGSE lead to carbon dioxide emission reduction. Electric vehicles have zero tailpipe emissions, but carbon dioxide emissions are produced in electricity generation. The CO_2 emission from fossil fuels consumed for generating one kWh of electricity in Croatia, in both electricity-only and combined heat and power plants, amounts to 305 grams. In areas that use relatively low-polluting energy sources for electricity production, electrical vehicles typically have emissions advantage over similar conventional vehicles running on gasoline or diesel. In areas that are heavily dependent on conventional fossil fuels for electricity generation, electrical vehicles may not demonstrate carbon dioxide emission reduction. The replacement of belt loaders in both business models and the replacement of potable water truck and lavatory service vehicle in network business model do not result in the emission reduction. These vehicles do not have high diesel consumptions; hence generation of electricity used to charge batteries produces greater carbon dioxide emissions than tailpipe emissions from fossil fuel combustion. The replacement of ICE GSE with high fossil fuel consumption shows a significant carbon dioxide emission reduction.

Table 8: Environmental benefits of fuel replacement – network business model – A319/A320

			ICE GSE	eGSE		
Qty	GSE Type	Number of aircraft handling operations performed	Talpipe carbon dioxide emission [kg]	Tailpipe carbon dioxide emission [kg]	Carbon dioxide emission due to electricity generation [kg]	Reduction of carbon dioxide emission due to fuel replacement [kg]
2	Passenger boarding stairs	18	41,42	0,00	24,40	**17,02**
1	Baggage tractor	15	17,49	0,00	15,13	**2,36**
1	Cargo tractor	19	17,49	0,00	15,13	**2,36**
1	Station manager	148	10,81	0,00	4,88	**5,93**
1	Ramp Agent	54	10,81	0,00	4,88	**5,93**
1	"Follow me" vehicle	85	10,81	0,00	4,88	**5,93**
2	Bus	54	201,13	0,00	91,50	**109,63**
1	Cleaning vehicle	173	107,14	0,00	10,98	**96,16**
1	Catering vehicle	322	185,37	0,00	25,62	**159,75**

Source: Calculation was made by the authors based on the manufacture data

The reduction of carbon dioxide emission due to fuel replacement in the case of low cost business model is 3,64 kg per aircraft handling operation. Zagreb Airport has approximately sixteen network aircraft Airbus A319/A320 handling daily. The reduction of carbon dioxide emission due to fuel replacement is 58,24 kg daily and 21.257,60 kg annually.

Table 9 Environmental benefits of fuel replacement – low cost business model

			ICE GSE	eGSE		
Qty.	GSE Type	Number of aircraft handling operations performed	Talpipe carbon dioxide emission [kg]	Tailpipe carbon dioxide emission [kg]	Carbon dioxide emission due to electricity generation [kg]	Reduction of carbon dioxide emission due to fuel replacement[kg]
2	Passenger boarding stairs	34	41,42	0,00	24,40	**17,02**
1	Baggage tractor	15	17,49	0,00	15,13	**2,36**
1	Ramp Agent	54	10,81	0,00	4,88	**5,93**
1	"Follow me" vehicle	85	10,81	0,00	4,88	**5,93**
2	Bus	54	201,13	0,00	91,50	**109,63**

Source: Calculation was made by the authors based on the manufacture data

The reduction of carbon dioxide emission due to fuel replacement in the case of low cost business model is 1,98 kg per aircraft handling operation. Zagreb Airport has approximately three low cost aircraft Airbus A319/A320 handling operations daily. The reduction of carbon dioxide emission to fuel replacement is 5,95 kg daily and 2.170,34 kg annually. The calculated reduction of carbon dioxide emission due to fuel replacement in the case of sixteen network and three low cost aircraft Airbus A319/A320 handling operations is 38,70 kg daily. Calculated annual reduction of carbon dioxide emission is 23.427,94 kg.

5 CONCLUSION

The airport sustainability is very dependent on the care about the environment, and in future there will be much more pressure on airport management and aircraft handling agents to fulfill all the requirements that Countries will put in place. The results of economical and environmental benefits analysis due to fuel replacement in the cases of one aircraft handling procedure, as well as several handling procedures performed on a single battery charge, indicate that the higher the consumption of fossil fuels is, the greater savings and carbon dioxide emission reduction due to replacement there will be. In the case of replacing ICE GSE with low fossil fuel consumption with eGSE with a large battery capacity, there is no carbon dioxide emission reduction because the generation of electricity used to charge batteries produces greater carbon dioxide emissions than tailpipe emissions from fossil fuel combustion. This scientific paper showed that airports have space for improvement in environmental way, and there is a possibility in their core business for aircraft handling to be done with very low emissions provided by equipment. By using electric power equipment instead of the current diesel or gasoline, the research has showed that it is possible to create environmentally friendly business surroundings at an airport by creating the "Green Apron" system.

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HEATING TECHNIQUES IN BALLAST WATER TREATMENT

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ABSTRACT

Ballast water is recognized as a vector for transference of various species from one geographical region to others, all around the world. Consequences are influence on ecology of species in the environment where ballast water is discharged, with the possible impact on human health and/or economy. This paper is a review on different heating techniques that have been tested in accordance with the International Maritime Organization (IMO) propositions, to minimize the number and abundance of species that shift through the ballast water. Studies on heating techniques have shown certain following advantages: low environmental impact as well as economical benefit when utilising the available heat resources on board the ship. Potential disadvantages are achieving high temperatures during short voyages, heat system implementation on ship and insufficient temperatures for treatment of some organisms.

Keywords: ballast water, heat, marine organisms, environment

1 INTRODUCTION

Nowadays, due to current ship traffic, ballast water presents one of the greatest ecological issues, introducing new, allochthonous species in geographically very distant and different regions and environments [1]. Establishing their habitat in the new environment, this new species could have negative influence in activities, food chain, reproduction and ecology of autochthonic species [2]. Furthermore, some of those marine organisms are also a threat to human health [3].

However, ballast water is essential factor in maintaining the safety, maneuverability and stability of ships at sea. Therefore, to resolve the ballast water environmental problems and to prevent the introduction of potentially invasive species, different treatment methods have been proposed: filtration and separation, chemical methods (oxidizing and nonoxidizing biocides), heat treatment, ultraviolet (UV) radiation, ultrasonic, ionization, etc [4]. Implementation of all of these methods has shown their advantages and disadvantages. The greatest results in ballast water treatment came from combining two or more methods, such as heat-treatment technologies in combination with microwave and ultrasound, where efficiencies of 100% on various organisms have been reported [5].

This review paper summarizes the available technologies applied for ballast water heat treatment and their efficiency to inactivate fresh water and marine potentially invasive species.

2 BALLAST WATER MANAGEMENT ON BOARD THE SHIPS TODAY

According to IMO there are three recognized ballast water management methods:

1. Ballast water exchange at sea

2. Ballast water treatment
3. Isolation

At this moment, the exchange at sea method is the most commonly used method on board the ships. It is important to emphasize it is the least expensive and practically applicable to most of the existing ships today.

In this respect IMO recognizes only two methods:

1. Sequential
2. Flow-through (Overflow)

Sequential method requires that water in a ballast tank should be replaced in all ballast tanks by emptying and filling each ballast tank as much as it is practically possible. This method requires one ballast tank volume to be exchanged in order to achieve 95% of exchange ratio. Overflow method is a continuous exchange of ballast water in the tanks by pumping seawater in the ballast tanks and at the same time allowing ballast water to overflow through ballast ventilation heads on the decks. Due to the fact that by this method fresh sea water dilutes with old ballast water in the tanks, a minimum of three ballast tank volumes needs to be exchanged in order to achieve 95% of exchange ratio.

Both methods are complying with requirements that 95% of the original ballast water must be replaced, but problem usually imposed is that many organisms, with higher density than water, tend to settle as sediment at the bottom of the tanks.

However, as shown in Table 1, those methods are expected to completely give way to effective Ballast Water Treatment [6].

Table 1: Timetable for installation of ballast water treatment systems

Ballast capacity	Year of ship construction*			
	Before 2009	2009+	2009-2011	2012+
< 1,500 m^3	Ballast water exchange or treatment until 2016 Ballast water treatment only from 2016	Ballast water treatment only		
1,500 – 5,000 m^3	Ballast water exchange or treatment until 2014 Ballast water treatment only from 2014	Ballast water treatment only		
> 5,000 m^3	Ballast water exchange or treatment until 2016 Ballast water treatment only from 2016		Ballast water exchange or treatment until 2016 Ballast water treatment only from 2016	Ballast water treatment only

Source: (Lloyd's Register Ballast Water Treatment Technology 2011)

3 BALLAST WATER HEAT TREATMENT METHOD

One of the approved ballast water treatment methods is heat treatment, and it is noteworthy to say most of the known researches of ballast water treatment by heat stemmed from significant work by Boch & Hallegraeff [7] where it was found that a particular organism (*Gymnodinium catenatum*) can be efficiently killed by heating the water between 40˚ - 45˚C for the period of 30-90 seconds.

Bearing in mind (the) ships' construction and equipment on board, ballast water heat treatment method could be applied based one of the two following principles:

1. Open circle process
2. Closed circle process

3.1 Open circle process

Ballast water heat treatment method in the open circle process was suggested by Rigby & Hallegraeff [8] where heated seawater after being used for main engine cool down was delivered to a ballast tank, and excess water in the ballast tank was freely overflowing on the ship's deck. It was established that this method requires between 20 and 30 hrs. to achieve maximum temperature in the ballast tank, and therefore belongs to a biological criterion of middle and long exposure of the organisms.

This method in the open circle process is a combination of flow-through ballast water exchange method and heat treatment method in order to improve the efficiency of killing the organisms in the ballast water (Fig.1).

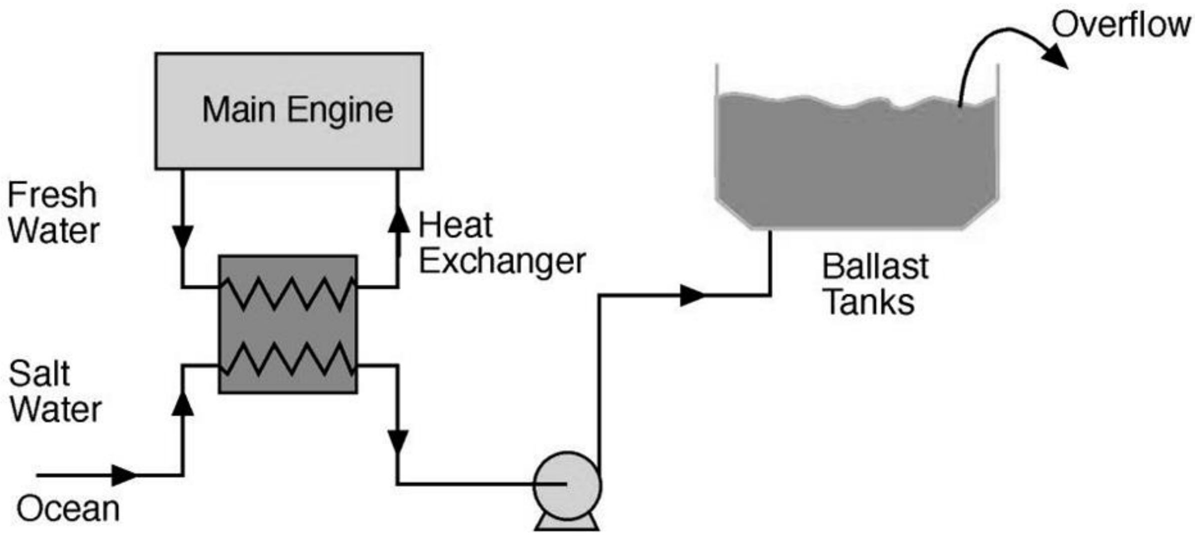

Figure 1: Heating circuit used to simultaneously flush and heat ballast water on the Iron Whyalla

Source: (Rigby, G., Hallegraeff, G. M., & Sutton, C., 1999. Novel ballast water heating technique offers cost-effective treatment to reduce the risk of global transport of harmful marine organisms. Mar. Ecol. Prog. Ser., 191, 289-293.)

3.2 Closed circle process

By using ballast water heat treatment method in the closed circle process, the goal is to achieve less time consuming process. This method belongs to a biological criterion of short exposure of the organisms. There are three common heat treatment methods in the closed circle process:

1. Sobol's water ballast heat treatment method
2. Thronton's water ballast heat treatment method
3. Ballast water heat treatment method in closed circle process as per biological criterion of middle exposure of organisms

obolet *et al.* [9] stipulates that ballast water is treated through three heat exchangers in the closed circle process, where it successfully increases ballast water temperature from 13˚C to

70˚C efficiently killing all organisms. It must be emphasized that applying Sobol's method, heat generated from cooling down system of the main engine is not fully utilized, and by certain modifications it would be possible to achieve better results in heating of ballast water.

Thornton [10] proposed recirculation of the ballast water in the same ballast tank. This method considers loading of heated ballast water on top of the ballast tank, and gradually discharging cold ballast water from the bottom of the ballast tank. Since cold ballast water is heavier than worm ballast water, dilution should not occur during controlled process, and it is expected that it would be necessary to exchange 1,2 volumes of the ballast tank capacity in order to achieve 90 % of successfully treated ballast water in the tank.

Ballast water heat treatment method in the closed circle process as per biological criterion of middle exposure of organisms directly derived from the method of heat treatment in the open circle process by Rigby *et al.* [11]. However, by applying this method heat losses are minimized by heating the ballast water with waste heat of main engine, circulating in a well-insulated tank for processing. Heating of the ballast water is maximized to a certain temperature after which, a part of the heated water is transferred to the first stage heat exchangers and remaining water to a cooling-down tank prior to returning to the original ballast water tank.

One of the recent researches on board the ships was carried out by Quilez-Badia *et al.* [12] on board M/S *Don Quijote* where ballast water was circulated by fire pump and fire main line on board, and heated using two heat exchangers. Pre-heater increased the temperature to 40-45˚C and second heat exchanger, using steam from the ship's boiler, increased temperature to the desired temperature for the particular trial (Fig. 2). After ballast water reached required treatment temperature, it was cooled prior to discharge overboard.

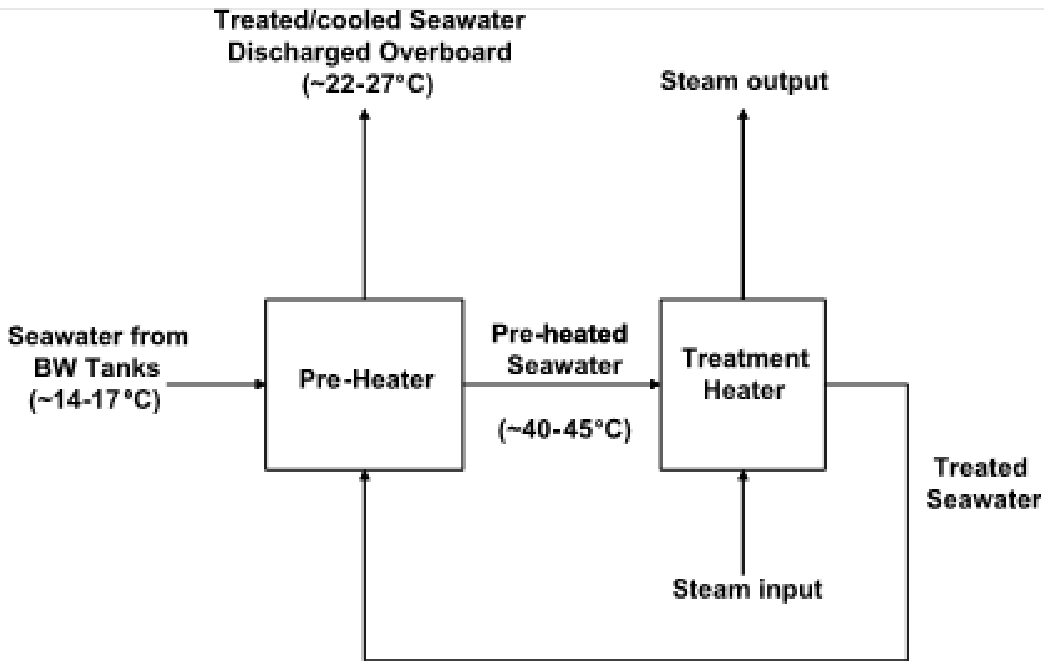

Figure 2: Simplified diagram of the heat treatmen system

Source: (Quilez-Badia, G., McCollin, T., Josefsen, K. D., Vourdachas, A., Gill, M. E., Mesbahi, E., & Frid, C. L. 2008. On board short-time high temperature heat treatment of ballast water: A field trial under operational conditions. Mar. Poll. Bull., 56, 127–135.)

4 BIO-ECOLOGICAL ASPECTS OF HEATING TECHNIQUES IN BALLAST WATER TREATMENT

PSP (paralytic shelf poisoning) was unknown in Australia until the late 1980s when the first toxic dinoflagellate blooms appeared in the ports of Hobart caused by *Gymnodinium catenatum*. Therefore, one of the first ballast water heat treatment, as already mentioned was done in Australia, where different temperatures and different periods were implemented to kill cists of *Gymnodinium catenatum*. Initial laboratory work indicated that heating *Gymnodinium catenatum* dinoflagellate cysts to temperatures of 40 to 45 ^{O}C for very short periods of time (90 to 30 s) resulted in death [7].

The Rigby & Hallegraeff [13] research on heating techniques of ballast water on the bulk carrier *Iron Whyall* indicated some problems with maintaining constant temperature of 45 ^{O}C in all ballast tanks, which was very effective for killing phytoplankton and zooplankton. In addition, Rigby & Taylor [14] proposed different heating treatment options for international voyages where the hot water from the main engine cooling circuit is flushed through each tank.

A series of further experimental tests demonstrated that most phytoplankton algae tested, including the diatom *Skeletonema costatum, dinoflagellates Amphidinium carterae, Gymnodinium catenatum* and *Alexandrium catenella*, and the golden brown flagellate *Heterosigma akashiwo* in the vegetative stage, could be killed at temperature 35 °C in period from 30 min to several hours [15].

Rigby *et al.* [16] suggested that heating of the entire tank for prolonged periods of time is more effective for killing plankton, than short term acute exposure. Short term heating (1–2 min at 38.5–42.5 ^{O}C) might not be sufficient to kill some planktonic organisms from tropical waters.

Thornton [10] reported significant plankton mortality (80-90% successful) in the treated tank, when using an on-board heat system with ballast from one of the 350 tones ballast tanks on the Australian bulk carrier *MV Sandra Marie* on a voyage from Sydney to Hobart in May 1997.

Mountfort *et al.* [17, 18] examined which temperature/time is more suitable for inactivation of different type of marine organisms. Authors were analyzing seaweed *Undaria pinnatifida,* mollusk *Crassostrea gigas* and starfish *Coscinasterias calamaria*, which were considered to be spread through the entire ballast tank. It was concluded that effective treatment would be one that is either long (≥16 h at ≤36 ^{O}C), medium (10 min to 16h at 36-45 ^{O}C) or short duration (≤10min at ≥46 ^{O}C).

Species mortality has been proven when temperatures are sustained for extended periods. However, in Europe where many vessels operate on short coastal journeys heat treatments that take hours to treat ballast water are not always optional. Therefore, on board study of a voyage from Egypt to Belgium was done using ballast water short-time high temperature heat treatment technique [12]. Ballast water from three tanks was subjected for a few seconds to temperatures ranging from 55 ^{0}C to 80 ^{0}C. The water was heated using the vessel's heat exchanger steam and a second heat exchanger was used to pre-heat and cool down the water. The treatment was effective at causing mortality of bacteria, phytoplankton and zooplankton. No differences were found when increasing the treatment temperature for either bacteria or zooplankton, which was unusual, especially for bacteria. Still, in this study bacterial endospore, which usually required more than 100 ^{0}C for several minutes to be killed, were not found. The low concentrations of phytoplankton present in the water made it difficult to ascertain whether this method was efficient for them.

Recent study of implementation of continuous microwave heating system showed that complete inactivation of the *Artemia nauplii* (zooplankton-shrimp) was done at a temperature of 47 °C and for Artemia adults at even lower temperatures (43 °C) during microwave treatment. Slightly higher temperatures of 53 and 51 °C were required for complete inactivation of the *Nannochloropsis oculata* (microalgae) and *Crassosstrea virginica* (oyster larvae) using the continuous microwave system. Therefore, the authors concluded that an optimum process temperature of 55 °C with a holding time of 200 s is sufficient for treatment of tested organisms [4].

Heat-treatment technologies singly and in combination with microwave and ultrasound have been tested with various organisms and efficiencies of 100% has been reported [5].

5 DISCUSSION

According to the Ballast Water Convention, the International Maritime Organisation (IMO) has set Ballast Water Exchange Standard, D1 and Ballast Water Performance Standard (BWPS), D2. From 2009, vessels follow D1 or D2, though the Regulations are not in full effect. As of 31 January 2011, 27 countries representing 25.32% of world's merchant shipping tonnage had ratified the ballast water treaty (IMO) [19]. As of 19 March 2013, 36 States have ratified the Convention, representing 29.07% of the world merchant fleet tonnage, whereas a minimum number of 30 countries representing not less than 35% of the gross tonnage are required for ratification. The BWM Convention will enter into force 12 months after ratification by 30 States, representing 35% of world merchant shipping tonnage. This data implies urgency in effecting the ballast-water management practices [20].

Above reviewed techniques indicate that heat treatment of ballast water using heat from ships engines, or together with additional heat exchangers, is strong candidate for stand-alone treatment for ballast water, offering ecologically acceptable, safe handling and cost effective solution excluding capital cost for initial modification of ship's systems.

However, strong concerns exist in connection to a time and energy required for achieving necessary temperature particularly for the ships operating in colder seas and on the short voyages. Initial cost of modifying ship's systems in order to utilize waste heat from the ships engines should not present decisive factor notably for the ships with steam driven equipment already fixed on board.

This could suggest the explanation why according to the Lloyd's Register list of approved ballast water treatment systems there is only one supplier offering Heat treatment for ballast water, but no units installed on board the ships yet.

In this respect an approach to optimize the ballast management would be to combine technologies in an economical way. A method such as heat treatment which can harness the easily available shipboard resources combined with another physical disinfection method such as filtration and/or deoxygenation can be worked upon. This would be seen as a well-considered optimisation in shipboard ballast-water management [19].

However, no treatment option has been shown to be 100% effective, environmentally acceptable, cost effective, safe and practical for use onboard ships yet.

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THE IMPACT OF ROAD USERS ON THE EFFECTIVENESS OF ROAD TRAFFIC

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ABSTRACT

Road traffic belongs among the most vast modes of transport that everyone starts using from an early age on. With regard to their participation in road traffic, we can distinguish between various groups of traffic participants, who cause different traffic situations through their participation, which make forecasts within the traffic system difficult. Every single participant in road traffic impacts its effectiveness, however we still cannot treat the entire field as homogeneous but from the aspects of people, roads, and vehicles. A comprehensive treatment of the aforementioned factors provides objective results and points out the directions of future development, as well as emphasizes the disadvantages that come along with it.
For a comprehensive representation of and a systematic approach to traffic participants, a pie chart is the most suitable means since it treats traffic as a model. Based on a model, also the effectiveness of individual groups of traffic participants can be demonstrated. People travel from point A to point B on foot or with a vehicle. For that purpose, they use roads, which are a part of the environment. In this model, the road network and the environment usually depend on the infrastructure. In this case, the model is used for forecasting.

Keywords: traffic participants, effectiveness of road traffic, road traffic

1 INTRODUCTION

The social and economic development calls for a modern traffic system, to which also road traffic belongs. The development of a society, positive attitude of the economic system, creative urban activities, and communicational connectivity largely depend on suitable support by the traffic system. If it is insufficient, spread wide apart and unconnected, no positive results in the macro social sphere, or the actual social and economic environment can be expected. Technological development requires traffic effectiveness that will reduce the costs of created or acquired goods, increase the added value, and provide a positive stance towards the users of traffic subsystems.

An effective and by means of proper actions supported road traffic significantly impacts the state and development of a certain social environment. Its positive attitude shows in the economy, society, demography, as well as safety. All the aforementioned effectiveness indicators are tightly interconnected and thus complementary, whereas their activities need to be balanced. The predominant impact of one or several factors mostly triggers negative response in other fields, which causes elementary discordances leading into a predominant impact of individual indicators, which step by step takes its toll on the system as a whole, and can bring it to a collapse.

It can be said that the traffic effectiveness in Slovenia is highly polarized and the state has no clearly defined long-term guidelines in that field that could gradually, but permanently, connect all the traffic subsystems. Sadly, political decisions often play the key role in these matters, therefore we often focus on only one traffic effectiveness subsystem, whereas in another political environment, another traffic subsystem gets all the attention. One way on another, none of them is completed so we keep going back to where it started and begin again.

In the short-term planning system, the problem is especially evident in the non-systematic traffic policy planning and its development, which significantly affects the effectiveness of the traffic system. At a time of absolute traffic repression, when the safety aspect is predominant pointing out people as the key factor of a traffic system, there is a widening gap between the technological development of traffic infrastructure and the actual needs since there is virtually no leverage for such development. Sadly, in Slovenia people as the users of traffic infrastructure have always had the predominant negative impact and have thus been an impediment for traffic effectiveness. With such evaluation, we create the feeling of absolute and complete responsibility. Of course, such a formulation is false but the most frequent and the easiest to describe in terms of its value in practice. Such a weight is not difficult to argument with the aid of numerous statistical data, which consequentially also impacts the response of the public, which virtually knows no other segments of traffic effectiveness.

The aim of the task is to achieve balance and interconnection between segments of traffic effectiveness. However, the path to the described theoretic starting points is not going to be easy since such a development also requires systematic responsibility and approach to the solutions. In this paper, pie charts are applied for an effective solution of all unsystematic approaches since they allow for systematic solutions to traffic effectiveness, which is a problem in most European countries.

In the treatment of traffic effectiveness, road traffic must not be a separate elementary subject. The same applies to rail, air, and marine traffic. An unsystematic development of one field causes the stagnation of another. But since a developing system in itself requires the establishment of a connection to other subsystems, it sooner or later brings us to the point where the progress stops. In other subsystems, gaps appear where the effectiveness of a developing subsystem starts vanishing and at the same time it also starts to stagnate.

The scientific research methods used in this paper are the following: descriptive method, classification method, compilation method, comparative method, statistical method.

2 TYPES OF ROAD USERS THAT IMPACT ITS EFFECTIVENESS

Pedestrians

Pedestrians as road users are most often classified as vulnerable road users whose safety largely depends on a suitably built infrastructure. The impact of pedestrians on the effectiveness of the traffic system is expressed especially in safety, whereas the impact on other categories is relatively limited. It can proportionally influence the movement speed of other subjects in the traffic system, thus influencing the travelling time needed for getting from point A to point B. If a pedestrian is noticed on the road early enough depends on their visibility, especially at night. A pedestrian causes various situations with their movement, which can be predictable and safe at certain times, but also unpredictable and dangerous at other times.

Traffic policies for these groups of vulnerable road users are mostly released too late or after they have been involved in tragic or fatal traffic accidents, when also the reaction of the public is stronger.

Cyclists

Also cyclists are classified as the so-called endangered road users whose movements in the traffic system are relatively fast, however they benefit from no technical protection (apart from cycling helmets) to protect them in case of an accident. Also in this category, the safety criterion of effectiveness obviously stands out, however especially in urban centres that are busy with traffic, cyclists represent an important work category, and a well developed network of cycle lanes in urban centres significantly impact the tourism development of individual areas. Also the weather influences this category therefore its prevalence in road traffic depends on the season.

Drivers of motorized bicycles, motorbikes and motorcycles

The users of those means of transport belong to one of the categories with the largest number of users, and also their prevalence in traffic depends on the weather even though the limit is not as clear as with cyclists. We are talking about the users of single track vehicles who also stand out for their vulnerability. Also their influence (partly also the influence on the working environment) is in the first line assessed by surveillance cameras.

Drivers of private vehicles

This is the most widespread and the fastest evolving category of road users, whose influence on the traffic effectiveness is very significant and also unpredictable in some specific circumstances. Infrastructural insufficiency of traffic surfaces can cause a withdrawal of this category of road users from this environment, which causes a technological and economic stagnation.

Drivers of freight vehicles

This category of traffic participants belongs to the so-called transport system that is tightly connected to the economic and demographic influences. Its basic purpose is the shipment of goods to various areas, thus making this category crucial for the development of a certain area in its broader sense. As a category of traffic participants it also has a significant impact in the field of safety effectiveness.

Bus drivers

Public transport plays a vital role in the development of society. Motor vehicle drivers in a public function, among others also bus drivers, perform their tasks for the needs and benefit of a larger or smaller group of people, therefore also this category can be defined as a traffic category that performs its tasks in a broader social sphere.

Passengers

The impact of passengers on traffic effectiveness is relatively small since it cannot easily be measured and defined due to its role. In this category, we have predominantly established effectiveness in the field of safety, which manifests itself as numbers involved in traffic accidents and their consequences. Also this category can have a significant impact on a better safety effectiveness of the traffic system through sufficient obedience of traffic regulations, especially through the usage of means of passive safety.

The focus of my paper is the impact of road users on the effectiveness of road traffic, whereas further into the paper I will focus on how much drivers of private vehicles contribute to road safety.

3 INFLUENCE FACTORS OF TRAFFIC EFFECTIVENESS

Road users significantly impact the effectiveness of road traffic. In case of an individual as a road user we have to pay attention to their psychosociological state, which is highly variable and differs greatly in individual characteristics. This influence is extremely important when it comes to the relation between the road and its users, and can be considered completely individually or manifested together with some other factors that impact the subjective state of people (influence of alcohol, drugs, medication, external influences, etc.). Those accompanying factors can only reinforce that state with even more strongly expressed external symptoms.

People also differ in their physical, sensory, psychomotor, and mental capabilities. Those also carry a significant impact on a safe usage of roads. Physical capabilities are otherwise not relevant for road users. More than physical strength, stamina is more important on certain long trips. Sensory capabilities are especially the capabilities of sense organs. Here, vision and in the first place its sharpness play the most important role. Speed, skillfulness, coordination, and quality of various movements represent the so-called psychomotor capabilities. What is important is to realize that fast reactions are not the most important. More relevant are suitable reactions.

The aforementioned factors have to be complemented by the so-called periodic impacts that appear in an unsystematic way and trigger more or less active reactions that can manifest themselves in positive or negative behaviour. Here, we are talking especially about anger, fear, disdain, various frustrations, envy, hatred, shame, but also pride, insult, and defiance. The actions of an individual in road traffic can therefore reflect their feelings that individually or in combination with other factors impact our stance towards road safety, and bigger or smaller responsibility in that regard.

The impact of man as a road user on the effectiveness of road traffic therefore is not irrelevant. Our relation towards the traffic system and our mental state have a significant impact in the measurable part of safety efficiency of the road traffic system.

A very large influence on traffic effectiveness are also the key players in the fields of planning, construction, and maintenance of road surfaces, as well as their users.

4 MODEL APPLICATION POSSIBILITIES

The pie chart has often been used in the field of vulnerable road users since the existing policies did not turn out to be efficient, or were only efficient in the short-term. But nowadays, that is not only a problem of vulnerable road users, but also of private vehicles since from year to year, there is a growing number of regulations that unfortunately do not turn out to implement significant improvements.

In such situations, the implementation of a pie chart is sensible and also to ask ourselves some key questions, which are:

- When is the system effective?
- How do the users actually impact it?
- What solutions are there for the problem in question?
- How can we develop a good programme or a smart policy?

In this regard, let us use the elementary problem (Figure 1). Initially, we are going to establish the details of the model in which the factors appear as a part of the problem that is defined in the “Causes” group; the cause is defined in the “Target” group, which at the same time serves as our goal. Goals can thus be resolved in the “Solution” phase. The final solution of the successfulness needs to be assessed or evaluated in the “Evaluation” phase.

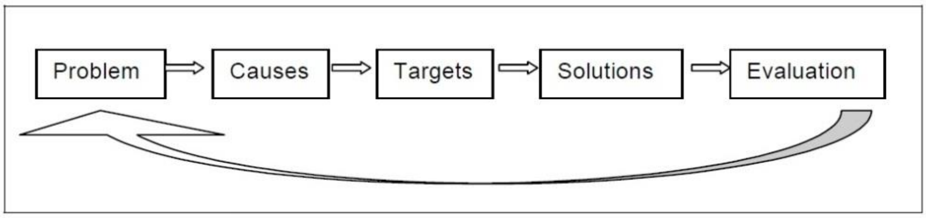

Figure 1: Planning model

Reference: Methors R.: Vulnerable road users: New approaches needed?

With the help of the pie chart, traffic can be presented as a system in which people use private vehicles to travel from point A to point B. The trip is executed on the road, which is part of urban planning. The road network and environment, however, are often defined as a concept of the infrastructure. The usage of roads itself needs to provide suitable rules that allow the users a safe and efficient usage of traffic surfaces.

For a group of private vehicles to constitute a system, its constituent parts (elements) have to be interconnected so that the group as a whole will have some kind of a content that will make the group different from the content of each individual constituent part. That is why in case of a pie chart or the effectiveness of this system, we can say that it depends on the qualities of micro/medium/macro components within the system. Those are represented as three layers, i.e. the core, the inner, and the outer layer. The basic model is depicted on Figure 2.

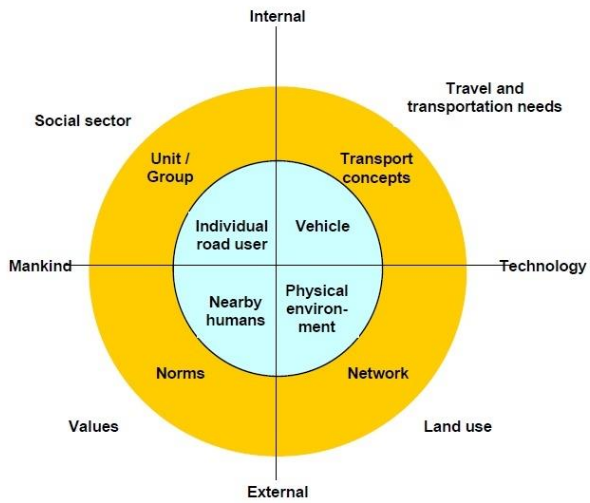

Figure 2: Basic model of the pie chart

Reference: Methors R.: Vulnerable road users: New approaches needed?

The part “Travel and transportation needs” of the model shown will have to be altered for private vehicles. In our case, the component will be named “Travel and infrastructure capacities”.

4.1 Transfer of the represented model into the field in question

Further in this paper, the presented model will be transferred into our research field. At this point, we can claim the following:

Core of the model: users of private vehicles communicate with the vehicle they are using and other road users.

Inner layer: includes road connections, road regulations, users, and transportation concepts. This component represents the social element since the number of trips is influenced by the size of a family, its income, etc.

Outer layer: This layer refers to the social trend of options. The value of standards is the relevance of the traffic system. The number of trips impacts the rate of traffic surface usage.

4.1.1 Analysis of individual components

In order to resolve the problems and determine the impact of private vehicle users the presented components have to be analysed from all aspects of the model.

Social trend

The social context impacts the presence of private vehicle users on traffic surfaces. The important trends of this field on the macro level are the fields of traffic safety, economic development, investments into know-how and technology, as well as the demographic and economic trend.

Demographic trend

With the help of the demographic trend, we can also predict the future of the development of private cars; if the population decreases, also the number of private vehicles will decrease over a certain period of time in the long-term thus reducing the usage rate of roads. If the pricing of vehicles remains comparable to the current pricing in case economic indicators are favourable, this presumption is not necessarily true.

Economic trend

The number of trips and the daily presence of private vehicles on roads represent the economic, social, demographic, and sociological trends, which can be proportional with the development of traffic infrastructure, or they can even surpass it.

Travel and infrastructure capacities

The presented segment can also be transferred to the means of informing road users, which is especially important on highways, where there are often traffic jams. As a result, private vehicle users can heavily impact the effectiveness, including traffic safety, with their actions depending on timely provision of information.

With suitable travelling habits and capacities, the number of kilometres travelled can be reduced, which can provide great benefits in various transport chains.

Infrastructure capacities

An important element is without doubt also road infrastructure, which is the basic element for the execution of freight traffic. It should be constructed in accordance with standards that allow a greater level of safety for private vehicles and smoother traffic flows, but at the same time it is important for a quality and effective system.

Road users

As I have mentioned several times already, there are various road users. They all have in common that they are travelling from one point to another, causing different traffic situations along the way. With their actions, road users impact traffic effectiveness, which can be higher or lower. The biggest group are certainly motor vehicles, whose movements depend on daily activities, active and passive elements of traffic safety, and other circumstances that road users can experience on the road.

Transport links

A transport corridor in road traffic is the road on which traffic movements take place. Roads need to be planned, constructed and equipped in order to meet their purpose and the requirements of traffic effectiveness. For private vehicles, there have been numerous plans or strategies developed on how to increase road traffic effectiveness with their aid.

Road traffic regulations are often relatively unclear, sometimes even ambiguous, therefore road users frequently interpret them in their own way. That is why we have to strive for a better implementation of those regulations.

In Slovenia, we face insufficiently organized public passenger transportation. Insufficient organization in this case means that public transportation is not organized on local levels therefore the number of private vehicles for short-distance trips will be even greater, thus affecting safety.

Roads are distinguished according to various criteria. When it comes to their role, we mostly distinguish between local and regional roads, as well as highways. The categorization of roads is based on their AADT, however it is often disregarded in practice and roads are categorized by the “appearance” of things. This trend is the most obvious on lower ranked roads.

Norms

Road users, among those also private vehicle users, need to comply with various policies on the national as well as local level. But the quality of those policies is seldom focused on all factors, i.e. people, the road, and the vehicle. The main focus is on people, which is also the right choice in certain situations since people most frequently impact the effectiveness of a system with numerous actions. However, their extreme exposition negatively impacts especially the quality of traffic infrastructure since people as the users of traffic surfaces remain the only relevant element of responsibility.

4.2 Indicators of change of private vehicle users

In Slovenia, the number of private vehicles is growing from year to year also meaning that private vehicles complete a growing number of passenger kilometres. There was a smaller decline between the years 2009 and 2010, whereas the trend from 2011 is comparable with 2009. [1]Interesting in this regard is the fact that the number of private vehicles and completed passenger kilometres increased from 2008 to 2009 regardless of the lack of economic growth. That growth was followed by an increase in unemployment rate. In the comparison period between 2007 and 2011, the number of private vehicles on traffic surfaces in Slovenia increased by 11%.

[1] Data obtained from the Statistical Office of the Republic of Slovenia

The number of newly constructed roads increased by 336km between the years 2007 and 2011. From that information it can be concluded that the trend is positive. The number of vehicles is going to grow from year to year, and so is the number of passenger kilometres. We can therefore claim that the systems necessary will have to be more efficient. The data described are represented in Table 1.

Table 1: Statistical data on private vehicles, newly constructed road kilometres, and completed passenger kilometres

Year	Private vehicles	Kilometres of roads	Passenger kilometres (in million)
2007	1,014,122	38,708	24,355
2008	1,045,183	38,872	24,878
2009	1,058,858	38,922	25,775
2010	1,061,646	39,070	25,636
2011	1,066,495	39,044	25,838

Reference: SORS, February 2011

5 CONCLUSION

In practice, the effectiveness of a traffic system is in the first place measured through economic and safety criteria. Those elements might really be the most significant ones, but they are by no means the only ones. A well developed and effective traffic system does impact all social segments, but the social environment also has a back impact on traffic effectiveness. It is hardly imaginable that an organized social community could operate well in an insufficiently developed traffic system, but also a reversed situation is not probable since insufficiently developed social systems cannot establish an effective traffic system.

In theory-based discussions, it can also be established that traffic effectiveness in a given social community largely depends on its development. An organized and systematically managed development of a social community needs to implement the elements of a well developed traffic infrastructure into its core, and define the direction of its development as well as create conditions in which such system can also operate efficiently. It needs to create positive effects and thus actively participate in the development of a certain social community. Economic and safety effectiveness are therefore only the two most expressive elements, which are also the most distinguishable ones due to their specificity. But we must also not disregard the environmental, sociological, and demographic components, which are also more or less distinguishably manifested in the effectiveness indicators of a traffic system.

Environmentalism is getting stronger therefore irrational traffic elements have no future and will be completely excluded by the system sooner rather than later. An outdated and environmentally inefficient fleet does not impact traffic effectiveness in a positive way. An inversely proportional positive influence might be possible (China), but virtually the whole world is already paying the price of that development.

Also various demographic contents, their level of development, habits, and structural stratification are an important factor of traffic system effectiveness. In an environment with complex technological processes, a high level of education, where an above-average added value is created, we can expect that also the traffic system will be developed in order to achieve higher effectiveness. But we cannot expect such trends in an environment with a lower level of development, low level of education, a population with a low standard of living, and where predominantly physical workforce is present in the labour market.

Sociological and social criteria and indicators of traffic effectiveness are harder to recognize in certain environments, and can only be obtained with a suitable analytical approach, but they still significantly impact the effectiveness. In a system with numerous social classes, in an environment with a high crime rate, social unrest, and inequality, systems tend to be less effective, and their development can even cause negative trends.

If we want to create an efficient traffic system, it has to be included in all of the effectiveness indicators, it has to be supported by the public, and it needs to be a constituent part of the development of a certain social community. But for its development and thus increase in the effectiveness, this society needs to create conditions that will be proportional with the development of the society.

The effectiveness in road traffic can also be measured in the same way. The positive and negative influences are similar as in the entire traffic system. Road traffic is still regarded as the most important transport category, which is also inevitable for the society and which includes large systems on the one hand, but also individual users of traffic surfaces on the other hand.

Road traffic might be a somewhat independent and complete unit, but merely in its theoretical foundations. In practice, it is tightly connected with all other subsystems in the entire traffic system chain. Road traffic has specific characteristics and is in that sense also regulated, but every individualization causes problems in the entire traffic chain since it creates dark fields that can make the traffic system irrational, extremely expensive, and it can start ruining the already established development criteria.

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ROBERT BARTINI AND HIS CONTRIBUTION TO THE DEVELOPMENT OF TRANSPORT

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ABSTRACT

In this article is a brief descriptive work of genial aircraft designer Robert Bartini and his role in the development of the military, passenger and transport aviation. It will also give his vision of the intercontinental and continental high speed transport, with which was he mainly occupied in the last years of his work and creation. He worked as a researcher and expert in the former Soviet Union, therefore, more detailed and relevant information of his work are coming to the public in recent years. He was born in 1897 and spent his youth in Rijeka (Fiume).

Keywords: Bartini, Air transport, Aviation history, Development of aircraft, Ekranoplan, Ground effect, Rijeka, Soviet Union

1 INTRODUCTION

During the cold war, the superpowers United States (USA) and Soviet Union (USSR) wanted to demonstrate achievements in the development of military technique and technology. The same two superpowers wanted to show the best in the field of engineering and technology for civil purposes. This match was most reflected in the conquest of space and in field of aviation, where the former Soviet Union wanted to present abroad in the best light. Knowledge in this area could not be obtained in a short time, but it was necessary to invest years and years of development, testing and learning from mistakes. Because of the lack of prior knowledge both superpowers were hungry for scientists and researchers, mainly from Europe. They contributed an important part in the development of space technology and aviation. Most of the necessary knowledge and human resources superpowers are gained after the Second World War. However, many scientists fled from the unstable pre-war Europe to Unated States before the war, while for the Soviet Union this phenomenon was not been detected.

Because of the size of the Soviet Union this state wanted after the First World War quicker progress in the field of aviation. In the twenties were in Russia most famous pioneers of ideas about space transportation (Tsiolkovsky) and builders of large airplanes (Sikorsky, Tupolev), but knowledge in Western Europe in the field of aerodynamics made great progress. Specially Italy was at that time possessed a superior knowledge in the field of aerodynamics. This was rewarded with a world speed record in aviation in years 1927-1929 and 1933-1934. It is not surprising that in 1923 emigrated to Russia Robert Bartını, a young Italian aviation engineer and communist, who showed his skills in the fields of aviation in Soviet Union in next 50 years. In this case, it was a classic transfer of knowledge in the new young soviet republic.

2 LIFE AND WORK OF ROBERT BARTINI IN THE FIELD OF AVIATION

Robert Bartini was born on May 14th 1897 in town Kanjiza (today it is the town in Serbia near Hungarian border). That was also written in his documents when he lived in Soviet Union. [1]. When he was 3 years old, he was adopted by the family of rich state official in the town of Fiume in the Austro-Hungarian monarchy (today Rijeka in Croatia). In his youth, he had a surname Orozdi (Orozhdi) [2][1].As a young boy he was very intelligent. He had additional education by the family teacher from the natural science (chemistry, biology), music and foreign languages [3]. In 1912 he saw in Rijeka an airplane and airshow of Russian aviator Slavorossov and he was fascinated. In 1915 he graduated from gymnasium in Budapest [2], was drafted and sent to school of officers' reserve located in the town of Bystritsa (in Czechoslovakia) and then in 1916, he was sent to Russian-Austrian-Hungarian front where he was captured in June 1916 [4]. He was sent into captivity in the Far East in a prison camps Khabarovsk and Vladivostok. He was released after the First World War, and then he was working like taxi driver in Shanghai. In 1920 he was returned home in Fiume. When working at Isotta-Fraschini facilities, in 1922 he graduated from Milan polytechnic institute. In the same year he graduated from pilot school in Rome. During the captivity in Russia, Bartıni came under the influence of communist literature, and in 1921 he became a member of Communist party of Italy. In 1923 the Fascists took over the control in Italy and Bartini was sent to the Soviet Union. When he was leaving the Italy over Alps, he vowed, that »red planes will always faster than black« [3]. When he was the member of the Communist party of Italy, he worked underground and he got nickname »Red baron«. He kept his nickname also in Soviet Union.

Since the arrival in the Soviet Union, Bartini served next six years as a mechanical engineer and the head of department at scientific and test aerodrome (now Chkalovsky). He was transferred then to the 1st Squadron of Naval forces of the Black and Azov Seas. In 1925 he participated in the national gliding championship in Crimea and together with designer Myasitchev cooperated as a constructor and pilot [1]. In 1928, he became the head of the department of amphibious experimental aircraft design and he was appointed to the chief engineer of the Black Sea aviation. Next year he participated in organization of ANT-4 "Soviet Country" aircraft flight to America, servicing in sea segment of the route. In the red army Bartiniy reached the rank of brigadier (Brigadier General).

Bartini returned to Moscow and worked as Chief designer of his projects in seaplane design bureaus at facilities No 22 and 39 until the August 1930. He was dismissed from the design bureau for critical letter wrote to Stalin, but Air Forces authorities organized small design bureau for him at facility No 22. In this design bureau he began to design a new aircraft, Stal-6 (Steel-6) with an incredible clean contour. “I saw an airplane like a beautiful naked girl” said former test pilot a half sencury later, when he first time saw "top-secret" aircraft [2]. Stal-6" aircraft was a monoplane configuration fighter airplane with inventive solutions: full retraction of bicycle landing wheel, closed cockpit, with transmission gear in elevator control linkage; engine evaporative cooling system with coolers-wing tips. Structure and aerodynamics of this aircraft permitted to reach the speed 420 km/h in 1933. [5] It was 150 km/h more than best fighters in Seviet Union at the time. The aircraft had V-12 engine with 630 hp and it was made of stainless steel "enerzh 6". Two years later (1935), Bartini designed fighter "Steel-8" with speed 630 km / h, but it was not selected for the proposed Soviet fighter. If the Soviet Union then choose this plane to the further development then the

[1] Official name of his father was Ludovico Oros di Bartini (from bigraphy I. Chutko: *Red Plane*), But there is no evidence about baron and vice governor di Bartini in Fiume (Rijeka).

Soviet Union in 1941 already had a superior fighter for defending "mother Russia" from Germans.

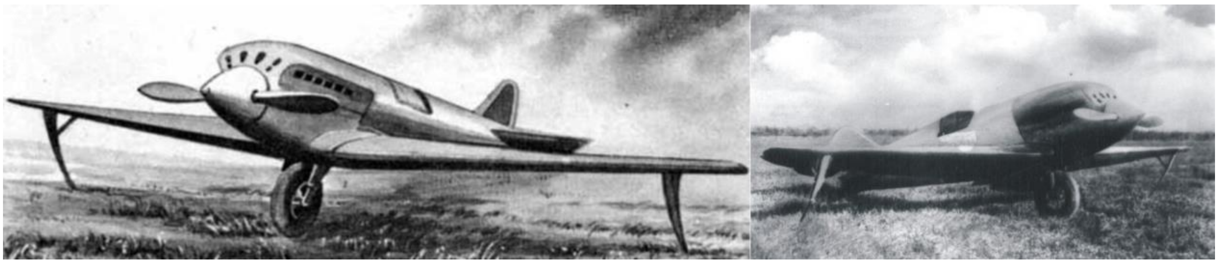

Figure 1: Aircraft Bartini Stal-6 (Steel 6)

Source: http://www.airwar.ru/enc/xplane/stal6.htm, web source: 2.4.2013

In 1934 Bartını began development of Stal-7 aircraft, which was twin-engine passenger aircraft and has been exhibited at the Paris Salon in 1936.In 1939, the aircraft has reached a new world record for a distance of 5000 km, it was flying over 5068 km with average speed 405 km/h. Top speed of this aircraft was 450 km/h. Stal-7 was ready for flight around the world, but this was prevented by the arrest of chief designer Bartini. They imprisoned him in 1938 and accused, that he is Mussolini's agent and that he participated in the burning of building no. 240, where the aircraft Stal-7 was. First, he was sentenced to death and imprisoned in the disreputable NKVD prison Lubyanka in Moscow. When his plane reached a world record, Stalin "personally" took care that Bartini's sentence reduced to standard 10 years in prison. Bartini was transferred to secret research and development camps KB (Sharaskas) in different towns: Moscow[2]., Omsk, Kazan ans Taganrog. At that time aircraft Stal-7 was one of the greatest secret of the Soviet Union. Of it left only one short film clip and some photos.Under the leadership of V. Ermolajev and advice of Bartini the plane began to transform into the long-range bomber Yer-2. About 400 aircrafts Yer-2 were made.

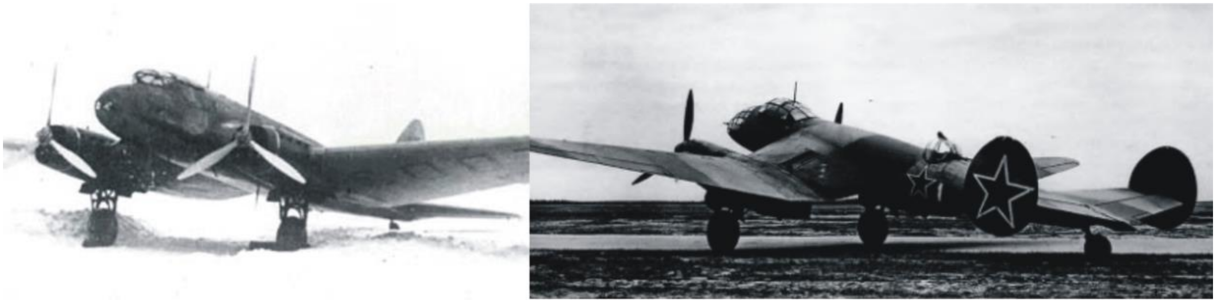

Figure 2: Passenger aircraft Bartini Stal-7 and bomber Yer-2 (Er-2)

Source: http://mig3.sovietwarplanes.com/colors/1945-50-oldtypes/yer2-splinter.jpg , web source: 2.4.2013

During the Molotov Ribbentrop pact, the aircraft was intended for attacks Britain and France and their bases in the Middle East. But Yer-2 aircrafts have been engaged in night-time attacks on Berlin at the time when the Germans were sure that they are invincible.The first bombing was already on August 8, 1941. In fact, the Soviets bombed Berlin directly from Moscow. Germans at the beginning did not even know what they were dealing with.Their fighters were simply too slow in 1941.

[2] He was together with Andrei Tupolev in Sharaska.

The main concern for Bartinini in the custody in Moscow and Omsk during the period from 1940 to 1943 was faster-than-sound aircraft with rocket power. The project of his first P-114 (Cyrillic P = R for rocket) interceptor with swept wing was not realized. [4]. The P-114 was designed for speed more than 2000 km/h. At that time (1943), Bartını already knew that for speeds above Mach 2 are best shape for wings - delta wings.

Then he started with constructing of the first wide fuselage (wide-body) transport aircraft T-117 for transport tanks. This aircraft was the first with transport ramp/door at the back of the plane, for easier loading/unloading of cargo. The plane was in Tagarnog already constructed, but necessary engines were not supplied. Engines were necessary for the production of bombers Tupolev Tu-4, which were a copy of the American B-29 bombers. Stalin said that Russia needs bombers, not transport aircrafts. And new invented aircraft T-117 did not flight. The project was laid off. T-117 aircraft drawings were sent to Antonov's company in Kiev. Many of Bartini's designs were later used on Antonov aircrafts. In 1946, Bartini released and his design bureau in Taganrog closed, plane T-117 was destroyed and cut. Antonov design bureau was the first wide-body transport aircraft constructed a decade later.

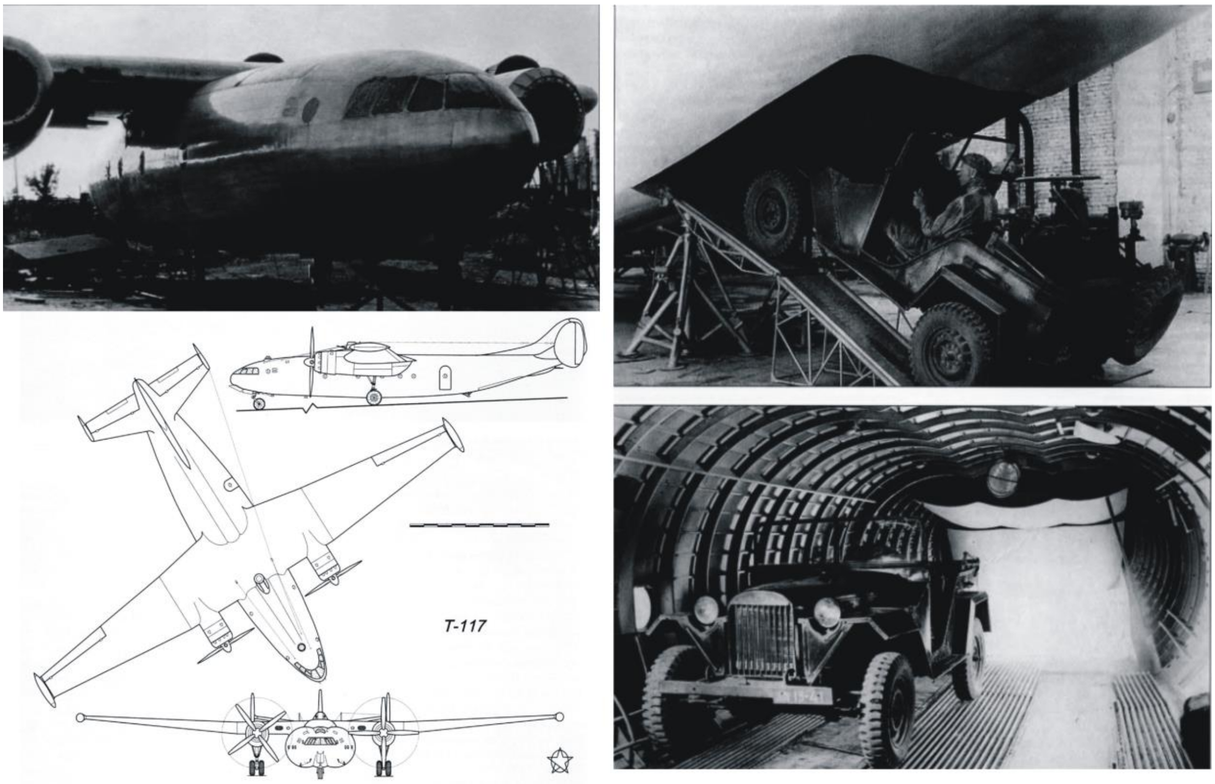

Figure 3: First wide body aircraft: Bartini T-117

Source: Н.В Якубович: самолету Р. Л. Бартин, N.V Jakubovich: Aircrafts R.L. Bartini, Rusavia, Moscow2006

After the release, Bartini decided to continue the work in Taganrog and design even more transport aircrafts T-200 and T210, but the realization of projects did not occur. In 1952, Bartini moved to Novosibirsk, where he began to research and made aerodynamic calculation for the optimum shape of wings for supersonic speeds. On the basis of these investigations he designed T-203 project - variable sweep wing with aerodynamic twist. So he began to develop the plans for strategic bombers A-57 and A-55 at speeds of 2200 to 2500 km / h with the possibility of landing on the water. At that time Soviet bombers did not have sufficient range to reach the coast of the United States and returned in Soviet Union. Bartini found an innovative solution for aircraft landing on the water, where Soviet submarines could supply fuel to aircraft. However, Soviet authorities refused the project because of the development of ballistic missiles. The results of Bartini`s research and results about wings for large aircrafts in supersonic speeds were sent to the Tupolev design bureau. These solutions were used there to desing supersonic passenger aircraft Tu-144. The same design of wings also had aircraft Concorde.

3 BARTINI´S VISION OF THE INTERCONTINENTAL HIGH SPEED TRANSPORT

Bartin was completely rehabilitated in 1957 and returned to Moscow, where he worked in a small Kamov construction bureau. During this time he began to study and compare the various forms of the transport and determine which would be the most energy corresponding to a certain speed.

Bartin developed a "Theory of intercontinental transport on Earth", which was completed in the sixties. In this theory, the entire planet Earth taken into account for the implementation of transport services for ships, planes, helicopters, railways…. In this theory was took into account the interdependencies between the various criteria: the amount of load, speed of delivery, the weather conditions and the area required for various operations (stopping and moving vehicles, facilities for loading and unloading ...). He came to the solution that the most optimal is such vehicle, that flies just above the surface, it can take off and land vertically and can be applied on all surfaces - snow, water, earth, ice, sand. [6]

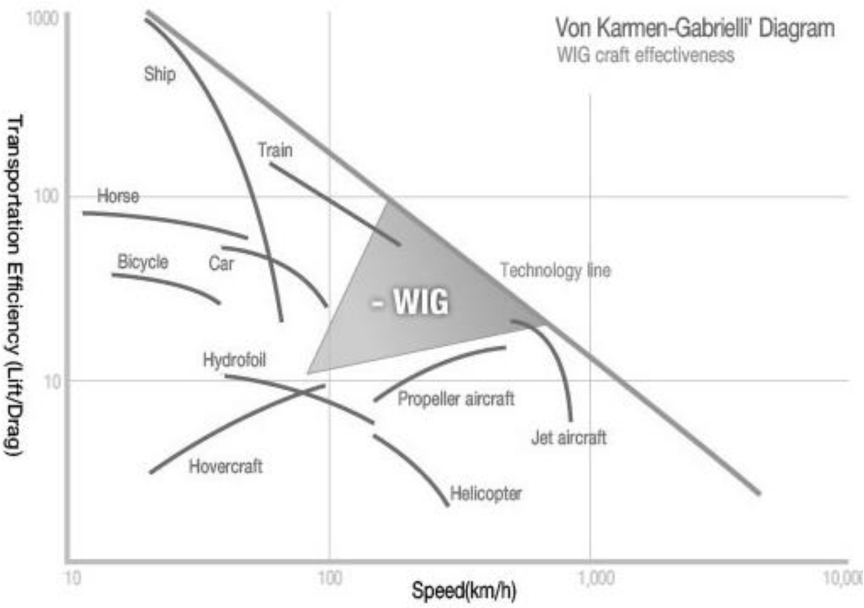

Figure 4: Transport efficiency diagram for different means of transport

Sourc: Wing in ground effect – the bassics, Wingship technology corporation *http://wingship.webs.com/technology.htm* *, web source: 2.4.2013*

Similar research about efficiency of the different means of the transport, has been worked Von Karman in the fifties of the last century. He noted that the highest efficiency possess "hydroglider," which was probably in those times the original term for the WIG vehicle or for ekranoplan (Russian term). [7] Term WIG vehicle or ekranoplan is used for vehicle which use ground effect – WIG effect (Wing In Ground effect).

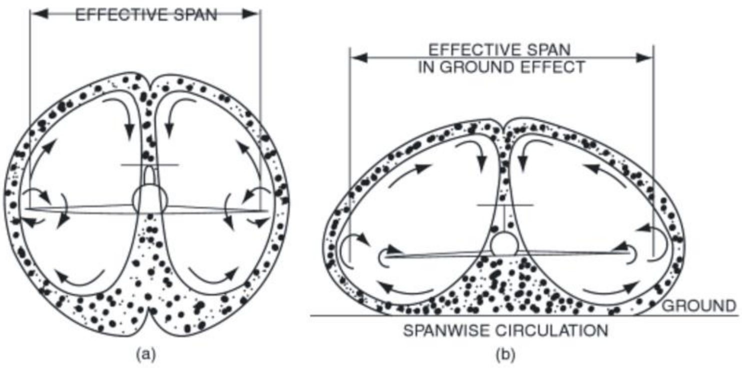

Figure 5: Airplane in normal flight and in fight with WIG effect

Source: Y. Lun, A. Bliault, J. Doo: WIG Craft and Ekranoplan: Ground Effect Craft Technology, web source: *http://www.google.si/books?hl=sl&lr=&id=oAXEphDmmEMC&oi=fnd&pg=PR5&dq=ekranoplan&ots=T6nutRSzgJ&sig=AotV_9I-0bKwWhLt_0xIiXYK_-A&redir_esc=y#v=onepage&q=ekranoplan&f=false*

Optimum flight is just above the flat surface where vehicles can take advantage of ground effect. Vehicles using ground effect is achieved up to 30 % more lift than normal planes at the same wing surface. Therefore, the surface of the wings for the same lift force is less with ground effect. It is also less resistance, which is best seen in the diagram below.

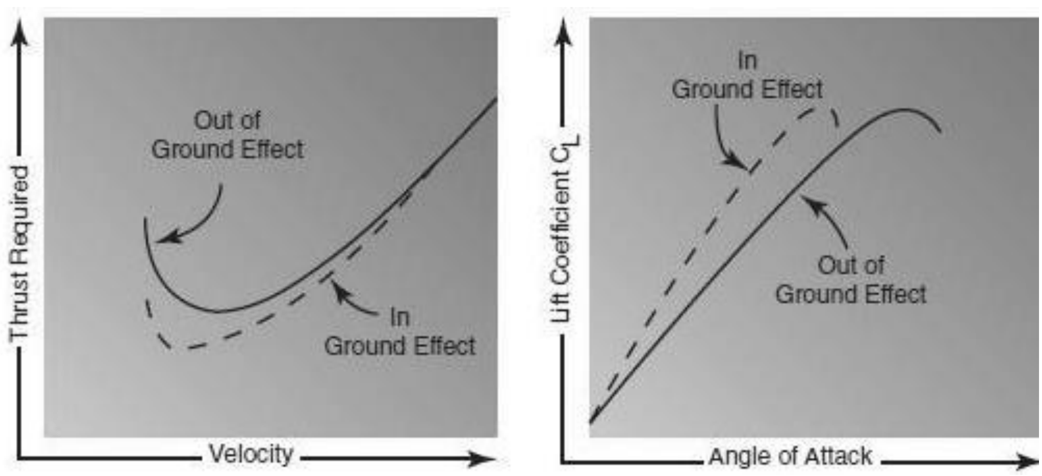

Figure 6: Wing in ground effect flight changes drag and lift

Source: Aerodinamics in flight – Airplane Ground Schools:web source *http://airplanegroundschools.com/Flight-Aerodynamics/index.html*

To prove Bartini his theory, he began to develop in the sixties a prototype aircraft VVA-14, an amphibian plane. This plane would be landing of all possible surfaces, sea, earth, ice, sand. It had an option to vertical takeoff and landing or conventional takeoff and landing from airports or water surfaces. That the aircraft had sufficient fuel to vertikal takeoff or landing, it could fuel saving based on WIG flight. The plane was made in a factory Beriev. The first test flight, the aircraft carried out in 1972, but 14 engines needed for vertical take-off was never delivered. The plane made a series of test flights, take off on land and water in the conventional way (without test vertical take-off and landing). Further development was not been approved.

Bartini`s design of WIG vehicles is probably the most efficient. Catamaran design with an open space between the floats, which accumulates compressed air provides additional lift.

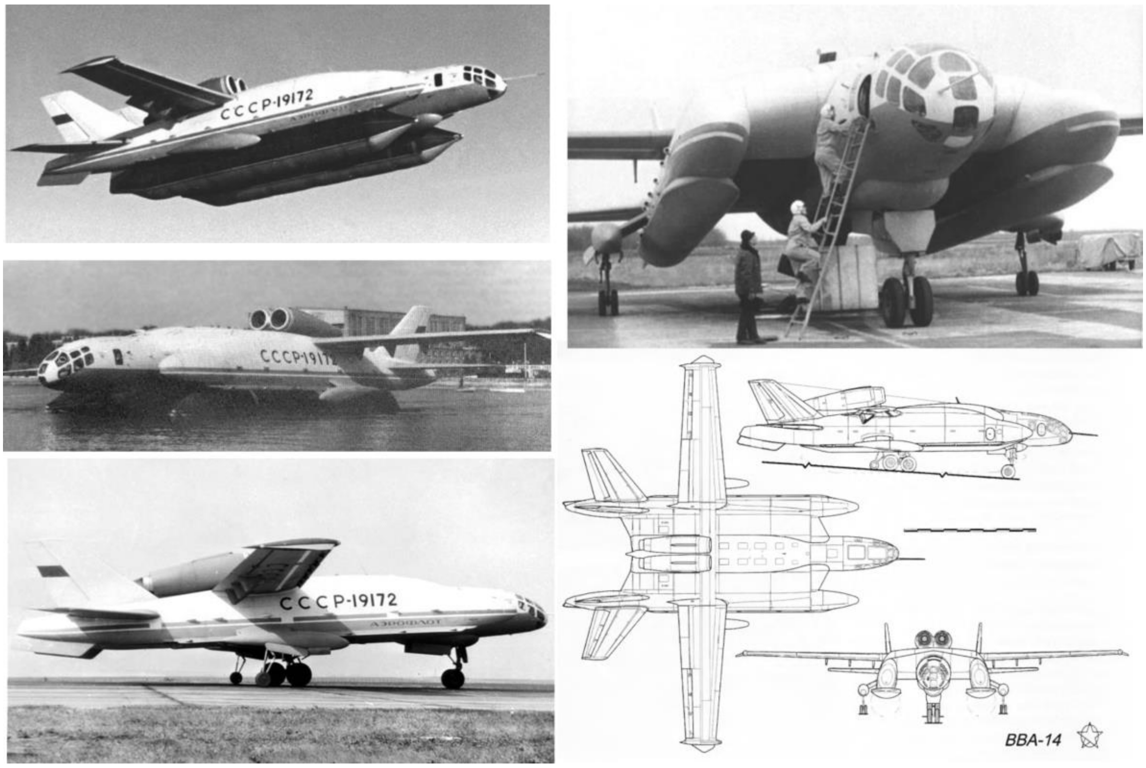

Figure 7: Amphibian airplane Bartini-Beriev VVA-14

Source: Н.В Якубович: самолету Р. Л. Бартин, N.V Jakubovich: Aircrafts R.L. Bartini, Rusavia, Moscow2006

Bartın imagined a vehicle with greater utilization of ground effect, which could be taking place at high speed transcontinental freight and peassenger transport. Such ekranoplans would more efficient with than today's airplanes, can be transported more passengers and cargo, and could actually still work in an environment that is much more "friendly", such as height above 10 km.

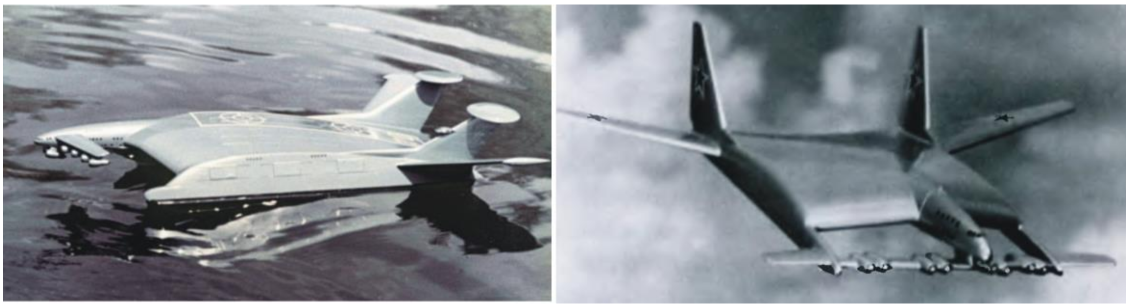

Figure 8: Model of the WIG aircraft carrier and ekranoplan T-500

Source: Код Бартини. Загадка красного барона, Code Bartini, Riddle of the Red Baron, film, web source: http://www.youtube.com/watch?v=3y_uIVL9Scc

He went with his ideas further. He also designed an ekranoplane with weight of 2500 tons and 5000 tons, which would serve as an aircraft carrier and operate at speeds of 500 km/h. In such high speeds aircrafts for take-off from the aircraft carriers do not need a long runway. Aircraft carrier would travel at the same speed as the airplane.

Bartını was also thinking about a quick continental transport. He was in the sixties imagined monorail vehicle, which traveled at high speed. It would work on the basis of compressed air like hovercraft (ekranohod) [3], or on the basis of magnetic levitation (magnitoplan) [1]. Project was presented to the minister of transport B.P. Beschev and was also approved, but never realized. Bartıni constructed additional aerodynamic surfaces at the sides of the vehicle to increase the lift or for control the correct distance of vehicle from the track.

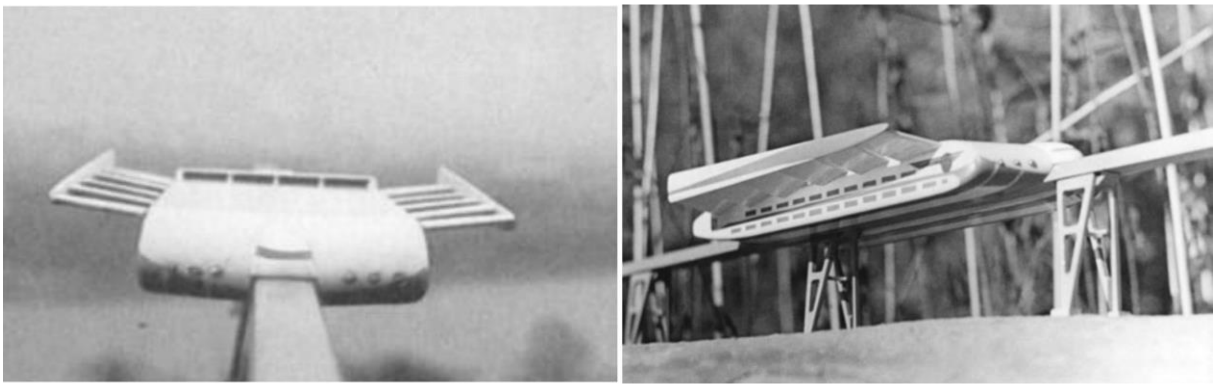

Figure 9: Model of the future transport system (magnitoplan or ekranohod)

Source: On accasion of 110-th Jubilee of Robert Bartini, Beriev Aircraft company, web source: http://www.beriev.com/eng/Pr_rel_e/pr_110e.html

4 BARTINI´S WORK IN OTHER FIELDS OF CREATION

In today's Russia, they describe Robert Ludcigovich Bartini as a misunderstood genius who with his ideas was ahead of his time. They compare him with Nikola Tesla. They describe him as the aircraft designer, physicist, astronomer, philosopher, painter, musician, and polyglot (he spoke 7 languages, read 9).

He was cooperating many times in his life with Sergei Korolev. When Sergei Korolev was appointed as the head of the Russian space program, he requested twice that his mentor is Robert Bartıni. Before his friends Korolev often called Bartini as his teacher. First time was Bartini a head of Korolev before the second world war, when he worked in Bartini`s desesign bureau. Secondly they cooperated in captivity (sharaska) when Bartini developed the rocket interceptor P-114. Sergei Korolev personaly took care at the Soviet authorities about Bartini`s project of the supersonic strategic bomber A-57. Korolev and Bartıni were also cooperating when they were looking for solutions to increase the range of strategic bomber Myasitschev M-4. If Bartini had and what role he had in advising the Soviet space program is not yet fully known. In the last years of his life he was primarily engaged in the exploration in physics, cosmology and philosophy.

Bartıni has always tried to encourage innovative solutions. Interesting is his statement about what to do, if to the class filled with young professionals is given a problem to solve it in an innovative way. “Class must be extended”, was answer of Bartini. It means that many experts from different fields of activity, with their ideas are more capable to get a better solution. Bartıni was thinking how to formulate with mathematical method or model to determine what idea or the patent is good and has future and what is not good. He developed a method AND-AND, which on the basis of recognized search solutions, which has already been used, can predict the success of a given patent/idea for a new problem. He developed the method already in the nineteen thirties. The method was called as a method for the detection of talents. A similar but more general method was developed over 20 years later Genrich Altschuller , who became famous with the method called TRIZ. TRIZ method was with the disintegration of the Soviet Union spread to Western countries and is now quite well known.

The whole time of working in the Soviet Union, Bartıni was solving problems in aerodynamics in a special way. He said that mathematics is the most exact science, and there is no doubt in it. While physics is derived science and the physical findings change over the centuries. He was most doubt about physical constants, which he considered to be dependent of the specific "time and space". On this subject, in 1965, he published an article entitled "The relation between physical constants” [8]. The English version of the article was published in 2005. [9]. He wrote that the universe takes the form of six dimensional torus - three dimensions of space and three dimensions of time. 3 dimensions of time should be as follows: the first dimension is a length of time (the duration of the existence of the object), the second dimension of time is the width of time (number of cases/copies/ images of body – parallel worlds), the third dimension is height of time (the speed of time is different in each of the worlds). Six-dimensional universe by Bartini is parallel streaming of times [1]. Of course he had with the such revolutionary ideas great problems, and they did not want to publish his article. (because he basically was not a physicist and was quite unknown in the world of science). But Bruno Pontecorvo took care about Robert Bartini and his article. Bartıni gave to this article great importance, he signed as the author with the full name Robert Oros di Bartini. [10] It is interesting that in the article, the author even promised proof of his theory, but he soon died. On the basis of this physical theory Bartıni was deal also with his aerodynamic problems and came to excellent solutions. On the basis of his physical theory of time Bartini is developed entire philosophy. 6-dimensional world, which is conceived by Bartıni was named Bartıni`s world. Russian scientists mentioned Bartıni`s theory of time as a basis for developing a time machine.

Bartıni in his life drew pictures. Some pictures he drew on the walls of his apartment - for his well-being and better concentration at work. In his life, Bartıni had 3 children, 2 sons and a daughter and three grandchildren. [11] The first son Gero as a climber died in the 1959, the second son Vladimir lives in Taganrog as an engineer. In 1967 Bartini got orden of Lenin for his life achievements. In 1957 he got orden of October revolution.

About life and work of Robert Bartini were written in Russia quite speculative and almost incredible or unbelievable but very interesting claims or mysterious stories [2]:

- Bartıni in the twenties and thirties founded and headed a secret group ATON in which were members of visible Soviet writers (sci-fi) and scientists,
- Bartıni was as a prototype for Woland at the novel The Master and Margarita. Bulgakov as a writer was also a member of the ATON. The novel was written at a time when the Stalin gave in the prisons and kill "blossom" of Soviet intelligence (writers, engineers, scientists, officers) and during this time was also imprisoned Bartıni.
- Bartın was mentioned as the mysterious aircraft designer »Dunaev" that constructed the invisible plane.
- Bartıni was the whole story of his youth invented, so the NKVD was to him very suspicious.

- Altschuller summarized the ideas of Bartini to develop his own method of TRIZ, as they have been in contact.
- In high school in Budapest were sitting at the same table Robert Bartını and Leo Szilard - physicist who discovered a chain reaction.
- Before his death Bartini wrote a will, that his manuscripts be sealed and opened in 2197 (at 300th anniversary of his birth).

5 CONCLUSION

The story of Robert Bartini is very interesting because he was unlike any other European scientists and researchers worked in the Soviet Union. It is even more interesting because he was son of powerful and rich Baron and he decided to communism. Otherwise, stormy first half of the 20th century with two world wars in Europe was not lenient to the fate of the people who are mutually intertwined in the most unusual combinations.

Early in his career Bartini had luck and was rapidly promoted in the army and in the construction of aircraft. He had his patron Marshal Tukhachevsky, former leader of the Soviet armed forces (Red army). When Tukhachevsky, Bartini and other officers arrested before Second World War, had Bartını luck, that he even survived. Since then, he was no more supported from the authorities in Moscow. After the war he was able to realize only one idea - a prototype of aircraft VVA-14. With his work Bartini was the most competive to his colleauges - Russian aircraft constructors. New ideas boiled out of him and so they were jealous. Probably Soviet authorities could not allow that their planes had an Italian name.

Although as a designer managed to make fly only 4 aircrafts-prototypes, its ideas and solutions were used by other aircraft designers. Like many other geniuses, he was not suitable for the implementation of mass production of aircrafts but he was always looking for something new. In his work, he designed about 60 aircrafts and gave an idea for about 200 aircrafts. As a genius Bartını had similar characteristics like Nikola Tesla, his devices he formed in his head and than just draw what he saw in his minds.

Above all he was acclaimed as a very good teacher, because he gave with happines his knowledge to the younger Soviet designers, who later created very succesfull aircrafts such as Beriev, Korolev, Simonov (cheef designer of Su-27) and others.

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PERFORMANCE MANAGEMENT IN THE TRANSPORT ORGANIZATIONS - FROM THEORY TO PRACTICE

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ABSTRACT

The concept of sustainable economic development, as well as the significant changes that have occurred in recent decades in the transport market, has caused a change of the basic suppositions on which it is possible to build a competitive position in that same market. In the last few years economic crisis significantly complicates the business, so the requirements and standards, both in terms of performance management and the methods by which those perforamnces are mesured, are becoming more and more actual because they become a condition of the organization’s survival and success. The use of traditional performance measurement systems, no longer meets the needs of transport organizations and demands of the transport market which are more complex. This situation presents a challenge for a huge number of authors, who are now dealing with this issue, and thatsway the literature is spacious and diverse. Regardless of the fact that there is still enough space for the consideration of these issues in a new context. The aim of this paper is to expose the basic principles of this issue, which would also be suitable for the application in the relatively underdeveloped practice of performance management, which dominates the transport organizations in Serbia.

Keywords**:** performance management, performance measurement systems, transport organizations

1 INTRODUCTION

Sustainability as a term can be represented as a manifestation of desire to make life of all people on our planet better and as such, it should be available to all [1]. It implies the availability to meet existential needs of the present without compromising the possibility of future generations to satisfy their own needs in a same or similar way. It should be kept in mind that the economic crisis during last few years has a strong impact on business of all organizations, including transport organizations. Therefore, the concept of sustainable economic development is the dominant research topic for most of authors.

Regarding the transport, the precondition of sustainable economic development is sustainable mobility of people and goods, whose task is to find appropriate balance between environmental protection and quality of transport service oriented to customers. It can be noted that the high level of transport services is a part of the culture of quality of contemporary society. In this society, intermodal and acceptable transport service is the right answer for social and economic demands for mobility [2].

Significant changes occur at the market of transport services in EU (globalization, liberalization, deregulation and harmonisation). There is a very important question: When and in which way transport organizations in Serbia will be equally able to fight for place and position in European market of transport services? This market includes organizations with longstanding tradition and they can be used as a model for successful business for transport organizations from countries in transition.

Questions which are related to successful organizations are following: How did they do it? What they had to do to achieve such results?

The answer is not simple because the problematic regarded to management and improvement of transport organizations business is complex. However, it can be noted that successful organizations realized that the market is changeable category and that the business environment has become very dynamic, interactive with numerous factors which are daily related to risks and surprises. It is necessary to replace traditional way of business with modern way of business.

The contribution of EU in preparation of environment for realization of concrete demands for sustainable development of transport in the future is very important. Creation of this vision goes from the fact that the transport essentially contributes to development of economy and society, while the mobility is very important for development of internal market and quality of social life. Citizens have the right to enjoy the possibility of travel. Also, efficient and sustainable transport provides economic growth and new jobs. In order to realize that, global action including intensive international cooperation is needed [5].

Such approach directly and indirectly implies that new demands will lead to changes in organization and technology of conducting of transport service, because management of these processes will be more complicated in the future. Also, these processes will be conducted under the influence of following factors:

- **Development of international trade**: Because of the distribution of cargo through different states, national regulations and legislations has to be known, including customs, language of unknown environments, etc.
- **Tightening of conflict between efficient distribution and transport**: In order to “reconcile” the conflict between decisions of sales managers and transporters, it is needed to optimize transport routes.
- **Market transformations of all kinds of transport**: Road and to some extent rail transport at liberalized transport market are exposed to stricter quality control.

- **Increased environmental constrains**: Transport undoubtedly influences on environment. Therefore, it is exposed to certain constrains (especially road transport),
- **Necessity of application of modern technology** – transportation, trans-shipment and communication: some of latest distribution systems include satellite navigation/communication, voice-input computers, on-board computers, software for planning based on artificial Intelligence etc. [2].

The basis of all changes includes concern for customer and quality of service, which are placed in function of business success and became important precondition of survival of transport organization in domestic and European market. [3,4].

Using large number of directives and other documents, EU promotes and supports improvement of transport service quality. It is impossible to realize it without acceptance of elements related to competency and productivity, with large investment in Human Resources. Therefore, the quality of transport service will depend of performance of individual, his/her dedication and motivation [6]. Also, elements related to security of transport processes and protecting the environment are considered as important. They contribute to protection of interests of consumers and all citizens who suffer the consequences of transport process.

According to presented, it can be noted that defining of strategy for management of practices regarded to European practice is important for domestic transport organizations. Management of practices of transport services has become reality because there is increasing number of private and public companies in sector whose experiences regarded for establishment, monitoring and continuous improvement of services quality are positive. All of this is achieved by establishing of appropriate system for management of organizational performances.

2 A SHORT REVIEW OF THE PERFORMANCE MANAGEMENT THEORY

Performance management is a new term used in organization management theory according to most of theorists. However, analyzing the meaning of such term, it can be said that origin of this science can be found in ancient past. The best example is the famous book "The art of War", written by Sun Tzu in 500BC. In this book, the success in war is compared with success in business: "the success in war and business is very similar and depends on: internal and external data collection, understanding of the patterns and the meaning of data and quick response to the received information".

Beginnings of serious studying of performance are made by industrial engineers from year 1900. Their work was led by Frederick Taylor who is considered as author of first formal system for officer ranking in American military service, before the WWII [7]. He argued following: „One of bases for future performance management was scientific management method oriented on receiving a higher performance of employees. The concept was ideal for optimizing and simplifying the tasks. Its main goal was to create a maximum level of motivation by directly linking gratification with productivity". [8]

In 1922, graphic scales for ranking are introduced. They were used for the assessment of performance of employees (employee exceeds, meets or does not meet expectations). Limitation of this approach can be observed in appearance of different standards doe similar or same positions, which had a strong influence on possibility for objective, systematic and fair assessment of employees.

The important progress in development of performance management theory was made by Piter Draker in 1954. He introduced a term Management by use of objectives (MBO) which includes defining of objectives understandable to managers and employees. These objectives are used for defining of expectations from employee, while the focus was placed on objectives and their realization. The application of this concept was not simple because it hard to define clear and measureable objectives for each employee. The problem was also related to updating and changing of objectives according to changes in defined period.

Later trends moved performance management focus to assessment and management of behaviour at. It included the evaluation of behaviour of employee aligned with predefined standards. During that period, Behaviorally Anchored Rating Scales (BARS) developed. They were used to place the focus during assessment to quantification of behaviour at work. Using these scales, performances related to business demands were assessed. Levels of behaviour with concrete qualitative description were defined within each dimension. Using this way, managers obtained concrete examples of behaviour types which are connected with certain mark.

Next phase in development of performance measurement were marks made from different sources, not only by managers. Klients (buyers, services users), employees from the same organizational level and employees from lower organizational levels joined in assessment. It provided creation of 360 degrees scale, which developed and became popular in 1990s. This scale included the assessment of employees by all interest groups in organization: immediate supervisor, colleagues from the same organizational level, co-workers from a lower organizational level and an independent group of evaluators.

During the period 1990-2000, assessment systems based on competencies became popular in performance management. The basis of the system is a model of competencies. Beyond their popularity, following questions appeared: what competencies exactly are, what they include and how they should be assessed. The best practice in performance management based on competencies claims that they should be defined as behaviour standards. These standards describe different levels of each competency in the best way.

Latest trends in performance management include orientation toward results which embraces effective behaviour management and achievement of high results. This principle implies that each employee is responsible for achievement of results in order to contribute to organizational success. Defined results include objectives and defined values of key performances indicators. Therefore, latest best practice includes the assessment of results and ways of results achievement or behaviour of employee.

Performance management process includes management of success and strategic development of company through management of behaviour of employees and their assigned objectives. The process includes quantitative and qualitative measures of success. The basis for creation of basis elements of system includes mission and vision of company. These elements highlight values and strategic objectives as key components for defining of behaviour standards (needed competencies) and objectives or key performance indicators which are managed in order to realize organizational vision [9].

3 PERFORMANCE MANAGEMENT IN TRANSPORT ORGANIZATIONS

Nowadays, there is large number of organizational performance management models, because numerous authors in the world studied this topic. The important contribution to development of performance management is given by the European Commission by financing of numerous projects in area of transport.

Significant contribution to development of strategy for public transport in cities was given by the project known as SPUTNIK9, which dedicated to challenges faced by local and regional public transport systems in transition. These challenges include the emergence of a competitive environment, changing institutional frameworks and increasingly scarce financial resources. Each of the 6th Framework Programmes seeks to help make public transport systems more attractive and efficient by providing:

- support to stakeholders to anticipate and prepare for emerging challenges;
- an overview of state-of-the-art knowledge and research;
- specific guidelines and practical tools [11].

The project activities cover four priority areas: market organisation, customer relations, corporate management and equipment and operational aspects. Challenges in the field of Business Performance Improvement can be determined by using the model which is shown in Figure 1. The measurement of business performance and measurements are crucial because of following:

- If you can't measure it, you can't control it…
- If you can't control it, you can't manage it…
- If you can't manage it, you can't improve it.

A) Cost efficiency measures

The amount of public transportation services produced for the community is related to expended resources. This measure addresses the question: "How many resources were expended per unit of PT service?". Units of service are measured in terms of service outputs such as vehicle hours or vehicle kilometres. Resources expended include labour, capital, materials and services. Primary cost efficiency measures include total operating cost per vehicle service hour and total operating cost per vehicle service kilometre.

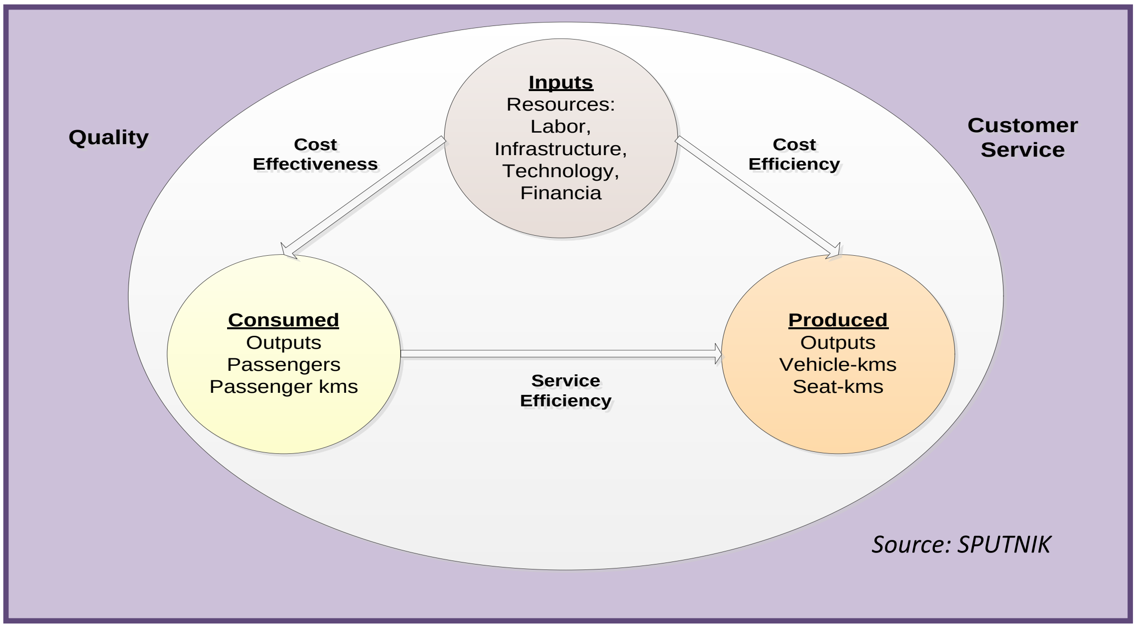

Figure 1: Model of business performance improvement in transport organizations

9 SPUTNIK (Strategies for Public Transport in Cities) is a project funded by the European Commission under the 6th Framework Programme, project start: 26 July 2006, duration: 36 months

B) Cost effectiveness

Cost effectiveness is the consumption of PT services in relation to the resources expended. This concept addresses the question: “How many resources were expended per unit of consumption or how much consumption was received per unit of resource expended? Consumption is measured by passenger trip or passenger kilometres. Primary cost effectiveness measures include total operating cost per passenger.

C) Service Quality

Service quality is the relationship between service delivery and customer expectations. This concept addresses the question: “Does the delivery or PT service meet or exceed customer expectations?” Service quality is defined as passengers, clients and the public receive it. Also, service quality has many dimensions and the importance of each attribute differs among people. However, the attributes of quality include at least accessibility, availability, reliability, safety and comfort.

Main challenges with respect to the field of Business Performance management:

- to increase overall performance at company and business unit levels in order to
- be more successful in fight with existing competition or new competition in the (near) future;
- to improve existing management methods (controlling for example) and/or
- introduce new more up-to-date methods like Balanced Score Card, Total Quality
- Management, Management by Objectives…
- to improve financial performance by further cost reduction, increase of revenues,
- to update and make better use of performance indicators on production, finance, quality and human resources [11].

For transport organizations, continuous increasing of the efficiency of organization’s functioning, accepting of the rules and logic of the transport market, applying of the modern management methods and continuous success measuring are necessary for the realization of a quality transport service, with possible engaging of resources (financial, human, time, material).

These are the requirements, which contain a certain number of conflicting criteria, which can be overcome by defining of business performances system. This system should present the support for business goals and strategy of the transport organization.

Business performances system can be defined as a group of different, mutually connected indicators, characteristics, and values, which describe business system, its resources and results. These elements represent the measure of its success. Figure 1 describes the business performances system, which is in the function of business goals and strategy of the organization [12].

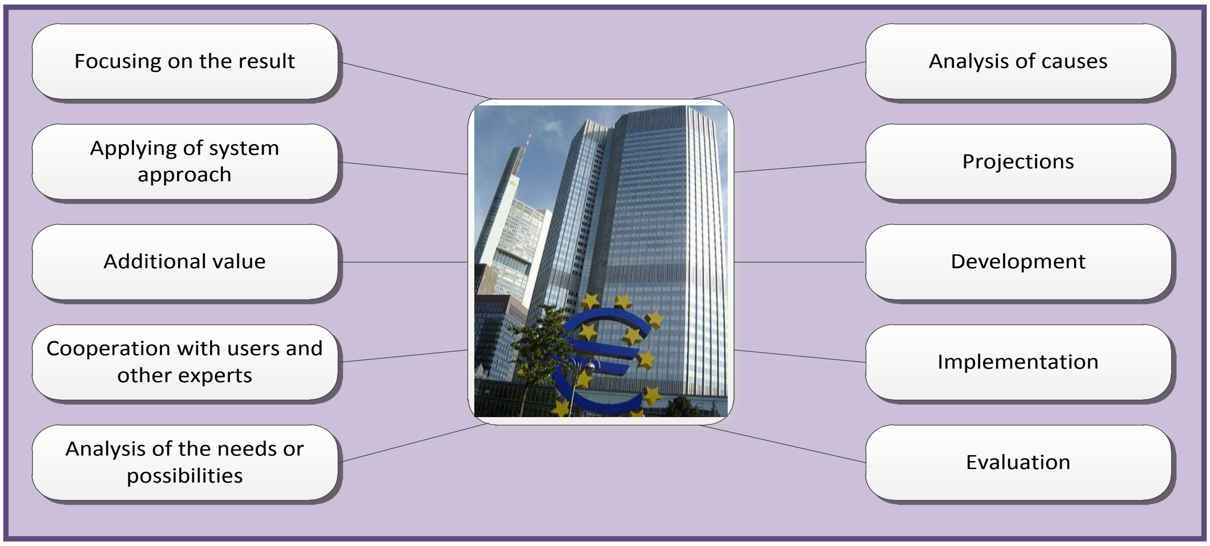

Figure 2: Ten principles of business performance improvement

Source: ISPI

Having in mind the fact that the defining of the system performances significantly contributes to the successful functioning of the organization, it can be said that choice, description, measuring process and the way of using performances have the extreme influence on the process.

That is the reason why literature and practice standards for defining of the performances are often used. They are defined and published by the International Association ISPI[10] which deals with performances and considers them from different aspects.

The essence of standards for defining performances is based on ten principles, shown on Figure 2.

Focusing on the results – defining the group of performances which depends on results we wish to achieve, and for transport organizations. These are mainly satisfaction of users of transport services, together with the increase of revenues, reducing of passenger or freight transport costs, proper using and development of the human resources;

Applying of system approach – enables realizing of interconnections and influences which exist between certain elements of the business system, and their relations with the environment in which the organization operates, including the efficiency of each individual part of the business system;

Additional value – means focusing of the organization on all those business processes which create additional value, in accordance with the expectations of users; it is desirable for the organization to make projections of different solutions for business processes, and then to attribute value to them, possibly in cooperation with users, permanently striving to improving of its business;

Cooperation with users and other experts – it is a necessary precondition for the successful business of the organization, and it is primarily based on sharing of responsibility in the process of decision making, forecasting and implementations of business goals, while respecting the principle of confidence and expertise and knowledge;

Analysis of the needs or possibilities – it is the situation when the organization wants to introduce a new business process, to harmonize its business with demands of users, to check

[10] ISPI – International Society for Performance Improvement, www. ispi.org

its business performances. Results of this analysis represent the basis for creation of the new development perspective, which will contribute to the success of the business;

Analysis of causes – enables establishing the difference between the performances or expectations, and the final goal is identifying and eliminating of weaknesses, which contribute to improvement of organization's business performances,

Projections – means introducing of a new solution into the organization, together with defining of the new business system structure and explanation of the influence of the new solution to the business performances of the organization,

Development - looking into elements of a new solution, supporting and coordinating it with the organization's business objectives and outputs,

Implementation - applying the solution and managing subsequent changes in order to fit the new solution into existing business processes,

Evaluation – assessment of effectiveness and efficiency of the new solution, comparing the investment against benefits and estimating effects of all previous standards.

Experiences of leading world transport organizations showed that performance management according defined standards is impossible only using "ad hoc" actions. It needs systematic approach, defining of management model which will be implemented and monitored continuously with active involvement of all employees.

4 BUSINESS PERFORMANCE IMPROVEMENT ON SERBIAN RAILWAY

Business performance management and their improvement are becoming a great challenge for large transport systems including Serbian Railways. This company should suggest strategy in a very short time. Using this strategy the organization with big losts would be transformed into organization which respects modern business principles and obtains profit. Realization of mentioned objective includes creating of sustainable balance between economic-finance interests of the organization and socially-ecologic interests of its environment, which can be achieved using appropriate standards.

Since the main product of transport organization is transport service, it can be said that Serbian Railways should follow the example of world famous transport organizations which apply business rules. Within these rules, the quality is the key term and the user of transport service is a measure of quality of offered transport.

The key question is how to achieve this objective. The answer is impossible without information about the existing condition in performance management in a large and complex system such as Serbian Railways. The aim of conducted research was to obtain information about opinion of employees. Their opinion is related to practice of organization performance management. Starting point of each research is the analysis of existing condition, which should answer the question: Where are we now? Pilot survey has been conducted for this work. It should represent the assessment of achieved level of performance management in Serbian Railways. Research is conducted on example of 68 employees who belong to middle level of management and work on a railway in sectors related to strategy and development, business plan, finances, transport technology and other activities (informatics and restructuring). Structure of respondents by organizational units is presented in figure 3. Also, the figure 4 presents respondents according their employment status in area where they are experts.

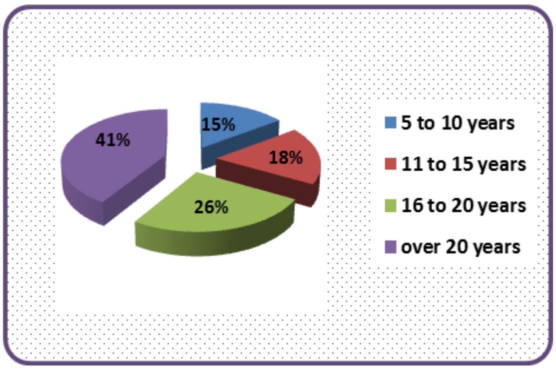

Figure 3: Structure of respondents by organizational units

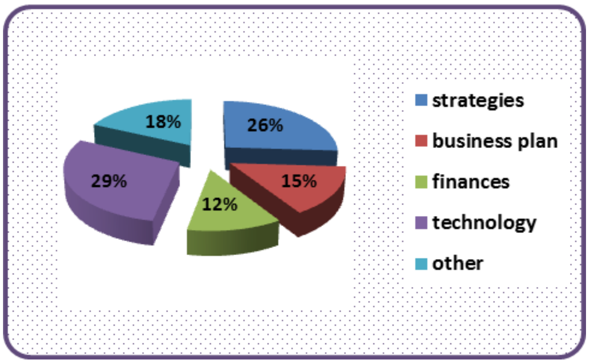

Figure 4: Structure of respondents by organizational units

The survey has been conducted during the March 2013. Respondents answered on questionnaires in written form. The respond to the survey was excellent, since 97% of toital number of survey lists was filled in a proper way. The anonymity was guaranteed to respondents. Information on organizational unit (where respondent works) and number of working years on a specific job were needed for the survey. Respondents belong to a category of middle management (heads of departments, coordinators, project managers). They are experts in their area of work, very familiar with events in organization, not politically oriented. The politics is present in election and work of top management. Whether the sample can be concerned as relatively small, survey results can be considered as valid because most of respondents are experts in their areas of work. The research included questions conceptualized in order to check practice placed in context of “Ten principles of business performance improvement” which are explained in previous chapter.

Results of this survey are extensive since each of ten questions included three to five additional questions on which respondents had to respond.

For purpose of this work, the presented essence needs to show the opinion of employees on a level of achieved or applied practice of business performance management. Respondents have a high level of competencies, since 67% of them have more than 15 years of working experience, which makes experts regarding familiarity of system and profession.

While talking about the focus on output results of business, application of systematic approach for work with added value and evaluation, most of respondents think that those principles are not applied for rail. Cooperation with service users, analysis of needs and causes and projection are partially applied.

There are also divided opinions regarding implementation of solutions and evaluation. In other words, the same number of respondents think that it is partially conducted or it is not conducted at all.

The final result of conducted survey is presented on Figure 5. According to this figure, 40% of respondents think that principles of business perfomances management are not applied, 36 % think they are partially applied, while 24% think these principles are totally applied.

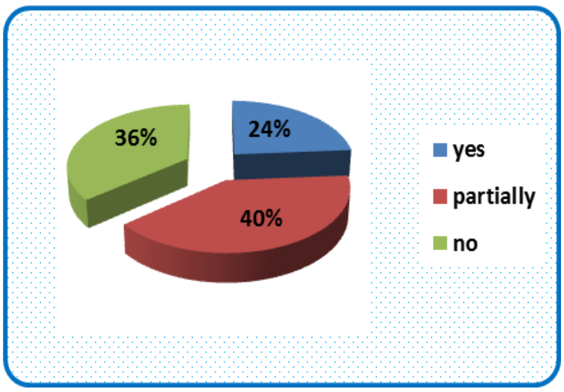

Figure 5: Improvement principles of business performance management on Serbian Railway

At the end of the survey, respondents were asked to rang factors which mostly contribute to success of the organization. Answers are presented in Figure 6.

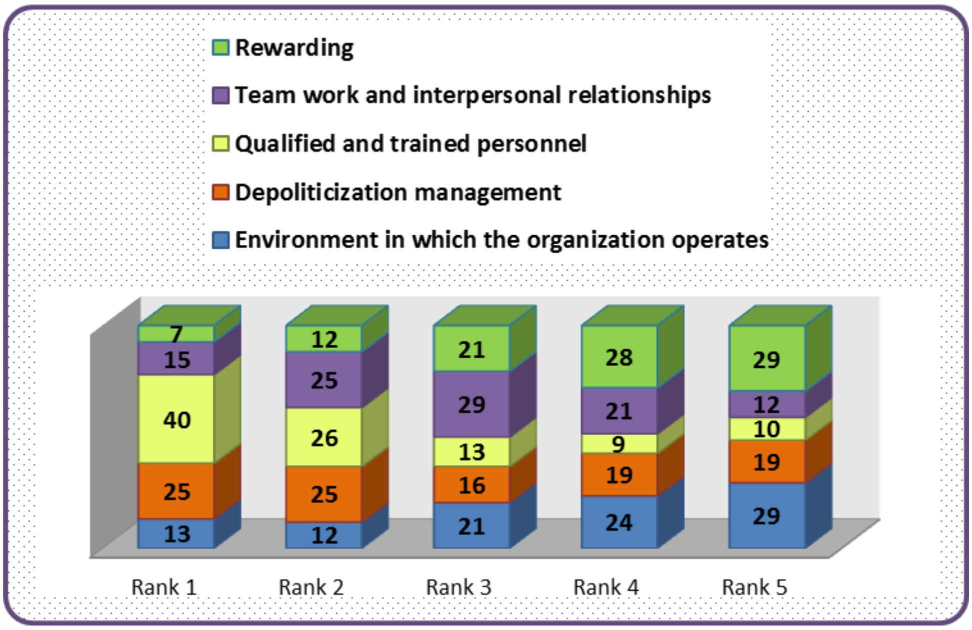

Figure 6: The factors that determine the success of the organization

The analysis of obtained results implies that there is a lack of attention dedicated to performance management in Serbian Railways. Respondents answered with "No" or "Partially" on most of questions, which suggests on a low level of development and application of performance management in this company. It is important to note that employees are aware of obstacles to creation of successful organization. As most important factors on which organizational success depends, respondents mentioned qualified and trained personnel, depoliticizing of management, teamwork and interpersonal skills, and the environment in which the organization operates and ultimately rewarding.

5 CONCLUSION

Presented research of achieved level of performance management in Serbian Railways implies on the complexity of this problem which received very low attention according to opinion of respondents. As a consequence of such approach, Serbian Railways are one inefficient and expensive system, in which resources are irrationally spent, which above all contributes to negative financial aspects of business. According to that, this is the organization which belongs to the group of largest debtors in Serbia.

Nowadays, the application of modern organization of work and decision making theory present the premise of modern management of complex processes within one system. Changes in way of work and business are necessary. Furthermore, quality decisions making, based on knowledge and application of modern science methods are the condition of the existence of the organization.

Conducted research implies to need to immediately conduct reforms in railway sector at all business levels in order to decrease gap in way and effects of business between Serbian and European railway administration. Starting point of changes could be defining of performance management model for Serbian Railways, whose application could be used for efficient management of success and strategic development of organization.

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CONTROL SYSTEM FOR INCREASING TRUCK PRODUCTIVITY

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ABSTRACT

Western European countries are facing problem of intense competition on transportation market. High oil prices are not helping to solve situation, so many transporters are facing company foreclosure. It raises a question how to help in this matter. Two aspects have to be overviewed. Firstly, how to lower costs and secondly, how to maximize loadings and increase truck productivity. A cleaver solution/-s has to fulfill gap between customer order and transport companies. In this research system monitoring with database for increasing truck productivity is proposed. It is a system based on receiving information in connection with partners. System uses genetic algorithm for restrictions and fuzzy system for division. Research concludes with future research, proposing other connection systems as neural networks.

Keywords: real-time regulator, truck productivity, forwarder company, genetic algorithm, fuzzy system

1 INTRODUCTION

There is a problem for forwarder companies on west side of Europe, which was affected by fall of borders. European Union (EU) brought many solutions, or we can even say simplifications to transportation, but on the other hand it also opened new issues. Fall of borders had lots of influence on income for forwarding companies, among them, earnings from customs procedures and also flood of Eastern European transporters entered on this market with cheaper labor force, creating tension in competition. New era has begun, era in which lots of new companies can be in transportation business. A spark was created, competition grew and also transportation lost its way in quality. If we look closely, we can see complexity of a problem. Sharp competition is actually ruining market as it is in search for lowest prices.

Nowadays typical customer looks for cheapest way to handle goods from A to B point and many times, they are willing to sacrifice quality in exchange for lower price. Here story begins, we have customers, but how to offer them lowest price with good quality. One of the possibility is to lower costs and second, to increase truck productivity. The biggest reason for low truck productivity is the huge number of competition. This is current situation in short, but we ask ourselves, is there another way?

Instead of being a competition, is it possible to cooperate and how affective this collaboration would be. We are proposing a solution of truck controlling system/regulator, which will provide real-time information, from which; we can lower truck costs and increase truck productivity (occupancy of truck space). Bottom line, we are looking for synergies from the information, so we can increase our profit, or in weak economy, this element could be used as a “safety guard” of lowering price (margins) and still stay at the market.

2 REVIEWS OF POSSIBILITIES REGARDING PROBLEM

Existence of problem is since beginning of crises, so all sort of solutions already exists and also helps in this matter. Many authors already review this problem in their researches and tried to find best possibility.

Firstly we have to mention, vehicle routing problem. It exists in many different forms. Authors like Bock [1] used it as combining with shortest routes and terminal services to achieve better truck productivity. Secondly, researches also review possibility to compete with cheaper work force from Eastern European countries which is employed at Western companies. Furthermore, researches also checked possibilities to lower labor costs on different ways inside the organization [4] or to hire outside truck sourcing, which can provide trucks or truck space to manage transportation tasks of forwarding companies, which in this case are working as an agent between transporters and customers. Finally, multi-agent system for truck fright collaboration had been developed [5].

In this research a new way of “trying to solve problem” is proposed in following order. In part 3 there will be description of system functioning. Problem is solved with help of genetic algorithm (GA) and fuzzy system. Furthermore, in part 4 there is test on real cases. Research concludes with future research.

3 PROPOSED SOLUTION - REGULATOR FOR TRUCK PRODUCTIVITY

In forwarding organization a common thing is to have partners for cooperation or collaboration on international markets. There is a rule; to achieve satisfactory level of performance outside your own company, firstly you need reliable partner who is specialist on one part of territory. A specialist knows territory very well. We expect from partner to have excellent truck coverage and possibility to fulfill all various transportation tasks.

Partners can be in all sizes from small till large, but that is not what interests us. Our focus is on partner connections. Many connections with various partners mean larger territory handling, which in praxis means lots of customers. Partner cooperation can be various. Partner work can also be risky, because you have to find a trustworthy company which will respect connection or collaboration. What else can we gain from this trust is our question. We can exchange valuable information. To be able to use information in right way, can bring us synergies, which transportation organization needs to survive. Idea behind this system is to use all available information.

System or regulator for truck controlling is an **information reader**, which can transform information into profit.

Key elements:

- **Partnership –** territory specialist
- **Database** – gathering all information from our company and partners
- **Truck location** – monitoring of all truck locations (own and partners)

Regulator consists of **database**. Database is the most important element. In this element all information are gathered, meaning, information about loading places, loading meters, truck position, etc. from where all transport plans will be done. Transport plan should start with knowledge of loadings and real time position of all vehicles that are available to load. In combination with that information we also need data as: empty truck space, weight, customers, etc. All this information will feed database.

Role of partners – specialist of one part of territory. Sharing information, feeding the database, and reliable in work. This connection is vice versa.

Regulator composition

Regulator can be in **2 levels**. It can control basic level, where the regular transport pickups are predicted up front (daily or weekly, etc.). In everyday scenario also non regular or extraordinary loadings can be done.

Second level is handling additional loadings in real time. This is level on which we can add shipments in expectation of increasing truck productivity. If we sell additional truck space (better utilization), then level 1 is automatically changed with level 2.

Level 1: regular business – real time control of shipments, vehicle positions, empty space, etc. that all partners are monitoring.

Level 2: regular business + additional/extra business – real time control, information providing and execution of loading additional loads.

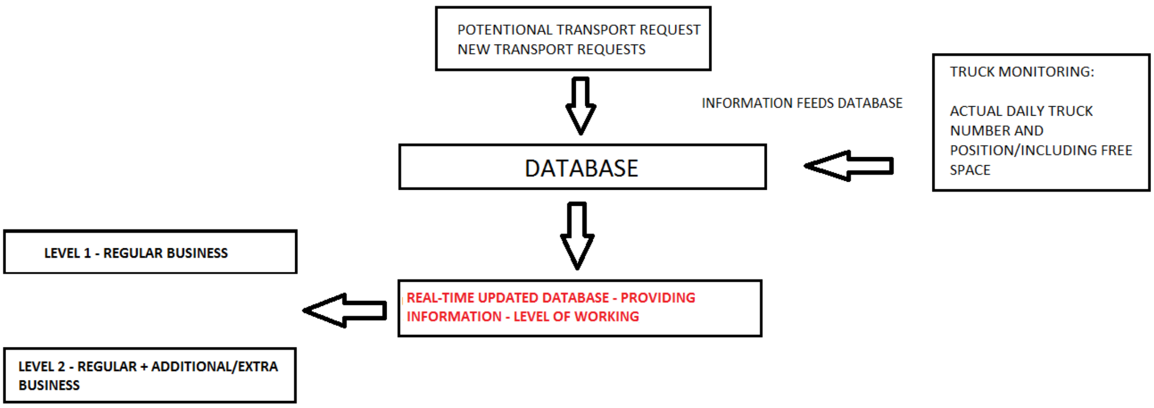

Figure 1: System proposal

Source: Author

Process of working

First level is including all regular pickings; in the meanwhile system is gathering information about other pickings in all areas that partners are in control. Both levels go simultaneously in real time. If truck is full based on first level, which means truck productivity is maximum then we can not change events for this truck. On the other hand, if plan on level 2 exceeds level 1 in truck productivity then plan on level 2 is accepted.

With better truck productivity we have 2 options. Both options are regulated and driven by market. First, if a market is in bad condition then with better truck productivity we can lower the price of transport and gain on competiveness and secondly, if market conditions are normal then truck productivity brings us more profit. Furthermore also with better truck productivity we have to use fewer trucks to fulfill tasks. Also side effect is, we produce less emission and because of it, we also do less damage on the environment.

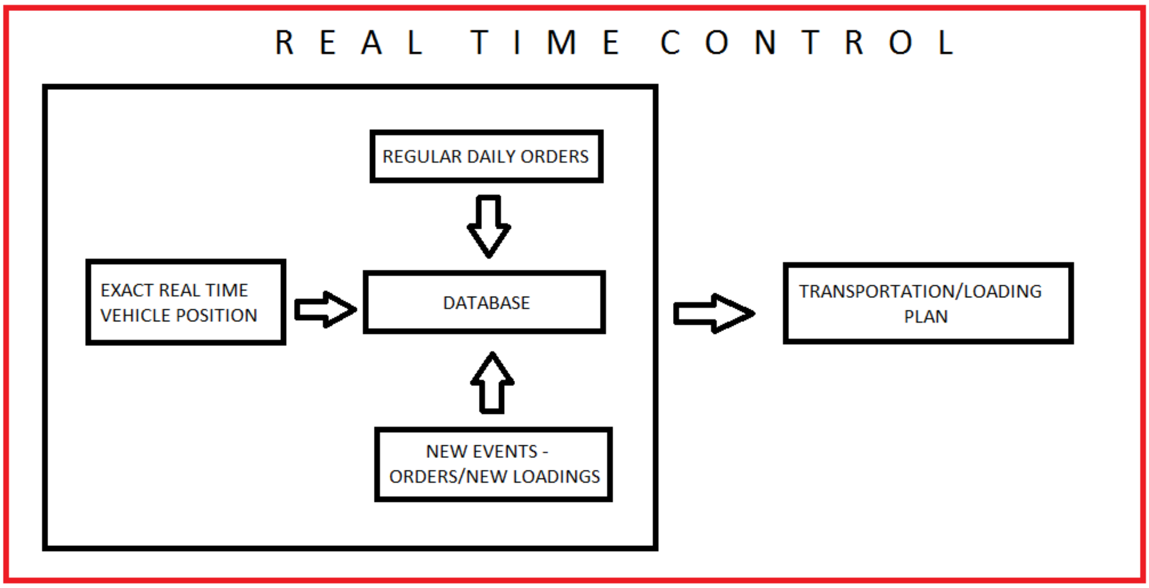

Figure 3: Real time controler

Source: Author

System operation

Step 1: System needs to find nearest truck in area, which can fulfill required task. If not then we make another review, we look for another closest truck and try to load

Step 2: Cost/earnings ratio has to be accepted

Step 3: If price is accepted (customer confirm loading) then level 2 overwrites level 1

Restrictions

- Truck restriction - Truck is limited by dimensions and loading weight which has to be respected in all ways. Truck restriction can be solved by genetic algorithm.
- Cost restriction – truck cannot pick up shipment if costs exceed earnings.

Problem solving

Shipment assignment – Genetic algorithm
Truck space restrictions – Genetic algorithm
Plan – Fuzzy system

Mathematical formulation

Problem of shipment assignment can be solved with genetic algorithm. Shipment can be assigned to certain truck based on "weight coding". Also trucks can be assigned to shipments based on costs and truck space. Both elements can be defined by "weight coding" system.

$$Maximize \qquad V = \sum_{i=1}^{C} \sum_{j=1}^{n} vjxij \tag{1}$$

Subject to $$\sum_{x=1}^{C} xij \leq 1, j = 1, \dots, n \tag{2}$$

$$\sum_{j=1}^{n} sj, xi, j \leq Smax, i = 1, \dots C \tag{3}$$

$$xij \in \{0,1\}, i = 1, \dots, C, j = 1, \dots, n \tag{4}$$

with $$sj > 0, vj > 0, Smax > 0$$

Where is,

xi,j (i = 1,…,C, j = 1,…,n)

If shipment j is loaded on truck C then value is 1 otherwise it is 0. Restriction N in (2) is assuring that shipment can be loaded only once and C restricts truck space. Solution is proposed with technic called weight coding. We put on shipments and also on trucks different weights.

As introduced, with genetic algorithm there is posibility to introduse options with weight vector t = (w1, w2,…wn). Weight wj is connecting with shipment j. For decoding that cromosome we can add weights to relative shipment value.

$$Rj = rj + wj \tag{5}$$

$$Vj = rjsj = vj + sjwj \tag{6}$$

$$W = \frac{\max(rj) - \min(rk)}{2} \tag{7}$$

Where is,

j = 1,…,n

k = 1,…,n

$$W = \max\{\frac{(Vmax - vj)}{sj}\} / \left\{\frac{(vj - Vmin)}{sj}\right\} \tag{8}$$

With $$Vmax = \max(vk), \qquad Vmin = \min(vk) \tag{9}$$

We can use method called »Decoding heuristics«. Very sophisticated method, which loads trucks as possibilities allows. So, algorithm searches for best possible truck and space on truck. Where there is best possibility, shipment is assigned. Algorithm simultaneous checks all other trucks and space and put on trucks in priority (value) sequence. More »value«

higher is in the rank. Also here we have order based on decreasing absolute value v_j or relative value r_j.
Costs are formulated as;

$$\text{Minimize} \qquad C = Cf + \sum Cv \tag{10}$$

$$\text{With restriction} \qquad C < I \tag{11}$$

Where is,
Cf – fix cost
Cv – variable cost
I - income

Fuzzy system

Remaining issue is how to change between levels. Problem can be solved with fuzzy system. In this system we have 3 inputs and 1 output. Our input positions are: Start load position, Additional load and Cost. Information is provided from database.

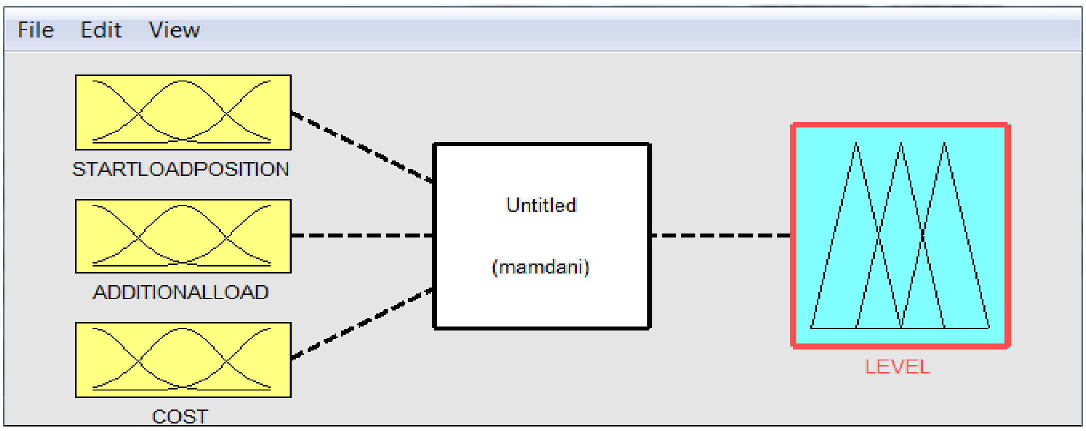

Figure 4: Fuzzy inputs/outputs

First input is start load position, which means, how much loading meters of loading space we already have sold. Start loading position (SLP) is in load meters (LDM). Membership functions are very low (VL), low (L), medium (M), high (H) and very high (VH). Second input is Additional load. Also here we have 5 membership functions:

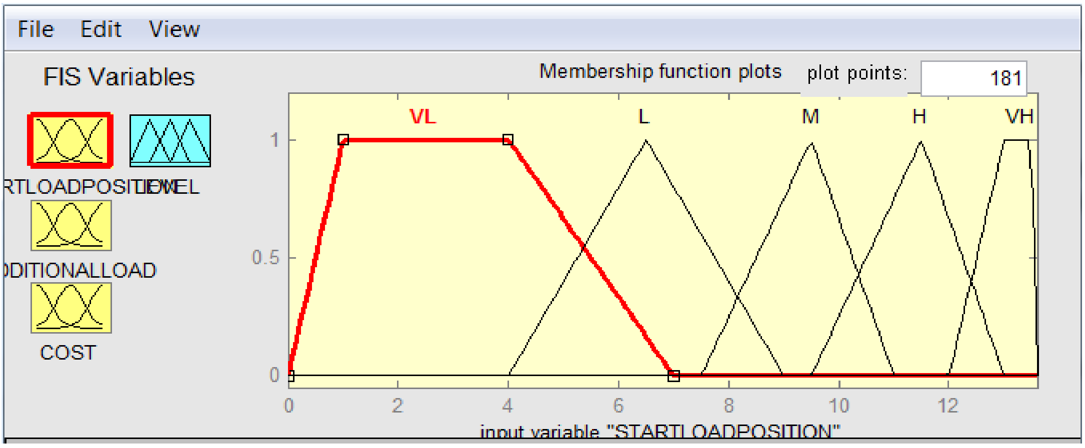

Figure 5: Membership functions for starl load positions

Second input is Additional load (AL). Also here we have 5 membership functions: Very low (VL), low (L), medium (M), high (H), very high (VH)

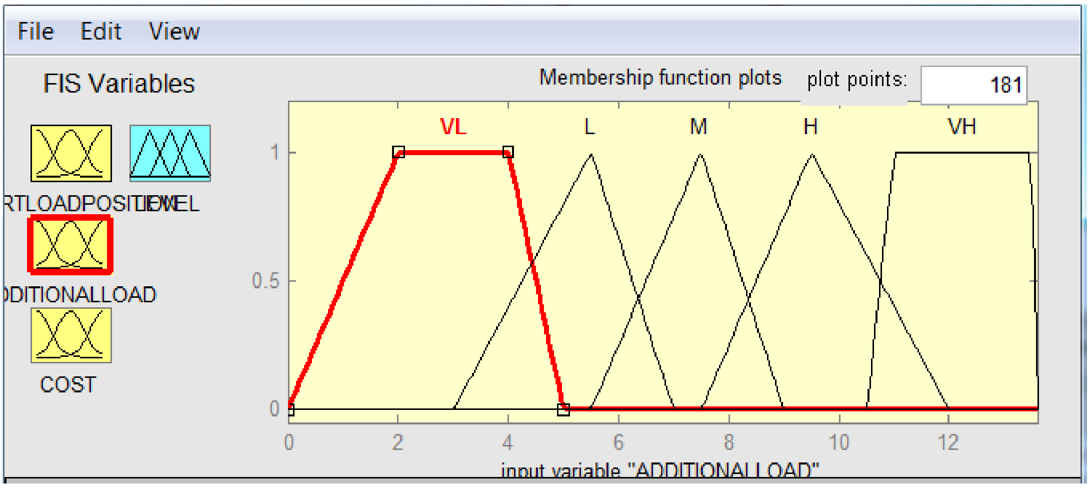

Figure 6: Membership functions for additional load

Third input variable is cost. Cost can be defined acceptable (A) or non-acceptable (NA). Output variable is basically levels of work. We have 2 possibilities, 1 and 2.

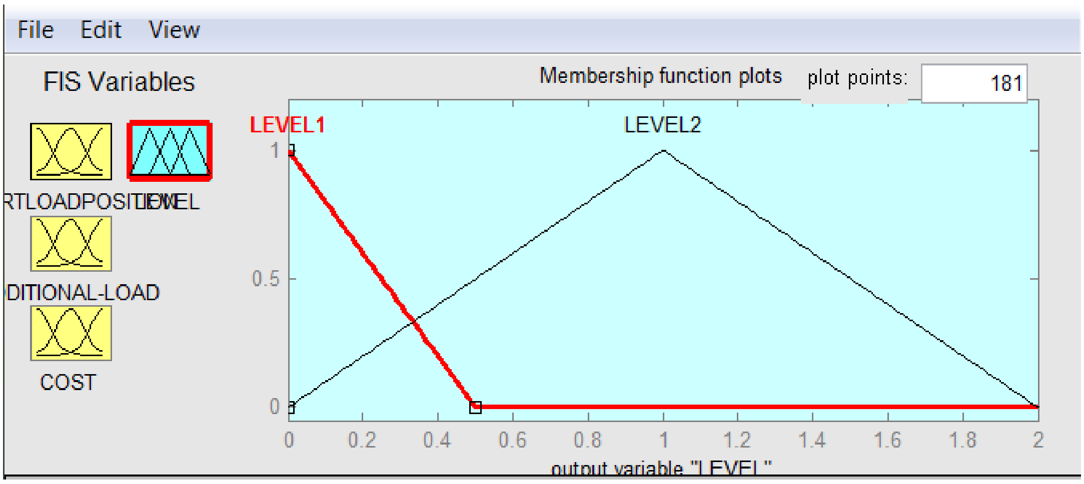

Figure 7: Output variable - levels

Rules

With all membership functions we have to make 24 rules to solve problem:

1. If SLP is none and AL is none and C is none then Level is none
2. If SLP is VL and AL is VL and C is A then Level is 2
3. If SLP is L and AL is VL and C is A then Level is 2
4. If SLP is M and AL is VL and C is A then Level is 2
5. If SLP is H and AL is VL and C is A then Level is 2
6. If SLP is VH and C is A then Level is 1
7. If SLP is VL and AL is L and C is A then Level is 2
8. If SLP is L and AL is L and C is A then Level is 2
9. If SLP is M and AL is L and C is A then Level is 2
10. If SLP is H and AL is L and C is A then Level is 2
11. If SLP is VL and AL is M and C is A then Level is 2
12. If SLP is L and AL is M and C is A then Level is 2
13. If SLP is M and AL is M and C is A then Level is 2
14. If SLP is VL and AL is VL and C is NA then Level is 1
15. If SLP is L and AL is VL and C is NA then Level is 1
16. If SLP is M and AL is VL and C is NA then Level is 1
17. If SLP is H and AL is VL and C is NA then Level is 1
18. If SLP is VL and AL is L and C is NA then Level is 1
19. If SLP is L and AL is L and C is NA then Level is 1
20. If SLP is M and AL is L and C is NA then Level is 1
21. If SLP is H and AL is L and C is NA then Level is 1
22. If SLP is VL and AL is M and C is NA then Level is 1
23. If SLP is L and AL is M and C is NA then Level is 1
24. If SLP is M and AL is M and C is NA then Level is 1

4 TEST OF CONCEPT OF TRUCK CONTOLING

Let us see how effective would system be in praxis. We will see effects of it, on 15 cases. For our testing we took population of 20 trucks in 1 country and see how effective this system is. With detailed information form small sized partner we have checked 3 different areas in 1 country – Germany. Those areas were around post number 2, 0 and 8. Biggest cities in those areas are Hamburg, Leipzig and Munchen. In every area we have made 5 cases of picking.

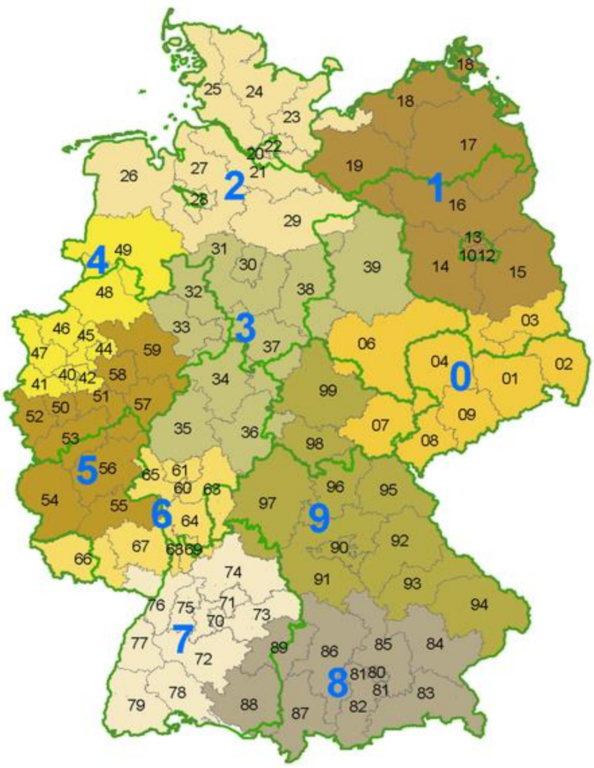

Figure 8: Post numbers of Germany

Source: http://en.wikipedia.org/wiki/File:German_postcode_information.png

Measurements methods

Research was done based on 2 aspects. We have look for time spend and influence on cost. We have made comparison between usual methods of truck searching and finding best price and systems time consumption and finding closest truck available.

For "usual" method we observe worker in transportation organization with 10+ years of working experience and we had measured time, that worker needed to look for best possible truck to do the required job, minding the price, based on his capabilities and possibilities.

Results

Table 4: Average measurement results for 3 different areas

Number of trucks (20)/cases	Area (post number)	Workers method average(t)	Controller average(t)	Cost (worker %)	Cost (controller %) average	Difference (approx.)
1	2	6,2 min	0,01 min	100%	103,78%	4%
2	0	9,1 min	0,01 min	100%	102,91%	3%
3	8	4,4 min	0,01 min	100%	107,24%	7%

Relative error for workers average time for truck searching:

- 6,2 ± 0,31 min

- 9,1 ± 0,455 min
- 4,4 ± 0,22 min

Research findings

We have find out, firstly, this system will lower searching times. It is difficult to conclude how much time we would save, because there are different size transporters with different internal organization, but we would not exaggerate if we say average worker uses up to 5% of working time just for searching. Time also have its own costs. On average, difference between worker and system can also be up to 7%. Percentage, which makes a difference.

Problem with these conclusions is relative small population. This needs to be big-size test on bigger territory. For example, whole EU and at least 500+ trucks, to see more of the effects.

5 CONCLUSION

Situation on west side of Europe is getting even more intense due to labor cost for eastern European transporters so change is inevitable. Any step further is step in the right way. Many west transport organizations have made change with the work force. They have change domestic workers which are more expensive for foreign ones, mostly from eastern European countries. Problems with cheaper work force are complex and not part of this research so they would not be discussed here.

Many transporters are looking for collaboration; many small transporters are merging to become bigger to be more competitive to larger ones. Bottom line transportation companies are searching for right solutions which they might work for short or even longer period of time, but if we see problem from higher point, then it is visible how complex this really is.

Future research could include other types of transportation organization connections. Research could also include system with neural networks. Neural networks are artificial neurons which have ability for similar problem solving as human brains. System should include database where all information can be stored from which with help of neural networks can outcome as similar as human decision. With this sort of system we can eliminate some labor costs and errors.

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ANALYSIS OF MARKET PRICES FOR FULL AND PART LOADS IN ROAD TRANSPORT

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ABSTRACT

Customers are searching lowest price for transport service, to fulfill their needs for transportation from their facilities to consignees. On the other hand, todays transport companies are facing problem of raising costs, especially rise in oil price, which is affecting selling transport price. Research start with analysis of transportation costs for 40t truck per kilometer. In part 4, question about, how to calculate sustainable market prices, which includes risks, for full and part loads, in road transport, for capital cities of former Yugoslav republics and Albania, is answered. Furthermore, research introduce proposal to develop a unified real-time database for truck costs/market pricelist, which can be used as a helper for price calculation and reduction in time spending. Research concludes with proposals for future research.

Keywords: market price, costs, road transport, former Yugoslav republics

1 INTRODUCTION

Nowadays customers for their transportation operations search for lowest price and so are the transportation companies in search for providing the most competitive price. Today's market is shattered in pieces, especially western European markets, which are mostly affected by EU. EU brought many simplifications to transportation market, but it also created many problems. Lots of new competitors came to EU market, especially from eastern European countries, and with their cheaper labor force is increasing competition.

Second aspect we have to pay attention is oil price. As mostly all of the state's funds are empty, state regulators are searching new ways of income and they are trying to find it on most affective parts, which are for example, excise duty on oil price. Price of oil on the market is also rising. A raise in both parts is skyrocketing costs for transportation. Margins in transportation were never high, like in other industries, so there is not much price regulation inside it, and if there were, this solution was already used. Prices are very delicate and complex subjects so we need to understand what "lies behind" competitive price. Problem: How to calculate correct competitive sustainable price for transportation? Competitive price is lowest possible price, minding all the costs we are facing. So question is how to find it. Answer is given by market. Customers developed few of their own market searching "tools" with which they are in search for lowest price. Many times they are willing to sacrifice better quality for lower price. That trend is giving transportation companies a picture of current situation in the market.

Furthermore, there is not much to do for transportation organization. Beside high oil prices transportation organizations are also facing rises in road taxes, toll, insurance, labor costs, etc.

2 LITERATURE REVIEW

Authors in [1], [11], [12] reviewed named problem, regarding calculation of costs for truck per kilometer, price calculation in transport is being fundamentally introduced also in many other researches, but the fact is, there is lack of information regarding calculation of market transport prices, todays diesel charge in road transport and calculations for territory of former Yugoslav republics and Albania.

In following part 3, research will discuss costs per kilometer for 40t truck and calculating market price for capital cities of former Yugoslav republics and Albania. Furthermore, an introduction of idea of real-time cost database from which we can make real-time price list is being proposed. Last part of research is conclusion.

3 METHODS OF PRICING AND ELEMENTS REGARDING TRANSPORTATION COSTS

Let us introduce simplified price calculation methods. We will use methodology regarding pricing from literature [6], which explains it in 4 possibilities. Firstly, **cost-plus pricing** - method where we have to consider costs, plus, we have to add margin. It is an accurate method, which is creating operations always with profit. This method is advised and proposed to be used also in transportation organizations and finally this method will be also used in our research. **Target return pricing** – it is a method which targets a return on investment. We are setting price based on initial investment. **Value-based pricing** – at this method we value based on what it represents to customer. **Psychological pricing** – there are 3 elements to look at. Positioning; we have to know in which price range we are selling. For example, if we are high quality provider, price has to be in higher price range. Popular price points; we are figuring price based on psychological thinking. For example; figure price 90 EUR, rather than 100 EUR, because it has more effect, and thirdly is fair pricing. We have to figure price with in limit what customer perceive as “fair”.

Every company has its own method of price calculating, so as much as there is companies there are also methods. We have to mention, in transportation, there are calculations per size of shipment and calculation per kilometer or per route of transportation. To go step back, we need to know what exactly we are selling. We are selling service of transportation of various shipments on various routes. From technical stand point of view, we are selling truck space, which is limited with restrictions, which are size of trailer and maximum carriage weight.

Size of shipment – we understand different sizes means different truck space occupancy. We can use different measurements for shipment. Shipment can be measured based on volume, weight and load meters, so in order to find correct price we need to include all of the aspects. When we talk about part loads (LTL) and full truck loads (FTL) there is difference in sizes. A full truck load, based on definition, is a load which requires all space of trailer and by definition does not allow loading anything besides, on the contrary, a part load is less than full truck load and it requires second or even third loading place to fill the truck, but our focus is what our costs of transportation are. In following subpart we will check cost of transport per kilometer for tractor truck with trailer – 40t.

Cost of transportation per kilometer

As already introduced we will check costs for most common used truck for transporting goods in international transport, which is tractor truck with 13,6 LDM trailer. Other, smaller trucks are not appropriate to fulfill required tasks, so they will not be part of research.

As already explained we cannot be competitive if we do not know our exact costs. We can either drive with loss or become expensive and not win any customers. Our first question is how in other EU countries calculations are made and we will compare it with Slovenia. We will start with price calculation in France. As also in Germany, there is more complex calculation. They are divided into 2 parts, time and kilometer costs. Sum of both is giving a real and correct cost. Moreover, we have to add, they are making calculation costs per day (time) and kilometer, after transport is finished. Based on data they received, they make conclusion if transport was profitable or not. For example if they have used too much time it will negatively affect costs. That is the reason why many French transporters have time conditions in connection with price. If we compare it with Slovenia, we see that in Slovenia, only price per kilometer is introduced and it is calculated before transport service. Also we have to add, for example, transporters in France are calculating road tax separately. They are not including in price calculation, but adding to it, in comparison to Slovenia, where is calculation per kilometer with road tax. Payment for transportation service or legislation for it is different in Slovenia as there is for example in France. Difference is, Slovenian legislation is not specifying lowest transportation fare, and furthermore most of the transporters in Slovenia do not have any price specified. On contrary in France they do. The lowest transport fare represents minimal costs to pay for all obligations, which laws require; among them are costs for fuel, maintenance, road tax, payment for driver, etc. These are some of the main differences in methodology of price calculation.

We have checked on the market and realize, that market share of tractor trucks is split among following manufacturers: Daimler (22%) has the biggest share, followed by MAN (14,9%), which is closely followed by DAF (13,8%), then Volvo (12,4%) and last but not least, Iveco (11,1%)[1]. Considering this data we will make a check of costs with bestselling model from Daimler, which is Mercedes Benz/Actros.

Next question is how to calculate average number of kilometers per month? We have used simple formula, starting form fact, that average speed of truck can be from 60 – 65 km/h[2], which means in 8 hours it can drive up to 520 km/day. If it drives approximately 5 days a week we have 2600 km per week, which on month bases represents around 11.000 km. This will be our ground point for calculation.

Costs in transportation are fixed and variable. Even if we are not driving we have costs, those fix costs are resulting from, labor cost, depreciation, storage space, insurance, annual road user charge, etc. and variable costs as for example; fuel, road tax, maintenance, etc. Due to the fix costs, the most expensive for transporters is, if the "wheels are not spinning". However, we have to add the fact, longer driving routes provide lover fix costs per kilometer, or we can say more kilometers per year provides lower fix costs per kilometer, so to be successful in international transportation we have to understand this fact.

Fix costs – we will start with labor costs. Labor costs represent cost of driver. Driver can be also the owner, but still payment for work of driving tasks must be aligned. Based on collective agreement there is 1230 EUR/gross of fix costs per month for driver, but we have to mention also that nowadays more and more transporters introduce new way of payment. Drivers are paid per monthly mileage. This fact is changing point of view. So we are talking about variable costs. From transporters data we found out that driver is paid form 0,09 – 0,13 EUR net per kilometer[3]. Here we have to also mention daily allowances for foreign countries. Those allowances actually represent variable costs, but they are going hand in hand with labor

[1] Source: www.statista.com
[2] Calculation based on simplified customs procedure at borders – no time loss at borders
[3] Source of data: Author

costs so we are mentioning it at this point. Research is for ex-Yugoslav republics and Albania, so daily allowances for these countries are 32 EUR per day[4]. Also in Slovenia there is obligation to pay for yearly recovery (holiday payment) for each worker. It represents fix costs. Secondly, there is depreciation. Depreciation has several tasks. We have to calculate wear of vehicle by each year; we have to collect resources for new vehicle after years of usage, so at bottom line we have resources to buy another one. We are concluding that nowadays product has some good quality and wear is not major. We will be very optimistic in this case and include minimal maintenance costs predicted for this vehicle. Wear of vehicle will be calculated 90 months and wear for trailer 120 month. Furthermore, fixed costs are also insurances. Transporters have obligatory insurance towards cargo and also vehicle have to be insured properly (basic and comprehensive). As well as for all, also for heavy vehicles we have to pay for annual road users charges. Moreover, we have to consider parking space or storage space for vehicle. Vehicle storage space can be rental or it can be owned. Both possibilities cost, rentals are much more expensive and they can be up to 5 EUR per day.

We have to also introduce **variable costs**. Most important variable cost is fuel, which is raging in recent times. We need to mention that prices of fuel in Slovenia are changing every 14 days, so every 14 days we have different calculation if price changes. It is important that driver drives based on regulations, pay attention on tires and keeps maintenance. Based on these elements we can keep up with manufacturer test of vehicle consumption, which is for our researched model 33 L/100 km. It is crucial to drive prudent in order to have fuel consumption as low as possible. Also prudent way of driving saves tires, which is important to keep costs low. Furthermore, we have maintenance, which is obligatory to have safe and reliable transport. Also by maintenance we have to follow the rules of manufacturer. Regular maintenance prolongs vehicle life. Last but not least we have to count unpredictable costs. They can be cost of escort or risk some customers will not pay us for transport service.

We have to touch also facts of time loss. We have to understand how much is it and in case we are losing time we have to calculate demurrage. Demurrage represents customer's reimbursement for damages, which in this case is time. The common fee for daily demurrage is 150 EUR per day[5], which can be fully calculated from 12 hours of time loss. However, we need to check if this calculation is correct and justified. But to be exact we have to look what our fix costs per day are, so we can check what our costs per hour are. Transporters have approximately 55.000 - 60.000 EUR/year fix costs. Divided into days they are 150 - 165 EUR per day. From this data we can see costs per hour are 6,25 – 6,875 EUR. If we have time loss in our transport service we have to include it into our transport service separately, meaning, we have to charge it to particular client.

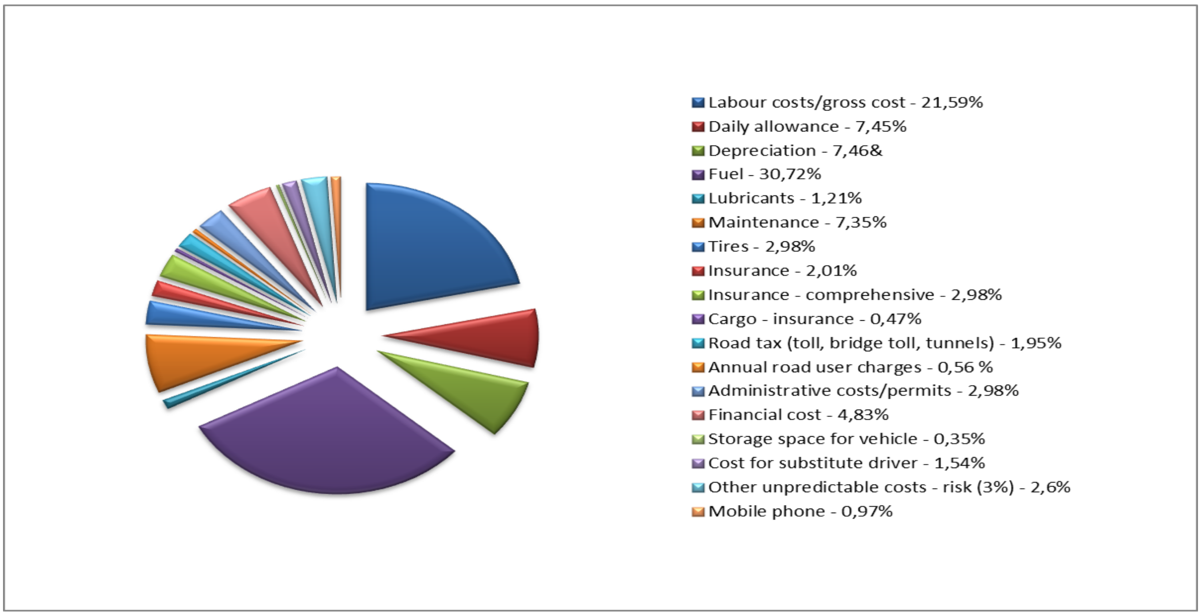
Two more elements have to be revised also. These elements are fees in transportation and "maintenance" of business relations. They are not included in costs, due to current situation on the market. Fees in transportation are paid due to the fact, most transporters do not know how to "find" work, so they need to pay agents to provide information and agree on business. These fees can be up to 3% per shipment. Finally, transporters have business partners, customers; towards it has cost of business "attention", meaning, cost for business lunch or New Year "gifts", which in this market are being pushed on side, due to the lowering costs as much as possible. In conclusion we have to mention, transporters have also expanses with fees toward chamber of commerce or chamber of crafts, which in this economy cannot be reversed to customers, so they would not be included.

[4] Source of data: www.racunovodja.com
[5] Source: Author

Table 1: Costs of transportation per kilometer for truck (40t) – International transport

Cost of vehicle in EUR (tractor + trailer)	89.000 EUR + 21.300 EUR
Depreciation/month	90 months/truck
	120 months/trailer
Number of kilometers/per month	11.000 km
Number of kilometers/per year	132.000 km
Fuel price	1,402 EUR(retail price) - excese duty(0,3998) = 1,002 EUR
Fuel consumption/100 km	33 L/100 km
Labour costs/gross cost	2562,00 EUR/month
	0,232 EUR/km
Daily allowance/abroad +	240 daily allowance per year
	7680 EUR/year
Recovery (holiday payment)	762 EUR/year
	0,07 EUR/km
Depreciation	822 EUR/month - truck, 135 eur/month - trailer
	0,074 EUR/km - truck, 0,012 eur/km - trailer
	0,086 EUR/km for whole vehicle
Fuel	3630 L/month
	3637,26 EUR/month
	0,341 EUR/km
Lubricants	1750 EUR/year
	0,013 EUR/km
Maintenance	3150 EUR/40.000 km
	0,079 EUR/km
Tires	2196 EUR/65.000 km (6 pieces)
	0,032 EUR/km
Insurance	2850 EUR/year; responsibility AO+
	0,0216 EUR/km
Insurance - comprehensive	4250 EUR/year
	0,032 EUR/km
Cargo - insurance	650 EUR/lyear
	0,005 EUR/km
Road tax (toll, brige toll, tunnels)	2750 EUR/leto
	0,021 EUR/km
Annual road user charges	900 EUR/year
	0,0063 EUR/km
Administrative costs/permits	4200 EUR/year
	0,032 EUR/km
Financial cost	6000 EUR/year
	0,045 EUR/km
Storage space for vehicle	500 EUR/year
	0,0038 EUR/km
Cost for substitute driver	2200 EUR/year
	0,0167 EUR/km
Other unpredictable costs - risk (3%)	3800 EUR/year
	0,029 EUR/km
Mobile phone	1200 EUR/year
	0,009 EUR/km
Cost per 1 km	**1,074 EUR/km**

Source: Author

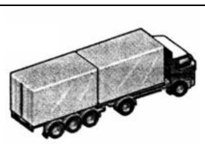
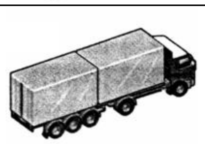


Graph 1: Breakdown of costs – in percentage (%)

Source: Author

Table 2 is showing how much cost of transport increased from 2008. In the last 5 years costs per kilometer increase for 8,5%. We have to take into considerations there is weak economy so every price increase is difficult to achieve. What interests us is why they have increased? Impact of raging fuel price have lot to do with it, but here we have to also mention fact, due to there is less driving kilometers on yearly basis, there is also increase of fix costs.

Table 2: Comparison of costs for transport kilometer for year 2008[6] and 2013

Type of truck		**Year**	**Cost/day**	**Cost/km**
Tractor with trailer – 40t		2008	Approx. – 160 EUR	0,99 EUR
		2013	Approx. – 165 EUR	1,074 EUR

From calculation per km, we can see that huge cost is fuel. Fuel cost represents ⅓ of whole cost. When fuel price increase it hurts transportation badly. Here we have situation, on one side, in weak market (recession), we cannot increase transport prices, but if prices of fuel increase we face situation where we need to lower expense on the other parts, but question is how and where? In praxis we can say every transport company is doing what is possible, especially the most common solution is to lower labor cost. But till where, is the question. Market is also saying, domestic labor force is not accepting these terms and in some cases they are exiting this business. In many cases new labor force represents labor force from Eastern European countries. Also some of transportation organization is trying to obtain better fuel price with collaboration with fuel providers, but in praxis we are talking about

[6] Source of data: M. Počuča, M. Zanne, Prometna ekonomika, Fakulteta za pomorstvo in promet, Portorož 2008

really small amount which do not have huge effect on prices and also some transportation organization is cutting maintenance of vehicle to survive, which in praxis represent big negative effect, because maintenance has to be done in order to guarantee safe and suitable transport operations.

We have to get back to fuel prices. Below we can see graph of fuel prices from 2007 till 2013. Figure 1 is showing exact situation transport companies are facing. Retail fuel prices increased from beginning of 2010 till end of 2012, 43 %[7]. Rise in oil prices we can find in bigger world consumption, especially China and India also in oil market speculations about potential war or unrested Middle East countries or another embargo on any of the Middle East countries, lack of new oil fields, etc., and also as already mentioned, states funds are "empty". Governments are looking for increasing charges, especially excise duty.

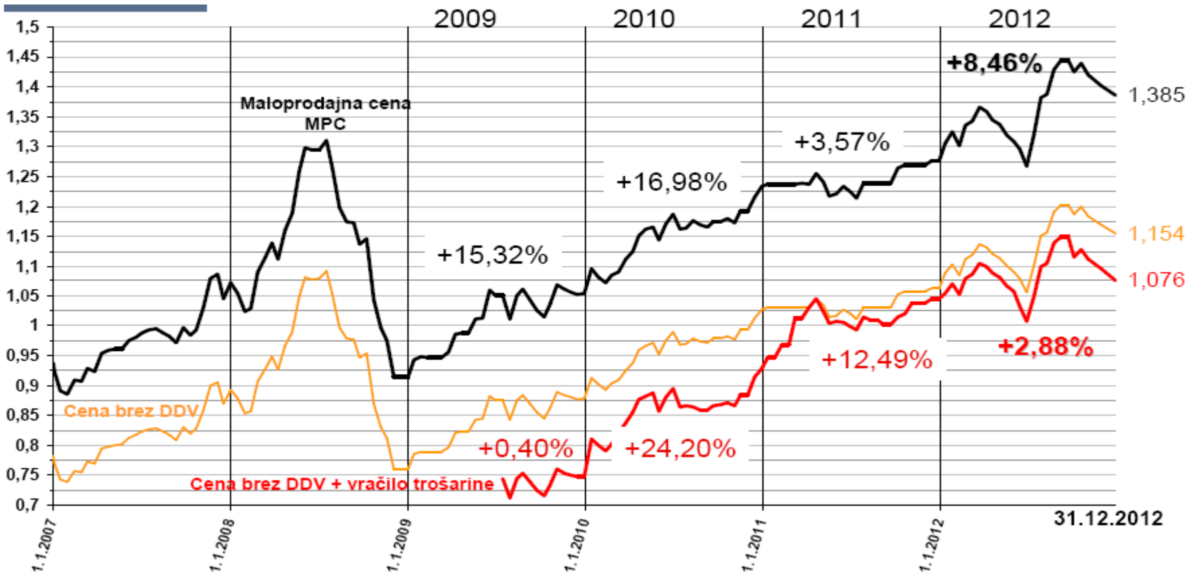
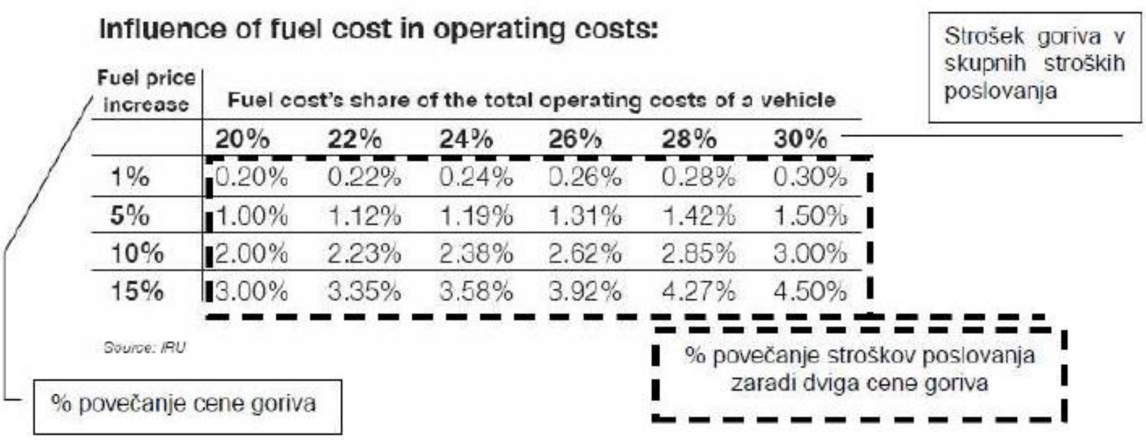


Figure 1: Comparison of retail and without excise duty fuel price from year 2007 till 2013

Source: I Šep, Cestnine, gorivo, pregled povišanj, January 2013

Following, figure 2, is showing how effective are fuel prices in operating costs of transport. We have comparison; if fuel costs increase from 1% till 15%. Also graph shows possibilities of how much percent, fuel cost, represent in overall operating costs, from 20 till 30%. So finally, if fuel prices increase for 15% and fuel represents 30% of operational costs it means 4,5% increase in all costs. Where to find that 4,5% in weak economy is a question. To simply put this expense on customers' shoulders is risk we will loose business and also we have to ask ourselves where customers will find funds to pay price increase and why? Some agreement has to be found and it is in most cases introduced as diesel charge or addition for diesel. In section (diesel charge) we will see how this diesel charge can and is dealt with customers.

[7] Source: I Šep, Cestnine, gorivo, pregled povišanj, January 2013


Influence of fuel cost in operating costs:

Fuel price increase	Fuel cost's share of the total operating costs of a vehicle					
	20%	22%	24%	26%	28%	30%
1%	0.20%	0.22%	0.24%	0.26%	0.28%	0.30%
5%	1.00%	1.12%	1.19%	1.31%	1.42%	1.50%
10%	2.00%	2.23%	2.38%	2.62%	2.85%	3.00%
15%	3.00%	3.35%	3.58%	3.92%	4.27%	4.50%

Source: IRU

Figure 2: Influence of fuel costs in operating costs

Source: I Šep, Cestnine, gorivo, pregled povišanj, januar 2013

Diesel charge

With raising diesel prices, we need to find some agreement with customers, due to the fact to explain and realize what is behind in asking for bigger transportation price. How can we do that? We can calculate with formula below (1).

SRP - starting retail price
CP - current retail price (it is price on last day on previous month)
SFC - share of fuel costs in the selling price
A - addition (%)

$$A = SFC \times (SRP/CP - 1) \times 100 \tag{1}$$

Source: Author

Technic of application of addition can be following (table 3, 4).

Addition for current month (valid for whole month) can be calculated with formula, starting with prices from last day of previous month. Difference is in class ranking. We can use larger intervals and make different percentage count. For example – 1% or 2% per group[8].

Table 3: Possibility of using addition to fuel price increase, based on larger class interval, with increase plus 2%

RETAIL PRICE From	RETAIL PRICE Till	ADDITION
1,170	1,259	2%
1,260	1,349	4%
1,350	1,439	6%
…	…	…
2,430	*2,52*	*30%*

Source: Author

[8] Source: Author

If fuel price exceeds 2,52 EUR/L, the amount of addition is increasing 2% for every 0,09 EUR increase of fuel price.

Table 4: Possibility of using addition to fuel price increase, based on larger class interval, with increase plus 1%.

RETAIL PRICE From	Till	ADDITION
1,090	1,125	1%
1,126	1,160	2%
1,161	1,196	3%
…	…	…
2,126	2,160	30%

Source: Author

If fuel price exceeds 2,16 EUR/L, the amount of addition is increasing 1% for every 0,034 EUR increase of fuel price.

These are examples of how to include diesel charge into selling transport price. Also, we have to be consistent; when or if price of oil would get lower we need to adjust, decrease percentage of diesel charge.

4 USE IN PRAXIS – HOW TO CREATE PRICE IN ROAD TRANSPORT

"Ask the market", is common term to use in economics, and market will tell you about prices. We are talking about complex problem, as we shall see below. For our example, we will take transportation from Ljubljana to capital cities in former Yugoslav republics – Croatia (Zagreb – post number: 11000), Bosnia (Sarajevo – post number: 71000), Serbia (Belgrade – post number: 11000), Kosovo (Pristine – post number: 10000), Montenegro (Podgorica – post number: 81000), Macedonia (Skopje – post number: 1000) and also Albania (Tirana – post number: 1000). So through our research we have saw aspect of what are our real costs. From this costs we have learn about our expenses, and now let us see how prices can be created.

Demand and offer – Since recession in 2008, there is significant drop in customer orders so this fact reflects on transportation business. At this point there is too much transportation providers on market, which are lowering price for customers, but as mention, lower than costs of transportation service we cannot go.

Furthermore we have to mention **operative customer demands**. Customers have different demands based on their needs. Needs are mostly following their production, selling terms, etc. They are depending on various things, among them: nature of goods, time table, packing, etc. Customer demands can be: loading and unloading according to specific time, sufficient space providing, packing, pallet stacking, customs clearance and other documents, reporting of transportation progress, carriage accuracy – performance, managing of claims, losses, damages – insurance, etc.

It is extremely hard or even impossible to check all transportation companies and influence of demands. There are different effects of various demands on work process. It is most important that transportation companies are **monitoring logistics demands and trends,** and makes adaptation accordingly to them and try to include majority of current, most often, demands in their process and with that fact we can see that many of the todays demands are already priced-in the transportation value. All in all, lower than our costs, if we want to have sustainable organization, we cannot go. If we try, on a long or longer run, we will be forced to foreclosure our company. So as already calculated we have normally 1,074 EUR/km cost.

This number excludes costs of margin. Margins are basically left to choose for individual transport companies. We can say on average there is around 3% - 5%[9] of margin in transportation.

A kilometer is not the only aspect to watch. A distance is not automatically only aspect we have to take in concern. However, from transport stand point we have to ask ourselves, where are we driving these goods? (Our main concern is: territory – country, purchasing power of the country, export from this country, etc.). Moreover, we have to look these elements as package of information, which we are including in price.

Why this data is necessary to look at? To create price we have to firstly understand territory that we are driving into. From technical stand point we are asking ourselves how many empty kilometers after finishing this unloading till another loading and how much time did we lost. Knowledge of territory is advantage. Our research is basically finding that market price for former Yugoslav republics and Albania at this current moment. We are facing oil price at 1,402 EUR/L. Diesel prices are very important, because from them we will make diesel addition to our price.

Figure 9: Researched territory – former Yugoslav republics and Albania

Source: http://www.icty.org/sid/321

As we can see, a distance has impact on prices, but as already mentioned, also other elements (risks) play role in price calculation.

These elements are:

- Territory
- Country/city industrial
- Competition
- Safety

Our focus is to capital cities of researched countries. These countries have main industry in capital cities. **Territory and knowledge of it** – in Europe there are differences based on territory. If we take our example, in former Yugoslavia, there was developed north of the former country and less developed south of the country. Based on this information we can conclude there is risk of empty kilometers and time lose in south of the former country. Yes

[9] Source of data: Author

on north of former country we do not have any guarantee about loading, but as there is developed industry it is likely to get some shipments. To stay inside former Yugoslav countries, there are especially some difficult territories as Kosovo and Albania. Problems by them, for example, Kosovo just recently become a country, but there is still tension between Serbia and this uncertainty is increasing **risk**. Risks are increasing the price. Risks can be: lots of empty kilometers, unrespecting of the laws - “wild” laws, which has potential that individuals interpret on their own way, unexpected waiting (increasing fix costs, lowering truck productivity, etc.). It is very important to assess the risk.

Also it occurs to us, to ask ourselves about **countries industrials**. Has country that we are driving into a developed industry and how strong are exports from this country. From transportation stand point, we are asking ourselves what we will be able to drive back. Here we also raise question about empty kilometers. So as specialists of territory transportation, we can have already organized routes to various cities, meaning, we already have established business to and from these cities. This is one way, mostly common for bigger transportation organizations. On the other hand, if we do not have established business, so we have to make research of industrials or to calculate risk of unknown, which has potential to escalate and it can come to creation of non-competitive price.

Furthermore, we have to **check our competition** and their capability. Data above shows territory and industrials and providing some of the information about competition, but we have to make a research of who, how and for what price is working and aim to be better or step ahead of them.

Bottom line it is all about **safety**. Where there is potential risk for criminal activities there is also price increase, due to named fact.

Prices in road transport from Slovenia to researched cities

In table 5 we can find calculated prices with all above (part 4) mentioned elements and diesel charge for capital cities of former Yugoslav republics and Albania. We have included all above named aspects and create sustainable market prices for named cities for part loads and full truck loads. If there are, from current logistic stand point, any additionally (non-standard) demands from customers, we have to add it in this price.

Table 5: Market prices for capital cities of former Yugoslav republics and Albania. All prices are in euro currency

		TRANSPORT PRICES (in EUR) Capital cities				
COUNTRY (POST NUM.)	**DISTANCE (km)**	**SMALL SHIP.(0,25)**	**3 LDM**	**6 LDM**	**9 LDM**	**FTL**
HR (10...)	138	15,93	230,20	290,20	320,29	409,40
BA (71...)	551	51,78	327,41	505,94	728,00	884,00
RS (11...)	533	43,39	255,50	475,20	612,30	853,00
XK (10...)	880	153,47	1280,75	1971,40	2185,60	2369,00
MK (1...)	957	112,11	511,20	732,60	1045,80	1452,00
ME (81...)	787	101,66	650,17	829,80	1184,70	1629,44
AL (1...)	962	113,30	1010,97	1528,60	2138,40	2414,00
		TRANSPORT PRICES (in EUR) Other cities				
BA (R.Srpska 78….)	323	44,98	363,70	472,00	617,52	767,37
HR (21...)	450	58,02	303,40	530,80	666,30	937,38

BA (88...)	548	55,11	481,38	684,80	808,20	1001,28
RS (21...)	506	63,74	281,70	495,30	682,40	935,40
MK (6...)	1107	112,04	578,10	800,00	1141,80	1557,67

Note: 1 LDM – 1250 kg – 3,6 CBM
HR – Croatia, BA – Bosnia and Herzegovina, RS – Serbia, XK – Republic of Kosovo, MK – Macedonia, Me – Montenegro, AL – Albania.

Source: Author

Comparison among cities

Interesting, as we can see in table 5 we have data about distance and prices. As already discussed we can see on real life cases, distance is not and cannot be only provider of information of prices. For example, capital city of Macedonia is on longer route than capital city of Kosovo, but at Kosovo influence of risk is so much bigger, that price is 917 EUR bigger than to Skopje. If we compare RS and BA capital cities, we can see the problem of smaller industry in the BA capital city, which in this case is increasing price. Industry problem we can also see in Split area (HR – 21…). On shorter route we have to ask bigger price.

Real-time truck cost/market pricelist

What is a biggest problem regarding completive market prices? Answer to that question can be found in costs. We have to look for real-time costs, which are calculated from **indicators of exploitation.** We have to measure each trip, average number of trips, average time spend for trip, kilometers, empty kilometers, work hours (driving, loading/unloading maneuvers and failures), fuel consumption per 100 km, maximum achieved tonne–kilometers, average speed, time per kilometer, weight utilization, utilization of transport, intensity of exploitation, transport impact per hour of work, average weight of load and last but not least, static coefficient of utilization, etc.

Idea behind this real time pricelists is to accurately calculate them from costs. **System operation** (figure 4) – part of company, which is in charge for logistic have to provide real-time costs for transportation, calculates costs per kilometers, using indicators for exploitation. All this data feeds next part of organization, which are offerings of market prices to customers. Prices are accurate and also they can be very competitive.

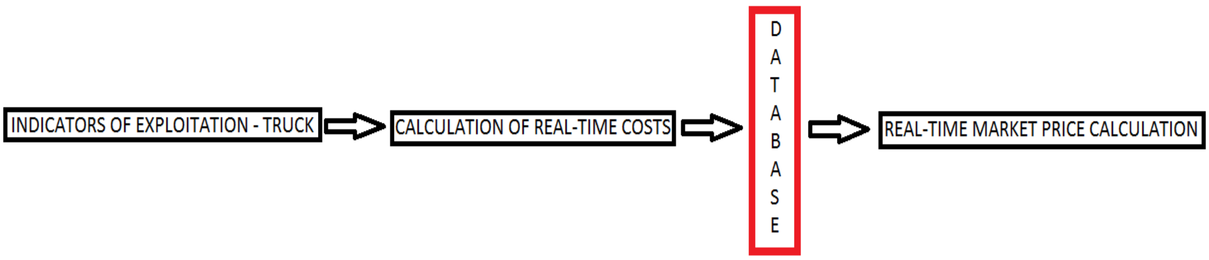


Figure 10: System of calculating real-time market prices for road transport

Source: Author

Benefits - firstly, the most affective benefit of handling real-time market pricelist, as already explained, is to become more competitive and secondly, to save time. To calculate correct price we are losing time, time means expense. We have to look this problem a bit closer. An average worker with 10+ years of experience is searching correct market price, depending on route approximately from 4 till 7 minutes[10]. If on average, worker search 10 times per day, this means from 40 till 70 min per day. On a larger scale of workers it means larger quantity of time. All in all we would spend less time to the job, and workers can devote their time for another logistic job. Searching for various types of prices can also create confusion for transport worker. From confusion a human error can be created. So in "refreshed all-territory" prices we have possibility to eliminate these errors. Also problems, connected to workers inexperience can be eliminated. A novice worker with little of experience would be able to check pricelist and figure the price.

5 CONCLUSION

As we have find out, knowledge of costs and market is most important for price calculation. We have to study factors that are affecting our searched element and find that correct price, which is between what market is offering and what is costly acceptable. We have to mention two paths of future research. One is to research effects of real-time cost/real-time market pricelist and second is how to eliminate or decrease effect of oil in "cost equation".

Time saving can reduce cost, eliminate errors and increase productivity, so transportation organization worker will have more time to increase quality of service. This will sooner or later become number one priority for customer. On time savings, prices will be more competitive and attractive for customers which in bottom line mean advantage on market.

Last but not least, our goal is to become more competitive. Some of the today process in logistic are out of date compared to the market requires. There are quick changes in today's market especially with quick change in oil price. Oil has huge influence on transport, therefore, market in this condition, is also screaming for change. It has to come over next step, which is introduction of vehicle, which uses other fuel, substitution to diesel. Future research can be looking for prices with vehicles that runs on gas.

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[10] Source: Author

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[15] M. Svetek, Lastna cena za "srednjake" v Italiji, Obvestilo št. 408, GIZ Intertransport 2004, www.intertansport.si, March 2013

[16] M. Svetek, Lastna cena v Franciji 2003, Obvestilo št. 407, GIZ Intertransport 2004, www.intertansport.si, March 2013

REGULATION ON THE PROTECTION OF THE MARINE ENVIRONMENT AGAINST POLLUTION IN THE NORTHERN ADRATIC

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ABSTRACT

The Northern Adriatic is among the most endangered sea areas in the Mediterranean Sea. It is a semi-enclosed sea with very dense maritime traffic due to the numerous fairways that fleet there. If a major oil spill due to maritime accident were to occur somewhere in the Northern Adriatic, it could cause a disaster with severe environmental consequences.
There are some international treaties and multilateral agreements with the aim of preventing such catastrophes in the Mediterranean Sea. The most important international environmental convention covering this area is the Convention for the Protection of the Mediterranean Sea Against Pollution (Barcelona Convention) adopted in 1976 for the protection of the marine and coastal environment in the Mediterranean. In the Protocol to the Barcelona convention concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol to the Barcelona Convention) the contracting parties to the Barcelona Convention established the List of Specially Protected Areas of Mediterranean Importance (SPAMI List). Amongst these specially protected areas we were unable to find listed the entire area of the Northern Adriatic. The United Nations Convention on the Law of the Sea (UNCLOS) includes a chapter on the protection and preservation of the marine environment but its provisions are general and of a principle character. Neither the International Convention for the Prevention of Pollution from Ships (MARPOL) nor all other existing conventions regulating marine pollution cover all sources and aspects of marine pollution and nor do they entirely meet the special requirements of the Northern Adriatic.
The existing international regulation is therefore not satisfactory and there is an urgent need to adopt a regional agreement in the near future to prevent an environmental catastrophe from happening in the Northern Adriatic.

Keywords: marine pollution, the Northern Adriatic, international regulation, protection of the marine environment, Barcelona Convention, MARPOL

1 MAIN CHARATERISTCS OF THE ADRIATIC SEA AND THE NORTHERN ADRIATIC

The Adriatic Sea is a semi-enclosed sea and part of the Mediterranean Sea. It is surrounded by the coasts of several countries: Italy, Croatia, Albania, Montenegro, Slovenia and Bosnia and Herzegovina. The Strait of Otranto[1] between Italy and Albania connects the Adriatic with the Ionian Sea, another smaller part of the Mediterranean Sea.

[1] http://en.wikipedia.org/wiki/Strait_of_Otranto

https://www.google.si/search

https://www.google.si/search

The Adriatic Sea is geographically divided into three basins, the Northern Adriatic, Central (or Middle) Adriatic, and Southern Adriatic. The Northern is the shallowest and the Southern is the deepest; the entire Gulf of Trieste is an extremely shallow bay (with an average depth of 16 meters). The prevailing currents flow counterclockwise from the Strait of Otranto along the eastern coast and back to the strait along the western (Italian) coast. Tidal movements in the Adriatic Sea are slight.[2]

1.1 Flora and fauna of the Adriatic Sea

The Adriatic Sea is abundant in flora and fauna—more than 7,000 animal and plant species are identified as native to the Adriatic, many of them endemic, rare and threatened. The Northern Adriatic in particular is rich in endemic fish fauna. In the Adriatic there are at least 410 species and subspecies of fish representing approximately 70% of all fish species found in the Mediterranean, with at least 7 species endemic to the Adriatic. Around thirty

[2] http://en.wikipedia.org/wiki/Adriatic_Sea

species of fish are found in only one or two countries bordering the Adriatic Sea - particularly due to or dependent upon the karst morphology of the coastal or submarine topography. Many of these species are threatened with extinction.[3]

1.2 Protected areas in the Northern Adriatic

The biodiversity of the Adriatic is relatively high and several protected marine areas have been established by countries along its coast. In the Northern Adriatic, these are Miramare in the Gulf of Trieste (Italy), seven marine protected areas in Brijuni and the Lim Canal off the coast of the Istrian peninsula (Croatia) and six protected marine and coastal nature areas in Slovenia (the Sečovlje Salina Landscape park with its four nature reserves, Strunjan Landscape Park with two nature reserves, Škocjan Inlet Nature Reserve and three natural monuments: Debeli Rtič, Cape Madona and Lakes in Fiesa).[4]

1.3 Sources of marine pollution in the Northern Adriatic

The Adriatic Sea ecosystem is threatened by the excessive input of nutrients through drainage from agricultural land and wastewater flowing from the cities; this includes both along the coast and from rivers draining into the sea—especially from the Po River. Venice is often cited as an example of polluted coastal waters where shipping, transportation, farming, manufacturing and wastewater disposal all contribute to polluting the sea.[5]

Another source of pollution of the Adriatic is solid waste. Drifting waste—occasionally relatively large quantities of material, especially plastic—is transported northwest by the Sirocco. Air pollution in the Adriatic Basin is associated with the large industrial centers in the Po River valley and the large industrial cities along the coast.[6]

As the countries bordering the Adriatic Sea are popular tourist destinations, Tourism is a significant source of income all along the Adriatic coast, however it is also a relevant source of pollution. The largest number of overnight tourist stays and the most numerous tourist accommodation facilities are to be found in the Veneto region in the Northern Adriatic (Venice, Italy) but the tourism industry along the eastern Adriatic coast (in Croatia) has grown faster economically than the rest of the Adriatic Basin.[7]

A further risk to the environment is posed by ballast water discharged by ships, especially tankers. Maritime transport is a significant branch of the area's economy—there are 19 seaports in the Adriatic, each of which handles more than a million tons of cargo per year. The largest Adriatic seaport by annual cargo turnover is the Port of Trieste in the Northern Adriatic (39,833,000 tons). Besides the Port of Trieste there are also other larger ports situated in the Northern Adriatic, such as the Port of Venice (32,042,000 tons and 1,097,000 passengers), the Port of Koper (17,051,000 tons), the Port of Ravenna (27,008,000 tons) and the Port of Rijeka (15,441,000 tons). Still, since most of the cargo handled by the Adriatic ports and virtually all liquid (tanker) cargo handled by the ports, is coming to—not coming from—the Adriatic Basin, the risk of pollution due to ballast water (from tankers expelling ballast water then loading in the Adriatic) remains minimal. Proposed export oil pipelines were objected to specifically because of this issue.[8]

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[3] *Ibidem*
[4] *Ibidem*
[5] *Ibidem*
[6] *Ibidem*
[7] *Ibidem*
[8] http://en.wikipedia.org/wiki/Adriatic_Sea

Oil spills are a major concern in the Adriatic Sea in terms of the potential environmental impact and damage to tourism and fisheries. It is estimated that if a major oil spill were to occur due to an accident in the Central (Middle) Adriatic, a million people would lose their livelihoods in Croatia alone. If such a major oil spill were to happen in the Northern Adriatic, it would also cause the extinction of all animal and plant species living there (extinction of all flora and fauna), being the shallowest, the narrowest and the most enclosed part of the Adriatic Sea. An additional risk is presented by the oil refineries in the Po River basin which drains into the Northern Adriatic and where oil spills have occurred before.[9]

2 INTERNATIONAL REGULATION AND REGIONAL AGREEMENTS ON THE PROTECTION OF THE MARINE ENVIRONMENT AGAINST POLLUTION

Pollution of the marine environment is an input of substances or energy into the marine environment that causes or might cause damage to the marine flora and fauna, threaten the health of the human population or diminish the quality of the sea with long-term consequences.[10]

The most hazardous and noxious substances are oil (petroleum) and its derivates, nuclear waste, various dangerous chemicals, substances containing heavy metals, floating plastic and other similar waste. The most important international regulations on marine pollution contain a list of hazardous and noxious oils as well as a list of chemicals that are the most harmful and potentially dangerous to people and the environment. We can also find such lists in the national legislation of the coastal countries. These substances are numerous and the lists are continuously growing. There are currently already several hundred substances defined as harmful.[11]

There are several sources of marine pollution:[12]

- pollution from land-based sources (industry, agriculture, tourism etc.),
- pollution from ships and other vessels (oil spills, ballast water discharge, discharge of dangerous goods, intentional or unintentional leakage of hazardous or noxious substances etc.),
- pollution from or through the atmosphere,
- pollution by dumping (disposal of wastes),
- pollution from sea-bed activities
- pollution caused by scientific exploration of the sea.

2.1 International regulation

The most important international environmental treaty which also covers the area of the Adriatic Sea is the *Convention for the Protection of the Mediterranean Sea Against Pollution (the Barcelona Convention)*,[13] signed in Barcelona (Spain) on February 16th 1976. It entered into force on February 12th 1978 and was revised in Barcelona on June 10th 1995 as the *Convention for the Protection of the Marine Environment and the Coastal Region of the*

[9] *Ibidem*
[10] Vlačič P. Pirš A. Pavliha M. *et altr.*: *Pomorsko pravo, 2. knjiga*, page 283
[11] *Ibidem*, pages 283 - 284
[12] *Ibidem*, page 284
[13] Uradni list SFRJ – MP, nr. 12/77

Mediterranean.[14] Many protocols to the Barcelona Convention have since then been adopted covering various types of pollution and listing specially protected areas in the Mediterranean.

All other existing international conventions on the topic do not cover all aspects and sources of marine pollution and do not entirely meet the special requirements of the Adriatic Sea area.[15] These are:

- the United Nations Convention on the Law of the Sea (UNCLOS),[16] signed in Jamaica on December 10th 1982;
- the *International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)*,[17] signed in London on November 2nd 1973 and later significantly modified with the 1978 Protocol[18];
- *the International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (Intervention convention)*,[19] adopted in 1969 and the Protocol Relating to Intervention on the High Seas in Cases of Pollution by Substances other than Oil,[20] adopted in 1973;
- *the International Convention on Civil Liability for Oil Pollution Damage (Civil Liability Convention - CLC)*,[21] adopted in 1969; it was superseded by the 1992 Protocol[22];
- *the International Convention on the Establishment of the International Fund for Compensation of Oil Pollution Damage (Fund convention)*,[23] adopted in 1971 and later revised and superseded by the 1992 Protocol[24];
- *the Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (London Convention - LC)*[25] adopted in London in 1972 and the 1996 Protocol[26] to this convention;
- *the International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC convention)*,[27] adopted in 1990;
- *the International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS convention)*,[28] adopted in 1996;
- *the International Convention on Civil Liability for Bunker Oil Pollution Damage (Bunkers Convention)*, signed in 2001 but which has not yet entered into force.

[14] Uradni list RS – MP, nr. 26/2002
[15] http://www.unep.ch/regionalseas/regions/med/t_barcel.htm
[16] Uradni list SFRJ – MP, nr. 1/86
[17] Uradni list SFRJ – MP, nr. 2/85
[18] Uradni list SFRJ – MP, nr. 2/85
[19] Uradni list SFRJ – MP, nr. 2/77
[20] Uradni list SFRJ – MP, nr. 12/81
[21] Uradni list SFRJ – MP, nr. 7/77
[22] Uradni list RS – MP, nr. 15/00, 58/00
[23] Uradni list SFRJ – MP, nr. 3/77
[24] Uradni list RS – MP, nr. 15/00
[25] Uradni list SFRJ – MP, nr. 13/77
[26] Uradni list RS – MP, nr. 10/05
[27] Uradni list RS – MP, nr. 9/01
[28] Uradni list RS – MP, nr. 18/04

2.1.1 The United Nations Convention on the Law of the Sea (UNCLOS 1982)

The UNCLOS convention was signed in Jamaica in December 1982 and it entered into force in 1994. It binds 160 countries all over the world including all the member states of the European Union. The European Union itself also acceded to this convention in 1994.[29]

One of the scopes of the UNCLOS convention is to contribute to the protection and preservation of the marine environment which is regulated in Part XII of the convention. It provides for the member states to take all appropriate and necessary measures to prevent, reduce and control pollution of the marine environment from any source.[30] The provisions of this part of the UNCLOS regulate the competences, rights and duties of the coastal countries to prevent the pollution of the sea in those marine zones where these countries have their sovereign rights or jurisdiction.[31] Co-operation between countries should be on a global and regional basis, taking into account characteristic regional features.[32]

Nevertheless, the provisions contained in Part XII of the UNCLOS are general and of principle and therefore do not provide any special measures for areas with specific characteristics such as the Northern Adriatic.

2.1.2 The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)

The main international convention covering the prevention of all types of pollution from ships from operational or accidental causes is the MARPOL convention, which has been ratified by almost 140 countries. The MARPOL Convention was adopted in 1973 at the International Maritime Organization (IMO). The Protocol of 1978 was adopted as a response to several tanker accidents in 1976 and 1977. As the 1973 MARPOL Convention had not yet entered into force when the 1978 Protocol was adopted, the 1978 Protocol absorbed and superseded the original text of the convention and the new instrument (MARPOL 73/78) entered into force on October 2nd 1983.[33]

The object of the MARPOL Convention is to prevent the pollution of the marine environment from the operational discharge of oil and other harmful substances and to minimize the accidental discharge of such substances. Contracting parties are obliged to apply the provisions of the MARPOL convention to ships flying their flag and to ships within their jurisdiction.[34]

The MARPOL convention currently includes six technical Annexes. Most Annexes include ‘special areas’ with specific geological and climate characteristics and high ecological sensitivity which require a high level of protection with strict controls on operational discharges. In the case of oils (Annex I) the entire Mediterranean Sea area is listed as a special area, where there is the strict prohibition of the discharge of any liquids that contain oils.[35]

Annexes of the MARPOL convention are:[36]

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[29] Marko Pavliha: *Mednarodnopravni argumenti v luči prava EU zoper plinske terminale v Tržaškem zalivu*, Podjetje in delo, Ljubljana 2010, nr. 8, page 1542
[30] UNCLOS, Article 194, Paragraph 1
[31] Vlačič P., Pirš A., Pavliha M. *et altr*.: *Pomorsko pravo, 2. knjiga*, page 288
[32] UNCLOS, Article 197
[33] http://www.imo.org/About/Conventions/listofconventions/pages/international-convention-for-the-prevention-of-pollution-from-ships-%28marpol%29.aspx
[34] *Ibidem*
[35] Vlačič P., Pirš A., Pavliha M. *et altr*.: *Pomorsko pravo, 2. knjiga*, page 292
[36] http://www.imo.org/About/Conventions/listofconventions/pages/international-convention-for-the-prevention-of-pollution-from-ships-%28marpol%29.aspx

- *Annex I: Regulations for the Prevention of Pollution by Oil* (entered into force in 1983); it covers prevention of pollution by oil from operational measures as well as from accidental discharge and includes a list of hazardous and noxious oils;
- *Annex II: Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk* (entered into force in 1983); it details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk;
- *Annex III: Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form* (entered into force in 1992); it contains the general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitations, exceptions and notifications of harmful substances ("harmful substances" are those substances which are identified as marine pollutants in *the International Maritime Dangerous Goods Code (IMDG Code)* or which meet the criteria noted in the Appendix of Annex III);
- *Annex IV: Prevention of Pollution by Sewage from Ships* (entered into force in 2003); the discharge of sewage into the sea is generally prohibited (except on some occasions; in July 2011, the IMO adopted the most recent amendments to MARPOL Annex IV;
- *Annex V: Prevention of Pollution by Garbage from Ships* (entered into force in 1988); it deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of; the most important feature of the Annex is the complete restriction imposed on the disposal of all forms of plastics; in the special areas under this Annex (which includes the Mediterranean Sea) only the disposal of domestic waste is permitted; in July 2011, the IMO adopted extensive amendments to Annex V (which are expected to enter into force soon);
- *Annex VI: Prevention of Air Pollution from Ships* (entered into force in 2005); it sets limits on emissions from ship exhaust and prohibits the deliberate emission of ozone depleting substances.

2.1.3 The International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (the Intervention Convention)

This is the most important international convention regulating the actions of the coastal states in case of oil pollution on the high seas. Oil pollution caused by an oil spill on the high seas often reaches the territorial sea of the coastal countries and to prevent this, early measures should be taken before this can occur. The convention authorizes the coastal states to take measures on the high seas to prevent, reduce or eliminate danger to their coastlines from pollution by oil or the threat thereof. The coastal country is empowered to take only such measures as necessary.[37]

In 2000, a protocol to this convention was adopted expanding the scope of the Intervention Convention in case of pollution with substances other than oil (*Protocol Relating to Intervention on the High Seas in Cases of Pollution by Substances other than Oil)*. It binds the contracting parties of the convention to take the same measures as provided in the Intervention Convention.[38]

[37] Vlačič P., Pirš A., Pavliha M. *et altr*.: *Pomorsko pravo, 2. knjiga*, page 289
[38] Vlačič P. Pirš A. Pavliha M. *et altr*.: *Pomorsko pravo, 2. knjiga*, page 290

2.1.4 The Convention for the protection of the Mediterranean Sea against pollution (the Barcelona Convention)

The Barcelona Convention is a regional convention that was adopted to protect the marine and coastal environment of the Mediterranean Sea area, contracting parties being conscious of the economic, social, health and cultural value of the marine environment, fully aware of their responsibility to preserve this common heritage and recognizing the threat posed by pollution to the marine environment. The Mediterranean Sea area has special hydrographic and ecological characteristics and it is particularly vulnerable to pollution. Therefore close co-operation is needed among the states and international organizations concerned in a coordinated and comprehensive regional approach for the protection and enhancement of the marine environment in this area.[39]

Member states agreed to take specific measures against pollution due to dumping from ships and airplanes and against incineration at sea, against pollution due to discharge from ships, against pollution caused by the exploitation of the continental shelf, the seabed and its subsoil, against land-based pollution and pollution due to the transboundary movement of dangerous wastes. They also agreed to cooperate in pollution incidents resulting in emergency situations, to protect biological diversity, to monitor pollution, to apply environmental legislation, to protect the marine environment and coastal zones through the prevention and reduction of pollution and as far as possible, to eliminate pollution and dangerous wastes and protect natural and cultural heritage.[40]

The Convention was amended and renamed in 1995 as the *Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean*. The main amendments concerned the extension of the Convention's geographical field of application to the coast, the application of the precautionary principle, the application of the "polluter pays" principle, the protection and preservation of biological diversity and combating pollution from cross-border movements of dangerous waste.[41]

Seven protocols to the Barcelona Convention have been adopted:[42]

- *Protocol for the prevention of pollution of the Mediterranean Sea by dumping from ships and aircraft (Dumping Protocol)*,[43] adopted in 1976;
- *Protocol for the protection of the Mediterranean Sea against pollution from land-based sources and activities (LBS Protocol)*,[44] adopted in 1980; it has three Annexes (discharges from rivers, outfalls, canals or other watercourses);
- *Protocol concerning specially protected areas and biological diversity in the Mediterranean (SPA/BD Protocol)*,[45] adopted in 1995, replacing the previous *1982 Protocol concerning Mediterranean specially protected areas*; in this protocol the contracting parties established the List of Specially Protected Areas of Mediterranean Importance (SPAMI List)[46] in order to promote cooperation in

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[39] http://www.unep.ch/regionalseas/regions/med/t_barcel.htm
[40] http://en.wikipedia.org/wiki/Barcelona_Convention
[41] http://europa.eu/legislation_summaries/environment/water_protection_management/l28084_en.htm
[42] *Ibidem*
[43] Uradni list SFRJ – MP, nr. 12/77
[44] Uradni list SRFJ – MP, nr. 1/90
[45] Uradni list RS – MP, nr. 46/98
[46] Article 8 (paragraph 2) containes the definition of *Specially Protected Areas of Mediterranean Importance (SPAMI)*. These are sites "of importance for conserving the components of biological diversity in the Mediterranean; contain ecosystems specific to the Mediterranean area or the habitats of endangered species; are of special interest at the scientific, aesthetic, cultural or educational levels".

the management and conservation of natural areas, as well as in the protection of threatened species and their habitats; it aims to protect natural resources in the Mediterranean region, preserve biodiversity and protect certain natural sites; it provides for the member states to adopt appropriate measures including the prohibition of the discharge or unloading of waste, the regulation of the shipping operations and of the introduction of any non-indigenous or genetically modified species and any other measures protecting the ecological and biological processes in these specially protected areas;

- *Protocol for the Protection of the Mediterranean Sea against Pollution, concerning cooperation in preventing pollution from ships and, in cases of emergency, combating pollution of the Mediterranean Sea (Prevention and Emergency Protocol),*[47] which was adopted in 2002 and entered into force in 2004; cooperation focuses on maintaining and promoting emergency plans and other means for preventing and combating pollution from ships, on the efforts to recover harmful and potentially dangerous substances and on the operational measures which the parties involved must take in the event of pollution caused by ships (evaluation, elimination/reduction, information measures), as well as emergency measures which must be taken onboard ships, in offshore installations and in ports (in particular the availability of and compliance with emergency plans);
- *Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil (Offshore Protocol)*, adopted in 1994 and entered into force in 2011;
- *Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal (Hazardous Wastes Protocol)*, adopted in 1996 and entered into force in 2008;
- *Protocol on Integrated Coastal Zone Management in the Mediterranean (ICZM Protocol),*[48] which was adopted in 1995 and entered into force in 2011.

The European Union acceded to the Barcelona convention and all its protocols and they became part of European Union Law. Today the Barcelona Convention has 22 contracting parties and they are determined to protect the Mediterranean marine and coastal environment while boosting regional and national plans to achieve sustainable development.[49] As a part of the "Barcelona System" the Mediterranean countries and the European Community have also adopted *the Action Plan for the Protection of the Marine Environment and the Sustainable Development of the Coastal Areas of the Mediterranean (MAP Phase II)* in 1995 which replaced the former *Mediterranean Action Plan (MAP)*. MAP's initial focus was aimed at marine pollution control, but over the years it broadened to include integrated coastal zone planning and management.[50]

2.2 Regional agreements and initiatives

Italy and Yugoslavia signed the *Agreement on Cooperation for the Protection of the Adriatic Sea and coastal areas from pollution* in Belgrade in 1974.[51] The agreement

[47] Uradni list RS – MP, nr. 1/04
[48] Uradni list RS – MP, nr. 16/09
[49] http://www.unepmap.org/index.php?module=content2&catid=001001004
[50] *Ibidem*
[51] Uradni list SFRJ – MP, nr. 2/77

established a Joint Commission for the protection of the Adriatic Sea and coastal areas in 1977 to address environmental issues in the Adriatic region in a multidisciplinary manner. The organization later changed with Slovenia, Croatia and Montenegro replacing Yugoslavia and taking part in the commission instead.[52]

The Commission considers all issues relating to the pollution of the Adriatic Sea waters and coastal areas, makes proposals and recommendations to governments on the issue of the research it considers necessary, gives an opinion on programmes and oversees their alignment, proposes to governments what measures should be taken in order to remove existing and prevent new causes of pollution of the Adriatic Sea.[53]

So far the commission has dealt with following activities:[54]

- working together on a continuous examination of the ecosystem of the Adriatic Sea,
- cooperation and mutual direct assistance in combating pollution incidents and special protection of sensitive areas as well as the adoption of a common (sub-regional) Contingency Plan for accidental pollution of the Adriatic (Subregional Contingency Plan which was signed in 2005 in Portorož)
- establishing a traffic separation scheme and establishing sailing routes in the Adriatic,
- identification and control of pollution caused by inadequate handling and disposal of solid and hazardous waste,
- cooperation concerning the revitalization and protection of environmental values (landscape, nature and construction heritage),
- remediation of the most burdened areas (Po, the Bay of Trieste, the Bay of Koper, Rijeka Bay, Kaštela Bay) and other areas of larger cities, industrial zones and ports,
- cooperation in preventive protection and further implementation of development strategies aligned with resource conservation,
- information activities,
- solving the issue of ballast waters in the Adriatic.
- On June 16th 2008 Albania, BIH, Montenegro, Croatia, Italy and Slovenia signed a *Joint Statement on Environmental Protection of the Adriatic Sea* in Portorož under the auspices of the Mixed Slovenian-Italian-Croatian Commission for the Protection of the Adriatic Sea and the Coastal Areas Against Pollution.[55] The commission is active in areas of research concerning the quality of the Adriatic Sea, the coordination of pollution prevention systems, environmental safety of maritime transport and integrated coastal management and it plans to adopt a strategy for the Adriatic Sea in the near future.[56]
- On May 19th 2000, Croatia, Italy and Slovenia signed the Memorandum of Understanding between the Government of the Republic of Croatia, the Government of the Italian Republic and the Government of the Republic of Slovenia on the Establishment of a Common Routing System and Traffic

[52] http://www.mzoip.hr/default.aspx?id=10251
[53] *Ibidem*
[54] *Ibidem*
[55] Marko Pavliha: *Mednarodnopravni argumenti v luči prava EU zoper plinske terminale v Tržaškem zalivu*, Podjetje in delo, Ljubljana 2010, nr. 8, page 1544
[56] http://www.arhiv.mop.gov.si/fileadmin/mop.gov.si/pageuploads/publikacije/drugo/en/morje.pdf

Separation Scheme in North Part of the North Adriatic[57] and other important documents. In the preamble of the aforementioned memorandum the three countries emphasized the importance of the dense maritime traffic on the Adriatic Sea and a significant percentage of passenger ships and ships carrying oil and hazardous and/or noxious substances (liquid or solid).

Adriatic-Ionian Initiative. In Ancona on May 20th 2000, the Foreign Ministers of the Adriatic countries together with Greece and the European Union signed the Ancona Declaration which defines intensified subregional cooperation in the area of the environment. A working group was established due to the urgent need to implement the Mediterranean Action Plan (MAP) at an accelerated pace in the Northern Adriatic, because it is a closed sea and an exceptional transport hazard.[58]

2.3 Conclusions

The Adriatic Sea basin has its own typical features, both at land and sea. Although part of the wider Mediterranean Sea basin, it is a semi-enclosed, narrow sea area solely connected to the rest of the Mediterranean through the Strait of Otranto, which is the narrowest part of the Adriatic Sea. The northern and north-western basin is characterised as a shallow enclosed sea area with shallow waters and sandy beaches. Although a number of Adriatic countries have established special zones, a considerable part of the Adriatic Sea basin is not at all or is only partially managed or controlled, since only a limited number of protected zones have been established or management is limited to certain aspects (in October 2005, Slovenia established an Ecological Protection Zone with the *Ecological Protection Zone and Continental Shelf of the Republic of Slovenia Act*,[59] but delimitation agreements with neighbouring coastal states are still pending). However, it is important to take into account the waters and the continental shelf of the whole Northern Adriatic in the future. Marine biodiversity in the Adriatic Sea is high, but at the same time a considerable number of species (both flora and fauna) are endangered. In order to preserve biodiversity and maintain stocks of species, countries surrounding the Adriatic Sea have established several marine protected areas – but, are these really sufficient measures to prevent a catastrophe that might happen there one day?

The Northern Adriatic is subject to intensive human use. Besides very dense maritime transport, the area is characterised by a significant number of other maritime activities, such as fishery, tourism, industry etc. For instance an **offshore terminal** is proposed in the Gulf of Trieste in the Italian territorial sea near Slovenia. The presence of such a terminal has significant consequences: fishing will be prohibited around the terminal and around the pipeline that connects the terminal with the shore. Offshore platforms also bring with them a certain risk of putting strong pressure on the environment; if an accident should happen, the effects on the marine environment could be significant. Allowing the construction of such a terminal in the Northern Adriatic is against the Integrated Maritime Policy for the EU (October 2007) which defines the entire Mediterranean as an extremely sensitive marine ecosystem and therefore demands a sustainable usage of the sea and the development of alternative energy sources that would ensure the highest safety of the sea, security and quality of life in the coastal regions and not only preserve but also improve the quality of the marine environment.

[57] Uradni list RS - MP, nr. 27/2000
[58] *Ibidem*
[59] Uradni list RS, nr. 93/05

The intensive maritime transport in the Adriatic Sea basin implies a significant risk of accidents and consequently the potentially strong impact on the marine environment. Given the enclosed nature of the Adriatic Sea basin, the impact of a single accident– even though accidents are rare – could be highly disastrous. An overview of the international regulations shows that existing conventions governing marine pollution and protection of the marine environment in cases of an oil spill do not meet the needs and specific characteristics of the Adriatic Sea basin, especially the Northern Adriatic. Aside from this, the international conventions are not ratified by all countries, the European Union law is not necessarily consistently implemented in the national laws and the IMO directions and recommendations are not binding. Also several regional agreements, initiatives and joint-commissions are not always efficient while trying to prevent an environmental catastrophe from occurring.

A closer, more intensive and efficient cooperation between the Northern Adriatic countries (Croatia, Italy and Slovenia) is needed to prevent the pollution associated with shipping. But the first step is to proclaim the entire area of the Northern Adriatic as an extremely sensitive area in terms of pollution. Some efforts in this direction have already been made. Recently, the Adriatic Sea has been recognised as an area with a large marine biodiversity that is home to some significant treasures of world heritage by the proposal of Adriatic countries (initiated by Croatia), designating the whole Adriatic Sea as a Particularly Sensitive Sea Area (PSSA). A Particularly Sensitive Sea Area requires special protection through action by the International Maritime Organisation (IMO) because of its significance for recognised ecological, socio-economic or scientific reasons and because it may be vulnerable to damage by shipping. Once designated as a PSSA, specific measures can be approved by the IMO to reduce the risk associated with shipping. Perhaps we are finally moving in the right direction.

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WIND ENERGY POTENTIAL IN SLOVENIA

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ABSTRACT

The wind characteristics of the characteristic locations in Slovenia have been assessed. The annual average wind speed for the considered sites ranged from 4 to 6 m/s and a mean wind power density from 200 to 400 W/m2 at standard height of 50 m. The wind data at heights 10 and 50 m were obtained by extrapolation of the 10 m data using the Power-Law. The potential wind energy at different heights was estimated using Weibull parameters. The analyses of the most critical aspects for the success of a wind power investment that is, obtaining long-term, accurate wind field data in order to estimate the amount of future electricity production from wind turbines and thus the economic viability of the project. But, such large quantities of reliable wind speed measurements are not always available. Therefore, an analysis is also made of a wide variety of statistical tools, like Weibull distribution, topographical models, computational fluid dynamics, and forecasting methods that have been developed for estimating wind characteristics in different conditions of atmospheric stability and on complex terrain sites.

Keywords: Wind analysis; Wind energy; Wind turbines

1 INTRODUCTION

Wind energy is a form of energy, which is among the cleanest and does not constitute direct pollution. The production and use of energy has more impact on the environment than any other single human activity. Given the fact that fossil fuels, which are used for electricity generation, influence a large share of all greenhouse gases the rational concept is to encourage forms of "clean" electricity. Air and water pollution, oil spills, radioactive waste are just a few of the many impacts on the natural due to the use of fossil and nuclear fuels. Wind power avoids many of these problems but it has its own impacts, which can be harmful if not addressed carefully.

Modern wind turbines can take advantage of around 40% wind energy. To reach such efficiency, they need to be carefully designed, dimensioned, analyzed and tested. In the paper the methodology is presented how calculates wind turbines and describe the parameters that are important for such a procedure. We will investigate the relationship between wind speed and obtained electricity, or it is reasonable to invest in a wind farm. This engineering filed is poorly covered in Slovenia unlike in the other European countries, we will try to show a basic planning process of wind turbines, the impact of the wind strength on the produced electricity, and what are the economic indicators of investment in wind power. Given the type of wind turbines to be used, regional wind speed statistical data and the area of the farm, we can estimate the total annual energy output of the wind farm. In this case, the optimum number of wind turbines to be installed has to be determined under a certain economic environment. The determination of the optimal farm characteristics must be based on specific design objectives. In this case, the design problem may be formulated as a mathematical programming problem, involving an objective function representing the investment efficiency, which is expressed by the profits expected per unit of capital invested [1].

1.1 Key Environmental and Cultural Features

There are a few environmental and cultural features in the general area of the Project that could potentially be affected by the Project. These are presented in Figure showing the geographical context of the site.

These include:

- Environmental Features
- Avian fauna (birds and bats)
- Watercourse
- Wetland
- Species-at-Risk Habitat
- Land Use Features
- Forestry
- Residential properties
- Heritage Sites

Surveying Activities

In order to optimize the wind turbine (farm) project layout several surveys need to be conducted. These include a meteorological survey, environmental surveys, geotechnical surveys and land surveys.

Meteorological Survey

The purpose of a meteorological survey is to determine exact wind conditions. Prior to the construction of a wind farm, measurement towers (met towers or met masts) are erected. These masts are typically mounted with anemometers at a range of heights up to the hub height of the proposed wind turbines which log the wind speed data at frequent intervals (e.g. every ten minutes) for at least one year; preferably two or more. The data collected then allows the developer to determine if the site is economically viable for a wind farm, and to choose wind turbines optimized for the local wind speed distribution. The number of measurement towers implemented depends on the size of the project.

Environmental Surveys

In order to fully understand the environmental constraints, several environmental surveys are conducted. These include; walkthrough, bird surveys, bat surveys, vegetation survey, wetland survey, fish habitat survey, fish survey, archaeological survey

Please note that flora and fauna species at risk surveys were integrated in the vegetation, bird, bat, and fish surveys.

Geotechnical Survey

During the planning phase, a geotechnical survey is conducted to assess the general subsurface conditions by looking at the physical characteristics of soil and bedrock. The purpose of geotechnical investigations is to determine engineering recommendations for designing the earthworks and foundations for structures in order to prevent human and material damage due to earthquakes, foundation cracks and other catastrophes.

Land Survey

During the planning phase, land surveys are conducted to identify the exact location of the Project footprint as well as boundaries of properties located within the Study Area. This is necessary to ensure that the Project footprint is where it needs to be and that no element of the Project footprint impacts properties that have not signed an agreement with the Proponent. Land surveys consist of placing markers at the corners or along the lines of parcels and the Project footprint.

2 GEOGRAPHICAL POSSIBILITY FOR WIND ENERGY

In Slovenia, the strong winds are affected by two factors. One is the geostatic position and the second is the intersection of four relief units - the Alps, the Dinarides, the Pannonian Plain and the Mediterranean. Winds are blowing from the west in our region and are directed towards the north and south. They can be separated by large air vortices, called cyclones and anticyclones. Wind is the weakest in the heart of the anticyclone, the strongest and the highest geopotential gradient. Anticyclones are quite stable and can last for several weeks. They come to us from the Mediterranean, North Africa and sub-tropical Atlantic.

Areas where there are the strongest winds are Primorje with Kras and Vipava Valley Karavanke base, Logar Valley and the Upper Sava River and an area of thunderstorms (Arso, 2011). A very important factor is the Alps-mountains. The most frequent winds are northeast, southwest and north. The first is characteristic of Prekmurje, Šrajesko, Dolenjska and Eastern Slovenia. Southwest winds are blowing in central Slovenia, Prekmurje, Šrajesko and Dolenska. North winds are therefore present everywhere (ARSO). Our country has a leeward position of the Alps and the valley-flat terrain. As a result is the 30-40% of the leeward in the lowlands, valleys and basins. The average wind speed in the flat world is 2 m / s. The windiest parts of Slovenia are mountains and the Littoral.

In accordance with the study of the potential area for wind farms [1] the choice of parameters to determine the potential of wind energy, which are not naturalistic type dictates the wind energy technology that is available and the trends of development in this field. Given the fact that the development of onshore wind turbines, focused on the size of the wind turbines of 1.5 MW to 3 MW the potential for wind power generation by 2030 is chosen on reference size of 2 MW per wind turbine. The characteristic power output as a function of steady wind speed is presented below for Repower MM82-2MW wind turbine.

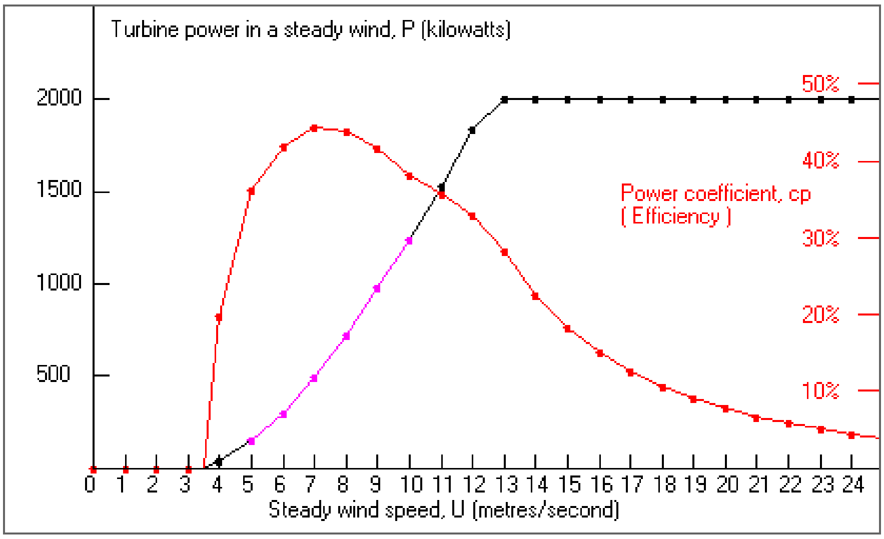

Figure 1: Steady power output as a function of steady wind speed

Profile of wind speed/power and energy follows that the production of electricity requires wind speed of 3,5 m/s. In practice, it is estimated that the installation of wind farms in areas where the average wind speed at 10 m below 5 m/s (6.3 m/s to 50 m, taking into account soil roughness factor 0.14) or, if the density wind power less than 300 to 400 W/m^2 at a height of 50 m (class 3 wind speed from 5.1 to 5.6 m/s) is economically not justifiable.

However the observation of steady wind power curve is not enough. Figure shows the average modeled wind speed that gives only a mean value of wind speed. It is a matter of common observation that the wind speed is not steady but varies a great deal over both short time scales in the range of seconds to long-term seasonal variations. At an average wind speed of 5 m/s wind farm capacity factor, which represents the ratio of the average annual production of electricity and declared electric power field, is around 20%. Fields with good conditions have a capacity factor of up to 45%.

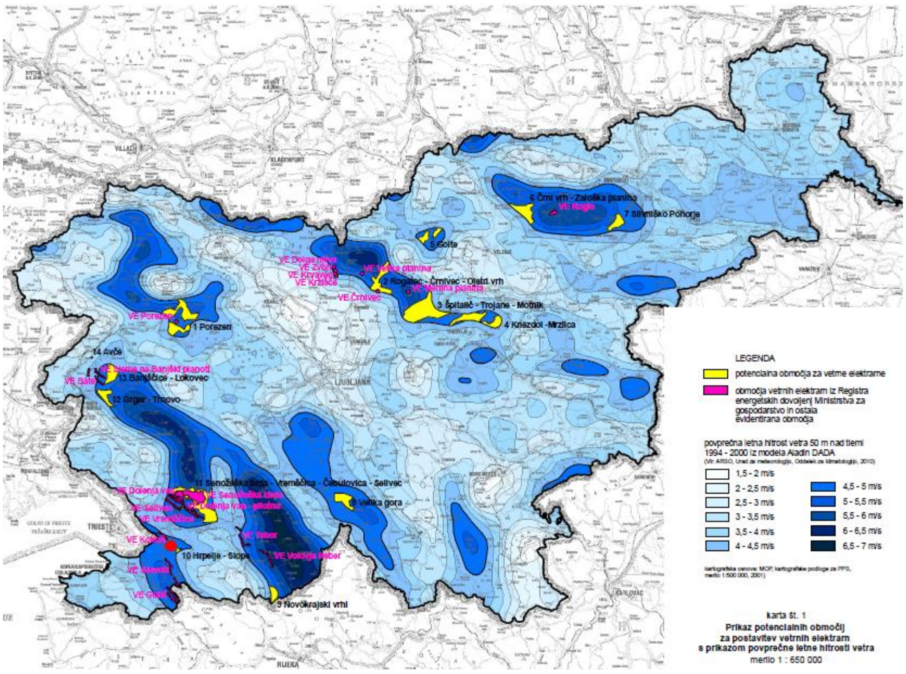

Figure2: Average wind velocity 50 m above ground (1994-2000 Aladin DADA model) [1]

The marked position on Figure shows the possible location of a wind turbine installation. Measurements of wind speed, direction, and temperature were logged for three weeks in winter season (January, February) and three weeks in summer (June, July).

2.1 Data analysis

Measured data sets often contain gaps or missing values. The Windographer can fill these gaps with synthetic data that have statistical properties similar to the measured data. In the example below, the original data set contained data between 1/1/2012 and 31/12/2012. The model ensures that the synthesized data splice together well the measured values before and after the gap, and that the statistical properties of the synthesized data (including the diurnal pattern and the random variability from one time step to the next) closely match those of the measured data. Windographer's gap filling algorithm is based on a Markov transition matrix approach. Windographer fills gaps in every column of a data set. The procedure works well with most types of data, including wind speed, wind direction, temperature, and many other types of meteorological data.

Table 1: Data of a weather station and its possition

Variable	Value
Latitude	N 45° 42' 23.000"
Longitude	E 14° 27' 2.002"
Elevation	520 m
Start date	20.1.2012 00:00
End date	22.12.2012 06:51
Duration	11 months
Length of time step	3 minutes
Calm threshold	0 km/hr
Mean temperature	12.1 °C
Mean pressure	95.26 kPa
Mean air density	1.164 kg/m³
Power density at 50m	46 W/m²
Wind power class	1 (Poor)
Power law exponent	-0.184

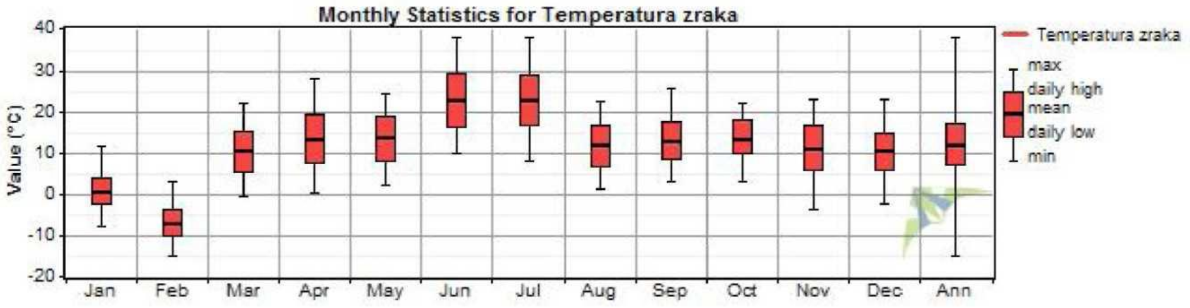

Figure 3: Statistics for temperature at measured location

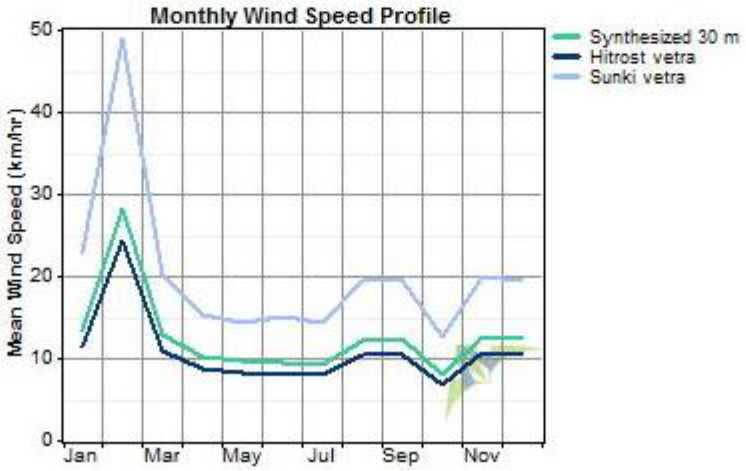

Figure 4: Wind speed profile for measured and sinthetised data

Rose of the wind gives us information about the direction of the wind and its speed. We also can illustrate the relative frequency of wind that tells us what percent of the hours the wind is blowing in a certain direction. Figure shows the measured data 10 m above the ground and the calculated mean wind speed at 30 m height.

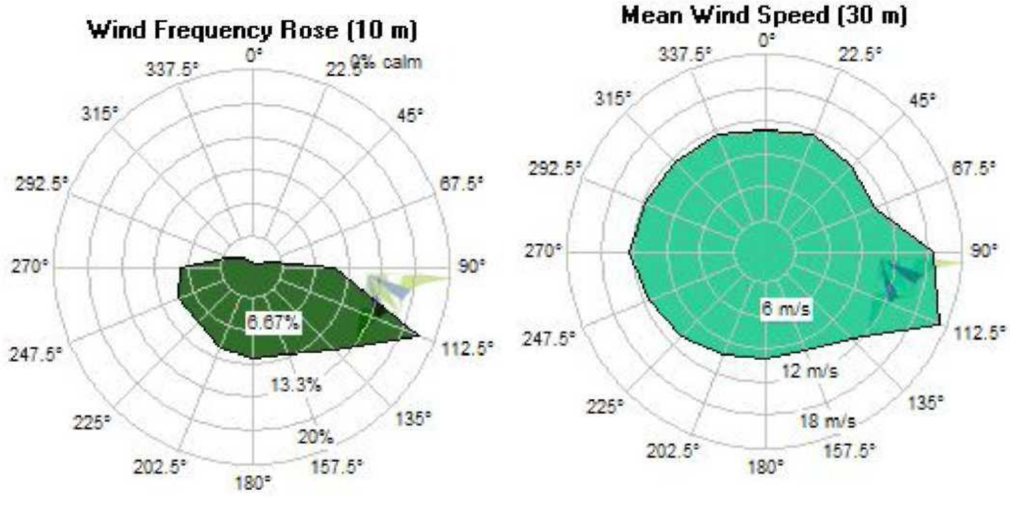

Figure 5: Wind rose for frequencies and computed mean wind speed

For the selected location of the WT are available annual measurements of wind. The average one-year wind speed is indicated by a distribution line or. to 13.68 km/h (3,8 m/s) Wind measurements are carried out at a height of 10 meters, which is lower than the height of the tower selected wind. However, as the wind speed increases with height, this information is considered in the vertical wind profile calculation. This mean wind speed is poor regarding the efficiency of the investment.

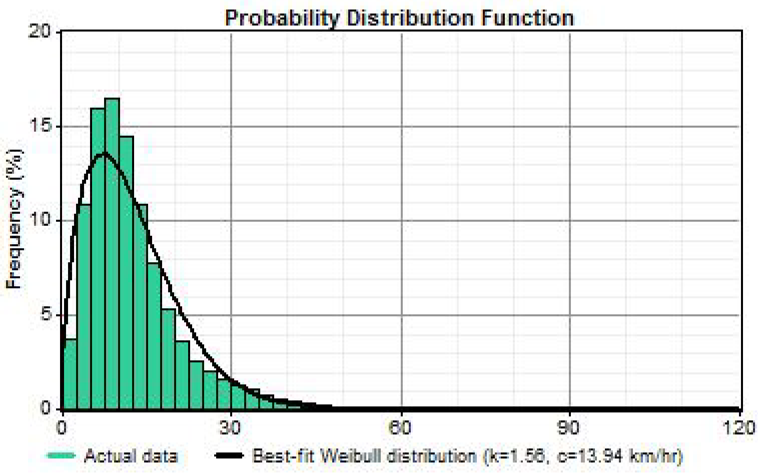

Figure 6: Wind speed distribution over the 2012

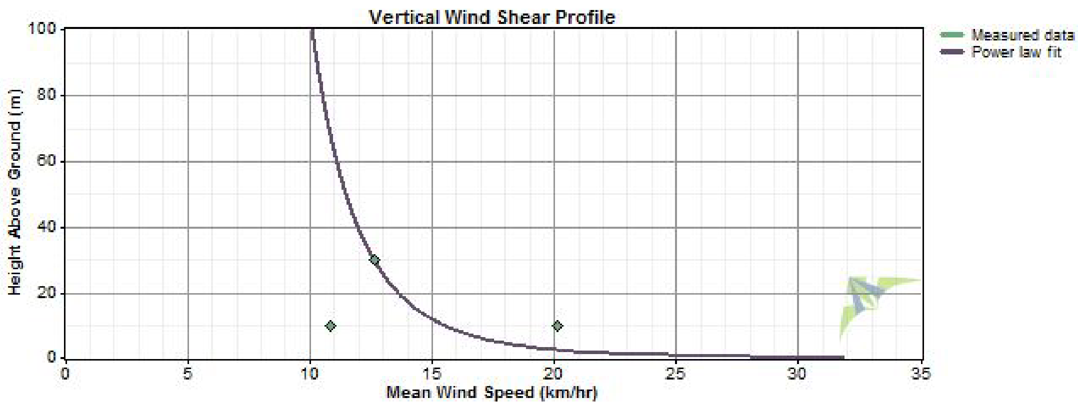

Figure 711: Vertical wind profile applying power law

3 WIND POWER COST REDUCTION

The LCOE is the price of electricity required for a project where revenues would equal costs, including making a return on the capital invested equal to the discount rate. An electricity price above this would yield a greater return on capital, while a price below it would yielder a lower return on capital, or even a loss.

Numerous studies have looked at where cost reductions could be achieved and how large these savings might be. Most analysis has looked at quantitative estimates of cost reduction possibilities for onshore wind, but there is an increasing number of studies that have done this for offshore wind. Most of these studies focus on cost reductions caused by improved designs of wind farms. However, other factors (e.g. learning-by-doing, standardization and economies of scale) may also contribute significantly to cost reductions. The improved performance of wind turbines and their location in higher average wind speed locations will also help to reduce the LCOE of wind by improving the average capacity factor. The formula used for calculating the LCOE of renewable energy technologies is:

$$LCOE = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

Where:

$LCOE$ = the average lifetime levelised cost of electricity generation,
I_t = investment expenditures in the year t,
M_t = operations and maintenance expenditures in the year t,
F_t = fuel expenditures in the year t,
E_t = electricity generation in the year t,
r = discount rate, and
n = economic life of the system.

For onshore and offshore wind power projects the key cost components, and hence areas for cost reduction, are:
Wind turbines,
Foundations,
Grid connection/cabling,
Installation, and
Project planning and development.

To achieve significant reductions in the LCOE of wind will require efforts to reduce the costs of each of these components of a wind power project. At the same time, efforts to improve the yield of wind farms (i.e. the capacity factor) will also need to be pursued [4].

The calculation of the electricity const in based on the assumption that the WT installation cost is 3.500.000 € and the annual maintenance cost is about 50.000 €. The calculated cost of kWh is presented in cents, 1/100€.

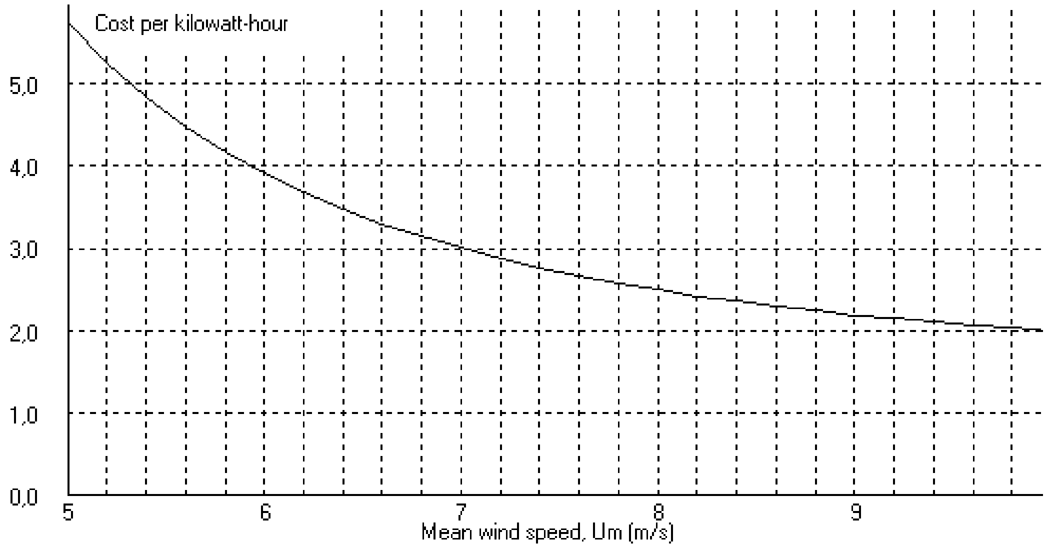

Figure 8: Cost of the electricity for 2 MW wind turbine depending on a mean wind speed

The returns ratio and payback period are the important financial calculations for anyone interested in investing in wind energy. However, some may also be interested in the intrinsic cost per kilowatt-hour of wind turbine generated electricity. Accountants have various methods for making such calculations but the estimate in the present case is obtained simply from the total cost of installing and running the turbine divided by the number of kilowatt-hours generated over the turbine lifetime, namely

$$\text{Cost per kilowatt-hour} = \frac{\text{Turbine and other fixed costs costs+(Annual recurrent costs Lifetime)}}{365 \text{ x } 24 \text{ x Lifetime(years) } P_m\ (U_m)}$$

where $P_m(U_m)$ is the mean power in kilowatts produced at a mean wind U_m. The factor (365x24) just converts the lifetime in years into the lifetime in hours. Once again, if interest charges are ignored, this will lead to a low estimate of the cost per kilowatt-hour and, in most analyses of costs from various power sources, it is usual to include interest payments in some way. A simple approach is to assume that a loan is taken out for the turbine and its installation and then calculate the overall cost of repaying this sum with interest payments over the lifetime of the turbine.

The payback period is also based on the assumption of the previously mentioned WT cost and the reference price of the electricity that is 0,1€/ kWh.

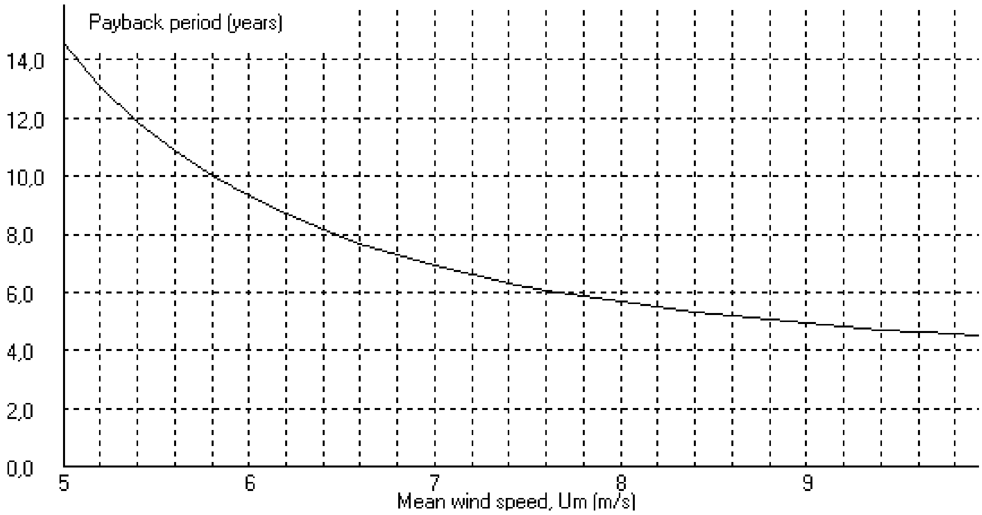

Figure 9: Payback period deppending of mean wind speed

Related to the calculated mean wind speed the investment at this location is outside the lower range and is therefore not recommended.

4 CONCLUSION

In Slovenia and around the world are increasingly striving to reduce pollution, because we recognize that pollution seriously affects the climate on our planet. One possible source is the use of wind energy. The aim of the paper was to approximate the process of planning of wind turbines to all who wish to undertake the exploitation of wind energy. We have found that, for example, calculated wind turbine efficiency equal from 6% to 44%, depending on season, which is fairly poor in comparison with the efficiency of wind turbines of similar characteristics. We must know that we carried out basic calculations and that this did not cover all losses which occur during the operation of the turbine, and wind speed data were available for near ground value not on huh height. We believe that the efficiency by taking into account all parameters could be about 10%, but this is still poor for satisfaction investment economics.

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DETERMINANTS FOR CHOOSING AIR CARRIER IN CONNECTING NORTH AMERICA AND CROATIA

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ABSTRACT

Before the Croatian War of Independence the Republic of Croatia was connected with many destinations in North America. Scheduled flights were operated by air-carriers JAT, PAN-AM and AIR CANADA, that connected Croatia with Toronto, Montreal, New York, Chicago and Los Angeles. During the War these flights were suspended. After the War Croatian airports are constantly trying to reopen direct flights to destinations that had once been directly connected. In the meantime, only for two summer seasons, there was organized a series of charter flights for Canada by Boeing B757. Because of the aircraft short range they should have always land on Iceland to refuel, and thus the time of flying was longer and the quality of service lower. With aim to incite air carriers to evaluate the project of establishing direct flight to new destination, this paper is going to analyze the existing market potentials, search for transport services towards particular destination, make projections of demands in case of direct flights, consider benchmark of surrounding airports, state of economy, and benchmark prices of basic airport services. After the analysis of domestic market potentials and determining of destinations that generate the highest demand for transport services, there will be identified air carriers which operate from North American destinations towards the European, analyzed types of aircraft which operate on scheduled routes, and analyzed number of weekly frequencies, i.e. how many seats are being offered on the market. On the basis of collected data and carried out analyses, potential air carriers which might connect North America with Croatia will be determined, which aircraft types they possess, what optimum capacities in accordance with market potential and demand, and what kind of commercial conditions would attract them to fly to Croatian airports.

Keywords: intercontinental flights, Croatia – US routes, airport strategy, airline network development

1 INTRODUCTION

Globalization and integration processes are characterized by new strategies that are tailored to the needs and habits of the market, which influences the changing business models in the new market conditions.[1] These changes have had a direct impact on the aviation market, including basic factors such as airports, airlines and air traffic control.

Economic problems of many states caused instability in the market economy and loss of a large number of jobs. Such business environment directly affected the insecure position of the working population, and hence the household budget. In such circumstances, the demand for air traffic service is significantly reduced.[2] By introducing large number of new aircraft into the market many positive and negative effects could be observed, which were manifested in a wider choice of destinations and simultaneously in congestion of air corridors and airports.

Incremental growth in airline capacity, especially with the significant increase in capacity offered by low-cost carriers, was not followed by proportional increase of capacity of air transport corridors and airports in order to meet the increased demand. The airspace over Europe is still very much divided, and has many no-fly zones which prevent the establishment of the shortest route between the origin point and destination point. Eurocontrol has the coordinating role in air traffic and manages air traffic capacity, with aim to achieve a maximum throughput with minimum delays. With this strategy in place, the fuel consumption and pollution emissions which contribute to greenhouse effect are reduced. Major obstacles of the air transport development and introduction of new routes are the insufficient capacities of airports and inadequate infrastructure that is not in compliance with ICAO standards.[3] With regard to the fact that most airports have no available space for expansion of infrastructure, nor the ability to solve the expansion problem or environment protection, neither they have successful communication with the local community in finding a compromise for capacity increase, airports often apply disincentive pricing policies to change the demand of services. High prices of airport services are unacceptable for low-cost carriers. In such cases low-cost carriers divert their operations to secondary airports, or apply other strategies to leave a certain market. Bilateral air transport agreements (ATA) governing traffic rights between countries used to represent an insurmountable barrier for better and more frequent connection of particular markets or destinations. ATA agreements had hindered transparent market competition and thus constituted discriminatory conditions for individual carriers who wanted to offer their services under the same or better conditions on some of the markets. Liberalization of air transport and signing of multilateral agreements (Open Skies, ECAA) has contributed to the removal of administrative barriers that blocked the development of air transport. Each airline strives to ensure sustainable competitiveness and profitability, while the influence of external factors, to which airlines have no immediate effect, is tried to be annulled by search of new business models and tactics of penetration into new markets.

2 AIR TRANSPORT DEMAND

The demand for air transport is influenced by several factors. Demand dependents primarily on potentials of emissive and receptive market. Another important factor are airlines that serve specific markets. The demand for air transportation can be viewed as the interaction of the following components: meeting the needs of passengers, the legal framework that regulates the relationships in the market and the existence of air carriers who are willing to exploit the condition of bilateral and multilateral agreements on the establishment of air

[1] Vince D.; Razvoj zračnog prometa u funkciji razvoja ekonomskih odnosa Republike Hrvatske s inozemstvom, Znanstveni magistarski rad, Sveučillište u Zagrebu, Ekonomski fakultet, Zagreb, 2009

[2] Steinen E., Joerss I., Mendes de Leon P.: The Economic impacts of an open aviation area between the EU and the US: Booz Allen Hamilton Ltd.; London, in association with CAMPBELL HILL AVIATION GROUP - Alexandria, January 2007

[3] ibid.

traffic.[4] To meet the demand for air transport, air carriers establish flight schedules (departure time, flight duration, waiting at the transfer airports for a transfer - connecting flight, selection of transfer flights, type of aircraft that operates between city pairs, the quality of in-flight services, including catering, flight schedule accuracy and frequency of flight delays or cancellations, etc). Furthermore, demand depends on the number of frequencies that service individual destination or origin, number and type of carriers servicing specific markets and price of airline tickets and established loyalty program (eg. Miles & More, Flying Blue, Executive Club, AAdvantage, MileagePlus, SkyMiles, dividend Miles, etc.). Another important components are market characteristics, which imply distance of mutual markets, the availability of different market by other modes of transport, market orientation to business or leisure travel, destination attractiveness and additional amenities and programs offered to visitors. The competition amongst air carriers and the division of areas of interest between global alliances (Star Alliance, Sky Team, Oneworld) are equally important. Determining potential and competitiveness of a given market, it is necessary to create a benchmark of potential or competing carriers, analyzing the destination network of each carrier, the price range for transport, and comparison with offered prices by other modes of transport.

Attractiveness of market or destination substantially increased after the introduction of direct flights. Direct flight reduces total travel time, avoids waiting at transfer, avoid losing connection flight due to delay of preceding flight, as well as a number of security controls that are often long and tedious for travelers in transfer. If there is only one flight a week between city pairs, then a journey with connection(s) is still more acceptable option, because it allows far greater flexibility. By increasing the frequency of flights, number of possible city pairs and market share will increase proportionally. Direct flights are especially attractive for business travel segment, where the price is not the primary factor. In general, the demand in segment of business travel is inelastic, while the demand in tourist and "visit friends and relatives," traveling is elastic and highly dependent on price. When making a decision about journey, the choice of mode of transport, travel time, choice of destination, we determine the cross-section of factors that comprise quality of service, trip duration, frequency, time of takeoff and landing, as well as the attractiveness of transport service, or the total package of services which are the integral part of the undertaken enterprise. Nowadays, the demand for air transportation is exposed to a number of factors that have negative effect on it.[5] The demand for air transport affects large number of direct and indirect factors:

- Gross domestic product growth
- The amount of direct foreign investment, primarily into Green Field Investment
- State and development of the industry and the development of international trade
- Market competitiveness
- Existence of legal framework for air transport
- Existence of administrative barriers in air transport
- Liberalization of market
- Air carriers operating in a particular market and servicing network destinations
- Potential tourist facilities and promotional activities in tourist-generating markets
- Income per capita
- Selection of mode of transport for travel

[4] Vrdoljak-Šalamon B., Gatti P.; Hrvatski turizam u brojkama/ broj 4, Institut za turizam, Zagreb, Hrvatska, 2011
[5] Belobaba P., Odoni A., Barnhart C.; The Global Airline Industry: MIT, Library of Flight Series, Published by John Wiley & Sons, 2009

- The size and connectivity of the catchment zone
- The carrier's pricing policy and fares
- Political stability and the level of personal security in the destination
- The price of jet fuel

Negative impacts on growth of demand for air transport are:

- Long duration of the global economic crisis and the slow recovery of certain crucial economies
- Social insecurity and high percentage of unemployment
- Many markets that are affected by military operations or terrorist threats
- Consequences of natural disasters
- Administrative restrictions relating to demand for travelling to certain markets (visa requirement)
- Poor or inadequate transport infrastructure
- Requirements relating to sustainable environmental protection

3 AIR TRAFFIC POTENTIAL BETWEEN CROATIA AND NORTH AMERICA

By using marketing tools and various computer programs, it is possible to determine the strategic approach and activities of raising interest of an air carrier in particular market or airport.

Examples of such strategic activities include:

- Assessment of potential of new markets in order to determine which of them have sufficient resources, or which will generate the greatest demand in the number of passengers, and which markets will contribute to generating additional income, taking into account the ratio of business and tourist travels, potentials of immigrant communities, and potentials of trade exchange and impact of seasonality
- Identification of key competitors amongst air carriers and competitive destinations, the attractiveness of destinations and flight network serviced by each destination, and the selection of proactive access to new markets in order to increase market share
- Continuous monitoring of changes in the market, and evaluation of progress towards achieving strategic, financial and operational goals.

After analyzing the features of tourist supply and demand in Croatia, and its touristic micro-regions in commercial accommodation, further analyses refer to demand in the international competitive environment.[6] The goal is to determine the competitiveness of Croatian tourism in terms of its ability to retain the existing and to attract new customers, as well as the ability to meet the needs of customers.[7] This includes determining of Croatian market position related to its main competitors, in total and by individual emitting regions. Position on the market and competitiveness of Croatia is determined on the basis of physical indicators of demand and capacity, based on analysis of the market position of Croatian touristic macro-regions to their relevant international environment and based on an analysis of the Croatian offer price.

Croats in the United States are the largest group of Croatian immigrants outside their homeland. The majority of Croatian immigrants and their descendants are still largely

[6] Turistička zajednica grada Zagreba, website: www.zagreb-touristinfo.hr
[7] Vrdoljak-Šalamon B., Gatti P.; Hrvatski turizam u brojkama/ broj 4, Institut za turizam, Zagreb, Hrvatska, 2011

concentrated in the same states as in the first half of the 20th century.[8] Based on the evaluation of Croatian diplomatic missions and consular offices worldwide, the Croatian Catholic Mission, census of the countries in which Croatian immigrants and their descendants live, and based on their estimates of Croatian communities in some countries, it is considered that today in the world live about 3 million displaced Croats and their descendants, and the estimation of their actual number is shown in Table 1. Croats have migrated due to economic and/or political reasons, but it can be said that both reasons were often interlinked.

Table 1: Estimated number of the Croats and their descendants in various countries

State	**Number of Croats**		**State**	**Number of Croats**
Argentina	aprox 250.000		Luxembourg	aprox 2.000
Australia	aprox 250.000		Netherlands	aprox 10.000
Austria	aprox 90.000		Norway	aprox 2.000
Belgium	aprox 6.000		New Zealand	aprox 40.000
Brazil	aprox 20.000		Germany	aprox 350.000
Bolivia	aprox 5.000		Paraguay	aprox 5.000
Chile	aprox 200.000		Peru	aprox 6.000
Denmark	aprox 1.000		United States	aprox 1.200.000
Equador	aprox 4.000		Sweden	aprox 35.000
France	aprox 40.000		Switzerland	aprox 80.000
Italy	aprox 60.000		Uruguay	aprox 5.000
South Africa	aprox 8.000		Great Britain	aprox 5.000
Canada	aprox 250.000		Venezuela	aprox 5.000

Source: Ministry of Foreign Affairs and European Integration of the Republic of Croatia

The biggest migration wave of Croats into America started at the end of 19th century and lasted until the First World War. Extent of Croats in the United States and their immigration is difficult to determine. There are many sources, but the actual number is differing. It is a consequence of inability to express their nationality or origin during the census conducted in the United States. According to the census for 2005, 401,208 U.S. citizens declared themselves as Croats. According to the census for 1990, in the United States lived 544,270 Croats (citizens who pleaded Croatian descent or were born in Croatia). Based on estimates of the Croatian Embassy, General Consulate in the United States, Croatian catholic missions and the census in the United States, as well as based on the evaluation of Croatian community, today in the United States there are about 1.2 million people of Croatian descent. The spatial distribution of the population of Croatian origin according to data from 2000 indicates that the majority of our immigrants are concentrated in the far northeast and the southwest of the United States. Croatian diaspora in the U.S. is one of the largest in the world.[9] The most numerous are the Croatian community in Chicago and the surrounding area with about 150,000 citizens, about 40,000 in St. Louis, in Detroit about 7,000, about 35,000 in San Pedro, in San Jose about 5,000, and in New York, New Jersey and Connecticut there are about 80,000 people of Croatian descent. Pittsburg is a city inhabited by highest number of Croats in the U.S. Higher concentrations of Croatian emigrants are located in California, particularly in the broader area of Los Angeles and San Francisco. Emigration after 1990 is characterized by the wave of refugees from war-torn areas. The largest number moved to countries of western Europe and overseas countries (USA, Canada, Australia, New Zealand).

[8] Statistička izvješća; Republika Hrvatska, Ministarstvo vanjskih i europskih poslova, Državni ured za Hrvate izvan Republike Hrvatske, Ministarstvo vanjskih i europskih poslova Republike Hrvatske
[9] Državni zavod za statistiku, website: http://www.dzs.hr/

Characteristic for all generations of our immigration, whether in overseas countries, or in the immediate vicinity of the homeland, is their interest in cooperating with their homeland. Older adults, chiefly economic emigration to overseas countries, are still interested in the happenings in Croatia, while their younger generation is more assimilated, and more interested in their own roots. It is hard to expect from the second or third generation of Croats who were born in the U.S., and who are completely assimilated and have good living conditions to travel to Croatia in greater numbers. With younger generation there occurs the problem of insufficient knowledge of Croatian language, which makes the decision to travel to grandparents' homeland more difficult. The elderly population still expresses nostalgia for the homeland. This is our target group of passengers, who often visited their hometowns, to which can be counted as a secure potential emissive markets. Taking into account the total number of people who declared the Croatian origin, there could be generated false forecasts of demand for travelling to Croatian tourist destinations.

4 NORTH AMERICA AND CROATIA AIR TRAFFIC NETWORK BEFORE CROATIAN WAR OF INDEPENDENCE

Before the Croatian war of Independence, the Republic of Croatia was linked to several destinations in North America. These flights were operated by the following airlines: JAT, Pan Am and Air Canada. With scheduled flights Zagreb was associated with the following destinations: Toronto, Montreal, New York, Chicago and Los Angeles. During the Independence war, these flights were suspended. After the establishment of the independence of the Republic of Croatia, Zagreb Airport initiated a proactive approach to air carriers who possess an adequate aircraft fleet and would be capable of re-establishing direct flights from these destinations. In the postwar period, just during two summer seasons, one travel agency from Toronto, organized a series of charter flights to Canada engaging carrier Skyservice, which was operated by Boeing B757. This type of aircraft has cabin configuration with only one aisle, and the capacity of fuel tank does not allow flying so far as Zagreb. Because of such short range, the aircraft was forced to land in Iceland for refueling and supply of cabins with additional material. Such operations have caused longer duration of flight, and thus degraded the quality of service. U.S. estimates in 2006 showed having 298.45 million population. Despite the large number of inhabitants, only 56.2 million of inhabitants in 2006 travelled on vacation overseas, i.e. only 19 %. In 2006 the American tourists preferred air travel as a form of transport when going on holiday.

For travelling to Croatia air transport was also predominantly used. In 2006 there were realized 154,065 arrivals from the U.S. market. Croatia was repeatedly declared in the U.S. market as the preferred destination. Unfortunately, after the bankruptcy of Pan Am and the discontinuation of flying of JAT, due to the start of military operations on Croatian territory, until 2013 it was not possible to establish a direct flight between the U.S. and Croatia. Meanwhile, intensive efforts were made to stimulate the U.S. air carriers, which were presented feasibility studies of economic viability of introducing direct flights. The existence of direct flight would significantly facilitate the arrival of American tourists to Croatia. Until the introduction of direct flights, potential passengers must use one of transfer airports (London, Paris, Frankfurt and Amsterdam).

5 CURRENT SITUATION AND FUTURE STRATEGY TO ESTABLISH SUSTAINABLE OPERATION TO NORTH AMERICA

By the analysis of available data on total number of flights in the given surveyed period of one week, it is possible to present the structure of frequency of aircraft operations (Table 2).

Table 2: Structure of frequency of number of aircraft operations in the surveyed period

Aircraft type	From Europe to U. S. A.	Aircraft capacity – number of seats	From U. S. A. to Europe	Total
B763	567	261 – 299	568	1.135
B772	421	305 – 375	410	831
B744	348	416 - 524	369	717
A333	350	295 – 335	350	700
B752	337	186 – 239	338	675
A332	266	253 – 293	260	526
A343	152	295 – 440	154	306
B764	150	243 – 296	153	303
A346	124	380 – 440	122	246
B77W	94	354	93	187
MD11	67	323 – 410	77	144
B762	44	216 – 290	44	88
A388	43	525 – 853	43	86
B77L	37	301	28	65
B748	13	467 – 605	15	28
B742	7	366 – 452	10	17
A310	7	220 – 265	7	14
A345	3	313 - 375	0	3
Grand Total	3.030		3.041	6.071

Source: Prepared by the authors on the basis of the information from Eurocontrol[10]

When we put into correlation the demand for air transport and aircraft capacity with sufficient range to fly without landing over the distance between the origin and the destination, the choice falls down to only two or three types of aircraft with smaller seat capacity. Besides, these are relatively old types of aircraft, equipped with engines of huge fuel consumption, and only few air carriers still keep them in their fleet. Because of high costs that accompany the introduction of a new flight in regular air traffic, and because of high risks of low sales, or low occupancy of cabins, i.e. load factor and lower ticket prices that tend to stimulate the market, doubts were raised about the effectiveness and justification of the introduction of the flight route.

Furthermore, if undeveloped international trade and offer of goods that can handle the price of air travel is low, the overall income and profitability of such routes/lines is even more questionable. In such business environment it may be difficult for some of smaller air carriers with limited seat capacity and financial capacity to decide on such a risky venture.

[10] Eurocontrol database, European Aircraft Operational Data, 2013

Table 3: Total number of aircraft movements (take off + landing) by air carriers in the surveyed period (U.S. - Europe)

Air Carrier	Total
United Airlines	989
Delta Air Lines	984
British Airways	573
American Airlines	556
Deutsche Lufthansa	430
US Airways / America West Airlines	335
Air France	288
Virgin Atlantic Airways	246
KLM	134
Swiss International Air Lines	134
Alitalia Linee Aeree Italiane	108
Aer Lingus Irish Airlines	96
Iberia	88
Turkish Airlines	84
SAS Scandinavian Airlines	83
airberlin	72
FedEx	70
United Parcel Service	60
Polskie Linie Lotnicze LOT	41
Aeroflot Russian Airlines	40

Source: Prepared by the authors on the basis of the information from Eurocontrol[11]

Table 4: Presentation of ratio of frequency of flights towards major destinations in Europe

	Airport	Frequency number	PAX number (2011)	The population of the city according to ESPON project
1	London-Heathrow	686	69,4 Mil	13.709.000
2	Paris-Charles de Gaulle	344	60,9 Mil	11.175.000
3	Frankfurt-Main	319	56,4 Mil	2.764.000
4	Amsterdam-Schiphol	243	49,8 Mil	2.497.000
5	Rome-Fiumicino	116	37,7 Mil	3.190.000
6	Madrid-Barajas	114	49,7 Mil	5.263.000
7	Zurich (Zürich)-Kloten	103	24,3 Mil	1.615.000
8	Munich - Franz Josef Strauss	91	37,8 Mil	2.665.000
9	Brussels	86	18,8 Mil	2.639.000
10	Dublin	83	18,7 Mil	1.477.000
11	Manchester	66	18,8 Mil	2.556.000
12	Istanbul-Ataturk	56	37,5 Mil	13.000.000
13	London-Gatwick	50	33,6 Mil	13.709.000
14	Dusseldorf	44	20,3 Mil	1.525.000
15	Barcelona	42	33,4 Mil	4.082.000
n	Zagreb	0	2,3 Mil	1.107.000

Source: Prepared by the authors by data taken from the ESPON "Study on Urban Functions"[12]

According to the analysis of traffic potential, presented in Table 4, it is apparent that the majority of transatlantic air traffic takes place over four largest airports, which are also the bases of the largest airlines and leading alliance (Lufthansa - Star Alliance, British Airways -

[11] Ibid.
[12] Eurocontrol database, European Aircraft Operational Data, 2013

OneWorld, Air France and KLM - Team Sky). Also from the analysis it is visible that the transatlantic traffic has the largest potential market in Germany and Great Britain. When we put in correlation airport passengers and the a population of the city where the airport is located, there is a conclusion that only the population of these cities or regions centered around a specific airport does not have enough potential to generate such intense traffic.

Airports with the highest traffic volume were able to define themselves as strong transport hubs in the previous period, owing it mainly to transport policy in a particular state. In most countries, where the airports are considered as major transport hubs, there is an existence of a hub carrier that has "hub and spoke" network structure. For example, Frankfurt profiled as the primary airport for long-haul air traffic. Later, due to congestion and lack of infrastructure capacity at the airport in Frankfurt and joint ventures (Lufthansa + Airport Munich) in the construction of Terminal 2, it was allowed that the long-haul air traffic is further carried via Munich airport. Similar situation happened with Paris, Vienna, Amsterdam and London airports.

If we compare the number of residents who live in the area of certain cities, than Zagreb is not far behind particular cities, but its transport potentials are considerably smaller. Zagreb Airport, even more than 20 years after the end of Independence war, did not significantly increase the number of passengers, when compared with the pre-war situation. And none of other airports in the entire region was not sufficiently attractive for a scheduled long-hauled routes to be established with the markets of North America and Canada.

Another important factor that affects the potentials and development of an airport is a dominant air carrier. In the previous period states developed and protected with various administrative barriers the domestic carrier, often the national carrier, which was, including transport policy and economic interests of domicile country, had to develop its network destination. Recently there were more cases of smaller air carriers being took over by larger air carriers, or within the air carrier was formed a new company that uses a different business model (low cost). Small carriers or carriers which have entered into specific alliance, received thus the role of a "feeder" for major carriers in their network destinations.

It follows that besides the adequate transport policy and strong and dominant or national carrier, the key factor for the development of the airport is the volume of transfer air traffic. If we look at the area of ex-Yugoslavia, neither any airport nor any airline that was formed in an independent state succeeded to generate neither any network destination nor the volume of traffic that would be sufficiently attractive for air carriers that perform the long-haul flights.

Table 5: Top 10 airports with the lowest number of flights from the U.S.

	Airport	**Number of frequencies**	**PAX number (2011)**
1	Málaga	6	12,8 Mil
2	Glasgow-Prestwick	5	6,9 Mil
3	Pisa Galileo Galilei	4	4,5 Mil
4	Valencia	4	5,0 Mil
5	Porto	3	6,0 Mil
6	Naples	2	5,8 Mil
7	Palermo-Punta Raisi	2	5,0 Mil
8	Riga International Airport	2	5,1 Mil
9	Bristol International Airport	1	5,8 Mil
10	Newcastle	1	4,3 Mil

Source: Authors made it out by data processing[13]

[13] Eurocontrol database, European Aircraft Operational Data, 2013

The results gathered after the analysis, which are presented in Table 5, show the airports with established minimum number of frequencies in the long-haul traffic. Airports that have one or two frequencies on transatlantic routes have a significantly higher volume of traffic of any airport in the region. Furthermore, we have to keep in mind that small number of frequencies is not attractive for business travelers, and business travelers will continue to plan their trips through some of transfer airports, taking into consideration the criteria of shortest total duration of the travel. A smaller number of frequencies is acceptable for leisure travels and private travel when days and times of departure have little relevance to the decision. Limited potential of catchment area, small volume of traffic and low number of frequencies would not arouse the interest of major carriers in establishing direct flights to a market with such potential. Taking into account that the total volume of air traffic generated by all airports in the Republic of Croatia is slightly higher than 5.3 million passengers a year, there are minor possibilities that any airport in the region will be in the position to establish a year-round traffic from the North American market.

6 CONCLUSION

This paper attempts to point out the complexity of air traffic factors and many other factors that determine its further development. Without Transport Development Strategy of the Republic of Croatia, adequate transport policy and promoting of "hub and spoke" operating model for air carriers, and without stimulation of carriers in their expanding of network destinations, it is impossible to expect a substantial increase of air traffic in the future, as well as the establishment of transatlantic or other long-haul traffic. This trend of the future development of air transport should be followed by the dominant carrier as well.

Taking into consideration the small potentials of domestic market as emissive market, and relatively weak demand for transatlantic or global markets on destinations in Croatia, the air carriers are not interested in serious evaluations of economic feasibility of introducing direct flights to Croatian airports in scheduled air traffic. We can expect only sporadical organizing of charter flights and that only during summer seasons. To change this situation, it is primarily necessary to establish better transport links with neighboring regions and to develop a network of destinations in order to increase transfer traffic. Only after surpassing the traffic volume of 4 to 5 million passengers, it could be expected from the carriers to show the interest for establishing long-haul traffic.

Some air carriers which enjoyed during many years the subsidies and market protection by various administrative barriers missed the opportunity to adapt themselves to new market conditions that occurred on other markets where the process of liberalization began. Sluggish and inefficient systems of individual air carriers caused the loss of competitive capacity. The air carriers and operators who will not be able to adapt to new market conditions are doomed to failure and exit from the market. Delayed reaction in terms of restructuring, the implementation of a new business model, or the inability to compete with other carriers in the penetration of new markets, will be used by the alliance leaders who already jointly divided small markets and thus met and fulfilled their business interests.

Business policy implemented by market leaders in air transport will significantly affect the operations of Croatian airports. Air carriers in the near future will be the ones who will fulfill their own interests, and in accordance with mutual relations in certain markets, dictate the pace of development. In this way they will have a direct impact on pricing policies and steering of air traffic routes of passenger flows towards destinations that suits them best, and where they can expect the highest profits. In a broader context, it means that the mutual airlines' interests will have significant impact on business, on profitability of tourism industry and demand of hotel capacities.

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SUSTAINABLE DEVELOPMENT IN SHIPPING BY DECREASING GREENHOUSE GASES (GHG)

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ABSTRACT

Recently sustainability in a climate and an environmental perspective has become an issue of highest priority. The displacement of fossil fuel with renewable fuels has a wide range of environmental and economic impacts. International Maritime Organization - IMO has responded to the global focus on climate change and greenhouse gas emissions by developing specific technical and operational efficiency measures. According to IMO it can be noticed that cutting down emissions in shipping industry is developing in two directions; usage of hybrid systems for better performance where the main power source is still fossil fuel; and systems without fossil fuel.
Ship owners united under International Chamber of Shipping stated that shipping industry is determined to cut down emissions from ships by 20% until 2020 with significant reductions thereafter.
Interest in biodiesel is more enhanced nowadays primarily because of uncertainty in oil prices but advantages in environmental benefits can not be ignored. Board of Port Ploče also recognized the potential of bio fuels and with funds from EU invests in building eco-terminal.

Keywords: biodiesel, renewable energy, sustainable development

1 INTRODUCTION

Ships are the most environmentally friendly form of transportation. It is estimated that 2.7% of the global CO_2 emissions come from international shipping. Although it looks modest as contributor to a overall pollution IMO is implementing guidelines to improve energy efficiency and better emission control. As already acknowledged by the Kyoto Protocol, CO_2 emissions from international shipping cannot be attributed to any particular national economy due to its global activities and complex operation. Therefore, IMO has been energetically pursuing the limitation and reduction of greenhouse gas (GHG) emissions from international shipping, in recognition of the magnitude of the climate change challenge and the intense focus on this topic.

The IMO issued guidelines identify a significant potential for reduction of GHG emissions through technical and operational measures if implemented could increase efficiency and reduce the emissions rate by 25% to 75% below the current level.

However, the technical and operational measures will not be sufficient to satisfactorily reduce the amount of GHG emissions from international shipping in view of the growth projections of human population and world trade. Therefore, market-based mechanisms have also been considered and would serve two main purposes: providing a fiscal incentive for the maritime industry to invest in more energy efficient manner and off-setting of growing ship emissions.

2 EMISSION CONTROL

Cutting down emissions in shipping industry is developing in two directions; usage of hybrid systems for better performance where the main power source is still fossil fuel; and systems without fossil fuel. Overview of the possibilities for reducing GHG given by the leading companies included in a marine industry is presented by the Figure 1 below.

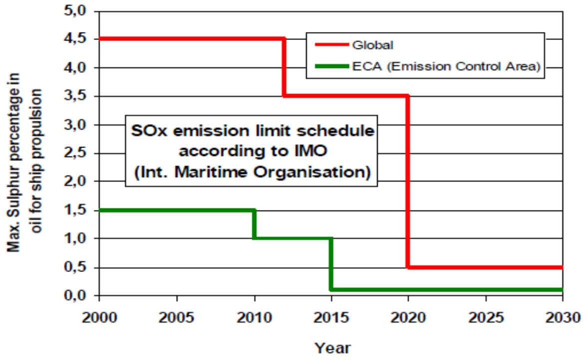
The figure does not show the effect, when the measures and methods are combined in a ship. The effect of combinations depend on ship type, size, and finally but not least of the actual combination of technologies used in an actual project.

Measure/Method	CO_2	NOx	SOx
MACHINERY			
Dual/Multi MCR certification	-1 to -3%	-	-1 to - 3 %
Turbo charging and variable nozzle ring			
Waste heat recovery (WHR systems)	-8 to -10 %	-8 to -10 %	- 8 to -10 %
Exhaust gas recirculation (EGR systems)	+2 to 3%	-70%	-19%
Pump and auxiliary systems	-1,5 %	- 1,5 %	-1,5 %
Pump- and cooling water systems	-1,5 %	- 1,5 %	- 1,5 %
Automated engine monitoring	-1%	-	- 1 %
Scrubber systems	(- 3 %)	-	-98 %
Optimised control for ship cooling			
LNG powering of a fast ferry	-25 %	-35 %	- 100 %
(Water In Fuel emulsion (WIF))	+1 to 2%	-30 to -35%	+ 1 to 2%
PROPULSION			
Air lubrication system (ACS)	-5 to -10 %	-5 to -10 %	-5 to -10 %
Innovative propeller	Not yet known	Not yet known	Not yet known
OPERATION			
SIMAC GSF Student forum	Not yet known	Not yet known	Not yet known
Performance monitoring of silicone antifouling	-6 %	-6 %	-6 %
Lab on a ship	0 to - 5 %	0 to - 5 %	0 to - 5 %

Figure 1: Future reported emission reduction potentials

Source: Green ship of the future concept study[5]

Emission restrictions coming in force internationally or regionally in ECA´s (ECA Emission Control Areas). The coming international rules for sulphur (SOx) content in fuel oil as decided by IMO will be as shown in Figure 2. Lately EPA (US Emission Pollution Agency) has put forward a proposal that will extend the ECA area to 200 nautical miles from the coast of Canada and USA.



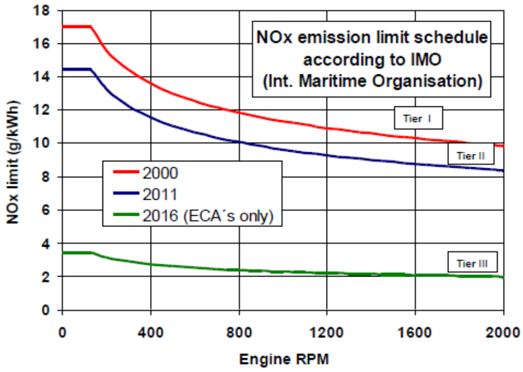


Figure 2: Future IMO requirements for maximum SOx and NOx emissions

Source: www.imo.org

The rules coming in force concerning NOx emissions presented on the Figure 2 is internationally controlled by IMO and to some extent by local national governments stating separate demands for NOx within ECA areas.

Concerning CO_2 it is expected, that rules will come in force in the near future for ships both as internationally and regionally. Different studies have stated CO_2 reduction of 10 to 30% over the coming years under different assumptions. What is sure is that the CO_2 will be reduced either by market based instruments or by introduction of technical requirements for new ships as stipulated by the introduction of the so-called Energy Efficiency Design Index (EEDI) or by a combination of these two measures.

3 HYBRID SYSTEMS

Industries market leaders suggest green solutions:

- M.E. Exhaust gas scrubber
- MGO fuel (Marine Gas Oil)
- Combined LNG/HFO
- Water in fuel

3.1 M.E. Exhaust gas scrubbers

The exhaust gas scrubber system removes sulphur oxides and particulates from exhaust gas. The scrubber system is a hybrid system being capable of operation both on fresh water as well as sea water. The shift between these operation modes can be made as flying changeover while the scrubber is in operation controlled by GPS signal informing about the position of the vessel. In Figure 3, the working/installation principle is shown.

Normal operation of the scrubber system is done by means of a control panel placed in the engine control room. The scrubber can be operated in automatic mode or semi-automatic mode. When operating in auto mode, the ‘engines running’ signal starts the scrubber, and the signals from the ship’s Global Positioning System (GPS) determine whether the scrubber operates in seawater mode or freshwater mode in a predefined manner. Normally the engines fuel flow index determines the amount of sea water used in the scrubber and/or the caustic soda dosing to the system if in fresh water mode. The performance of the scrubber is measured continuously, and the adjustment of the different operational parameters is controlled accordingly.

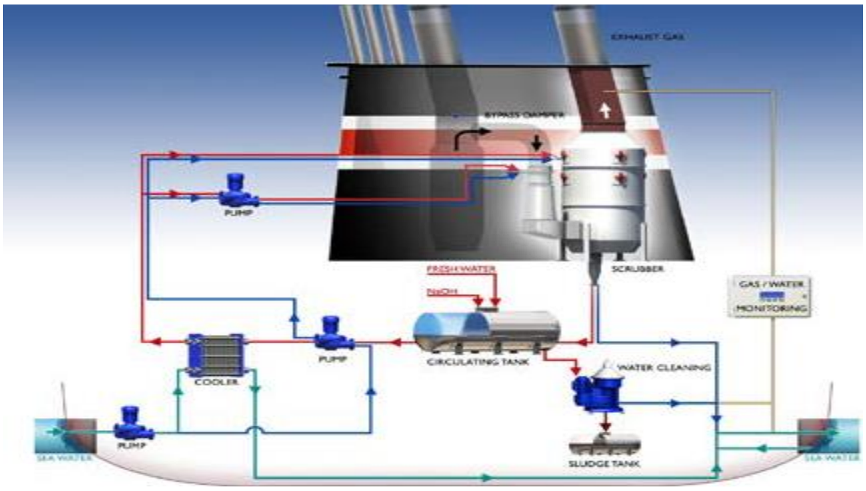


Figure 3: Scrubber principle

Source: Vessel emission study: Comparison of various abatement technologies to meet emission levels for ECA's [7]

3.2 Shift to low sulphur fuel (Marine Gas Oil)

In case of operation in ECA, the vessel will shift to low sulphur fuel (MGO) in order to comply with the prevailing emission requirements. Low sulphur fuel comprises fuel with not more than 0.1% sulphur in the case of ECA operation as of 2015. In addition, it comprises fuel that will satisfy the global sulphur cap of 0.5% as of 2020 (or 2025). For simplicity reasons, all of these low sulphur fuels are referred to as 'MGO' (marine grade oil, i.e. distillates). The expectation is that the price difference between 0.1% and 0.5% sulphur fuel will be limited.

3.3 LNG and Diesel

Operating LNG tankers on LNG is not new. There are many years of experience in operating LNG tankers on the "Boil off gas" using steam turbines and Dual Fuel Diesel Electric (DFDE) engines. The most crucial aspect for the future success of LNG as a fuel is the implementation of, and adherence to, adequate safety standards. Both the technical and emotional aspects of safety must be fully addressed, to ensure all persons involved in LNG handling are equipped with the correct information and can respond in the correct manner. For technical safety aspects, unified standards and specifications can go some way in ensuring safe LNG operation. Harmonisation of standards both for LNG bunkering, and for LNG as a fuel, will ensure consistent safety standards for vessels operating with LNG.

Availability of LNG is also an important issue to consider when investigating such a conversion, and many projects are underway to develop LNG bunkering terminals at ports.

3.4 Water in Fuel - WIF

Water in fuel decreases the NOx because the highest temperature is lowered due to the high heat capacity of vapour compared to ambient and the heat absorption by water vaporization. It has also been observed, that the formation of PM is lowered when WIF is used, which can be explained by the phenomenon of micro-explosions or secondary atomization of emulsified fuel. This occurs, because the boiling point of water is lower than that of the surrounding fuel oil. The overall effect of the improved mixing of fuel with the combustion air is a decrease of the final CO, THC and PM concentrations. The improved mixing is also due to an increased momentum of the vaporized fuel jet (the mass is increased due to addition of water), which also improves the mixing. The presence of water in the fuels leads to a potential ignition delay, which means that more time for premixing of fuel and air is available. The last effect of WIF is an increased amount of hydroxyl radicals due to the higher water concentration.

3.5 Cost analyses

Scrubber vs. LNG vs. MGO for the ships already in use:

Table 1: Scrubber fitting on existing ship

Scrubber machinery and equipment	2,600,000 USD
Steel (150t) / pipe / electrical installation and modification	2,400,000 USD
Design and classification cost	500,000 USD
Off-Hire (20 days @ rate 17.000 USD/day)	340,000 USD
TOTAL	5,840,000 USD

Source: Potential of bio fuels for shipping [2]

Table 2: Dual lng / fossil fuel engine fitting existing ship

LNG machinery and equipment, main engine conversion	4,300,000 USD
Steel (300t) / pipe / electrical installation and modification	2,000,000 USD
Design and classification cost	500,000 USD
Off-hire cost 40 days@17,000 USD/day	680,000 USD
TOTAL	7,560,000 USD

Source: Potential of bi fuels for shipping [2]

MGO (Marine Gas Oil) fuel
Current MGO prices are about 900USD/MT.

Complete cost analyses depend on how much time ship spends in the ECA, whether if the ship is new build. It is possible to apply dual fuel and scrubber system on existing ships to reduce GHG. Scrubber system can be used both on main and auxiliary engine and if it is used parallel with MGO results can be most encouraging, although one must be careful about MGO/LNG fuel spread per MT. Dual fuel system is in start more expensive for about 1,720,000 USD and is also dependable on MGO/LNG fuel spread per MT. Dual fuel system is more attractive if it is applied on newly build ship because of too many off hire days later on. As for now for the ship-owners it is cheaper to go only with MGO until 2020 when sulphur cap is expected.

4 SYSTEMS WITHOUT FOSSIL FUELS

4.1 Fuel cells

A fuel cell utilizes basic electrolytic properties of oxygen and hydrogen molecules to produce electricity. The transfer of electrons between the molecules can be used to supply direct current power. The supplied electrical power will be continuous as long as both oxygen and hydrogen flows are maintained and constant. The only waste by-product produced by this ideal system is pure water. Unlike batteries that also use this fundamental principle, this cell will not degenerate over time. This hypothetically provides a permanent electrical power supply needing minimal support, and requiring only the provision of a fuel and oxygen supply. Fuel cell power systems have attracted attention because of their potential for high efficiency, low emissions, flexible use of fuels and quietness. Application of fuel cell technology to the transportation field in general and marine transportation field in particular is still in the early exploratory stage. A unique problem related to transportation applications is the need for quick start up and rapid large power variations during operations.[1].

A fuel cell power pack consists of a fuel and gas processing system, and a stack of fuel cells that convert the chemical energy of the fuel to electric power through electrochemical reactions. The process can be described similar to that of a battery, with electrochemical reactions occurring at the interface between the anode or cathode and the electrolyte membrane, but with continuous fuel and air supplies. [1]. Different fuel cell types are available, and can be characterized by the materials used in the membrane.

There are some barriers relating to the commercialization of fuel cells for transportation and the most bear directly on cost and include: high cost of platinum and other catalysts; thermal control problems; difficult fuel processing requirements; system complexity; start-up time, especially in PAFCs; high reformer cost, especially in small systems; low volumetric power density; carbon monoxide intolerance of electrodes; high cost of membranes (for solid polymer electrolyte fuel cells); low efficiency of the oxygen electrode; deterioration of the cost/performance ratio small systems; and need to replace cells periodically.

Fuel cells must be competitively priced, reliable, and durable if they are to be accepted by the maritime industry.[1]. They will be competing with other types of power plants, especially with well-established diesel-electric plants, for a share of the marine market. The major factor inhibiting fuel cell usage for commercial marine applications is high cost. Other important factors to consider in selecting a fuel cell or other unconventional power plant include: system efficiency; system costs; future technology improvement potential; start up / transient; power supply reliability; power density; technology availability. [1].

4.2 Bio fuel

Bio fuels are currently globally available; they can be produced from many abundant types of biomass, and they can be optimized to match the existing distribution channels and applications of fuels in all forms of transport. [2]. Most commonly used and produced bio fuels are biodiesel (from oil containing agricultural crops) and bio-ethanol (from sugar or starch containing agricultural crops).Bio fuels are one of the options to minimize the effect of ship emissions on local air quality. Therefore IMO evaluating if and how bio fuels could be used in the shipping sector as an alternative fuel. To determine the potential of bio fuels for ships, a clearer picture is needed on technical and organizational limitations of bio fuels in ships, both on board of the ship as in the fuel supply chain to the ship. Economic and sustainability analysis of bio fuels should be included in this picture, as well as an overview on current and potential policy measures to stimulate the use of bio fuels in shipping.

4.2.1 Biodiesel

Interviews with shipping and bunker fuel industry revealed that biodiesel could probably be mixed without adaptations up to about 7-10% in the current supply chain. Application of low blends of biodiesel in distillate marine fuels could be introduced relatively easily. Bunker fuel suppliers can decide to include a small fraction of biodiesel, if accepted by the client.

The application of biodiesel as marine fuel two technical bottlenecks that are potentially problematic are often found in this applied tests [2].:

- Biodiesel acts as a solvent and has a tendency to soften and degrade certain rubber and elastomeric compounds which often are used in older engines. Therefore at higher blends, rubber hoses and seals and other materials used in delivering and transporting the fuel through the ship may need to be replaced with synthetic, biodiesel resistant material.
- Biodiesel potentially removes deposits in the fuel system left by petroleum diesel, which could then clog filters. Filters should thus be checked and cleaned regularly. Alternatively, the fuel tanks should be cleaned prior to using biodiesel filling.

Also there are some technical challenges around biodiesel: a tendency to oxidation and long-term storage issues; affinity to water and risk of microbial growth; degraded low-temperature flow properties; bio material deposition on exposed surfaces, including filter elements.

4.2.2 Di-Methyl ether - DME

For the last 20 years DME (di-methyl ether) has been a known substitute for diesel. It has been tested on small engines but this is no guarantee for its suitability for use in larger engines. [6]. Based on interviews with parties in the shipping sector the following items are of importance concerning DME as a possible alternative shipping fuel.[4]

Fuels like DME, LNG and methanol that have a low flashpoint require a lot of attention in order to manage and prove their safe use and are therefore probably more suited for new build ships and engines. Infrastructure is missing to introduce DME in ships. Industry proposes to produce DME onboard from methanol, by means of a relatively simple chemical installation. Furthermore, the on-board chemical installation, however simple, will require operation by dedicated and skilled personnel. In view of decreasing manpower onboard of ships, this option may not be realistic.

4.2.3 Straight vegetable oil - SVO

Vegetable oil is suitable for replacing residual fuels51. It is unknown if the vegetable oil has been tested for marine application, but there is some experience with land-based power stations that replaced HFO with vegetable oil, e.g. with engines from Man B&W and Wärtsilä.

Man B&W state that diesel engines designed for heavy fuel oil can be run on vegetable oil without problems, whereas engines designed for marine diesel or gas oil may have problems though due to higher density and viscosity of the vegetable oil.[3]. Wärtsilä has approved its engines to run on vegetable oils (within certain specifications). Rather, vegetable oil would be applied as a pure replacement (100% blend) of HFO. This ensures circulatory ability, optimal engine injection and efficient atomisation and combustion. An advantage of the application of vegetable oil is that less energy is needed for the preheating of fuels. This would result in a net fuel saving (on energy basis). Bio-methane

Bio-methane or bio-LNG could be an alternative to LNG (liquefied natural gas) which gains increasing interest in the shipping sector. It could connect to existing and upcoming LNG terminals in Europe. Bio-methane would be applied in exactly the same way as bio-LNG and therefore not lead to any additional challenges. In principle bio-methane could also be applied as CNG (compressed natural gas). This would have the following disadvantages:

High pressure of 200-250 bar in gaseous form; bulky storage (3 times LNG); very expensive storage (strong, heavy vessel); high pressure fuelling difficult and slow; and requires a bunker station with at least 10 times storage to avoid large pressure

4.2.4 Bio-ethanol

Bio-ethanol is produced all around the world in very large volumes, larger than biodiesel. In some locations, bio-ethanol is cheaper than gasoline (without incentives). In South America and South Asia it is produced from sugar cane, in the USA from maize and in Europe from wheat, maize and sugar beet. The final product quality is rather independent from the feedstock. Bio-ethanol is not a logic option for diesel engines. It is a poor diesel fuel, with low cetan number, low energy content, it is corrosive and has a poor lubricating ability. Nevertheless, it is possible to apply ethanol in diesel engines, as a neat fuel. There is much experience in Swedish busses (Scania engines) running on ethanol. This option requires modification of the engine, namely the introduction of a glow plug ignition, and an ignition improver must be added to the ethanol. For introduction into shipping, it would therefore be recommended to introduce bio-ethanol in blends only and for high speed, auxiliary engines.

4.3.5 Pyrolysis oil

Pyrolysis oil is potentially very cheap, because it can be produced from any biomass/ residue and anywhere around the world. Several Wärtsilä heavy fuel engines are running on pyrolysis oil. [2].

4.3 Greenhouse gas balance

Mentioned bio fuels were analyzed on their sustainability compared to marine fuels. Two main items are discussed here: the greenhouse gas balance of bio fuels compared to the fossil reference, and the emissions to air. For every selected bio fuel the greenhouse gas balance was determined for the different biomass resources which could lead to the selected type of bio fuel. The full greenhouse gas balance overview per bio fuel type is presented on Figure 4.

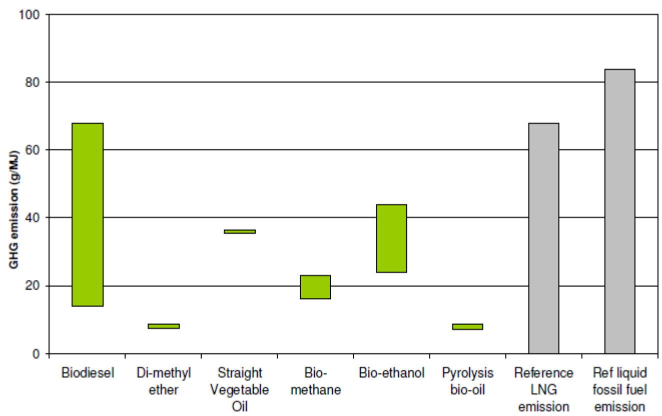


Figure 4: GHG balance comparison between bio fuels and fossil reference

Source: EMSA

4.4 Cost analysis

Figure 7 shows the market prices for biodiesel and several fossil derived diesel fuels over the past two years. The trend of future prices is impossible to predict. After the oil record of 145USD/barrel in July 2008, prices have gone up and down between 35 and 100 USD. Nevertheless, it is widely assumed that oil prices will increase in the next decades and that they will be increasingly more volatile as example shown in Figure 5.

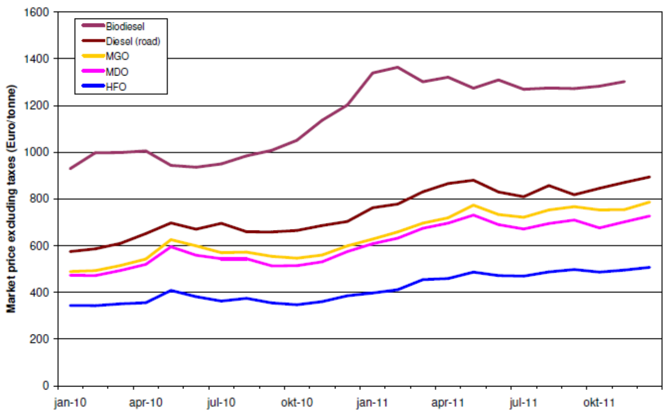


Figure 5: Historical prices for fuels without tax

Source: www.bunkerindex.com

Production costs of bio fuels are still more expensive than fossil marine fuels. However, the uncertainty in technological development, scaling and therefore cost reduction could lead to a competitive situation, if marine fuels are to be increasing in price, and if the obligation incentive for bio fuels remains within the renewable energy directive.

Operational costs are of major importance to ship owners and are largely dominated by the fuel costs (up to 50%). If Member States allow in their translation of the RED (Renewable Energy Directive)that bio fuels can also be introduced to the shipping sector to meet the obligation, biodiesel in ships would be evenly cost-effective as introduction in the road sector, based on the perspective of the obligation owner.

It could also be the case that bio fuels are cost-economic beneficial if sulphur restrictions are increasing for marine fuels, especially the cheaper and widely available bio fuels like straight vegetable oils and biodiesel.

5 OVERVIEW OF BIO FUELS POTENTIALS IN CROATIA - PORT OF PLOČE

Main activity of Port of Ploče LLC is the storage and handling of petroleum products and edible oil, and is done through technologically sophisticated liquid cargo terminal built 2001.Storage facilities at liquid cargo terminal are intended for the storage of diesel fuel, biodiesel, gasoline, kerosene and cooking oil. Strategical goal of Port of Ploče is implementation of production of biodiesel. Possibilities are presented by the SWOT analysis.

From the SWOT analysis presented by Table 3, it is notable that there is a particularly large competitive advantage and all the resources for attracting domestic and international investments in the development of activities for manipulation and storage of liquid cargo in the Port of Ploče.

Table 3: SWOT analysis for Port of Ploče LTD

STRENGTH Existence of infrastructure for storage of liquid cargo Berth made to accept tankers with liquid cargoes Highly skilled staff Experience with the transhipment of vegetable oil and petroleum products Belonging to the PORT OFPLOČE(image) Location in the Tax Free Zone Possibilities of investment Concessions in the port area for 30 years Strength of own distribution centre	WEAKNESS Unfinished privatization Low ability to finance additional concession payments or new equipment The absence of ground storage capacity Barge-warehouse without double bottom capacity of 40,000mt Lack of own fire department Insufficient knowledge of the production technology of biodiesel Lack of a unified information system
OPPORTUNITIES Finished highway to city Ploče The existence of rail traffic Traffic increase in Port of Ploče from the current 4,000,000 metric tons to 9 million tons of cargo The EU regulation on the percentage of biodiesel in the energy sources Business in the Free Zone Plates (taxes) Confrontation of supply and sale in "our backyard" Part of a national strategy on energy Positive measures(fiscal and other)	THREATS The planned investment projects in other ports High cost of capital Development of river ports and transport The lack of harmonization of legislation Political instability in the region The unknown aspect of the Biodiesel Tax(legislation) Poor Agrarian Policy in Croatia New sources of fossil fuels-oil price Car industry lobby and oil industry lobby The increase in domestic and foreign competition

Source: www.luka-ploce.hr

6 CONCLUSION

Engine manufacturers claim that the engines are suitable for bio fuels, but do not yet give guarantees. Engine manufacturers provide warranties for certain specifications of fuels. Therefore, engine manufacturers will be essential stakeholders in the process of setting new fuel specification standards. As long as the ship engine manufacturer does not take responsibility for accepting bio fuels, the risk is for the ship owner.

A current trend in shipping is a reduction of staff on board ships, and with that a decrease unavailability of knowledge and skills in different people, or rather condensation of knowledge and skills in fewer people. For bio fuels and other new fuels to be introduced, new knowledge and skills are needed. Interview market parties warn for a possible organizational threat or hurdle for the introduction of bio fuels, to properly train few shipping staff on board. Aside to the needed training and setting up new onboard procedures for handling, the MSDS safety sheets need to be updated to the introduced alternative fuels. From a technical integration point of view, small percentage biodiesel blends (up to 20%) with MDO/MGO seem the most promising fuel for shipping, aside to 100% replacement of HFO by straight vegetable oils, due to best compatibility with current engines and supply chain. Aside to the limited application of bio-ethanol in diesel engines, the investments needed to the supply chain seem manageable, although less favourable than for biodiesel and SVO. DME and bio-LNG are still upcoming technologies, with at this point limited biomass feedstock availability. Also, more investments are needed to the fuel supply chain in order to introduce these fuels. For new build ships these fuels seem more promising. Pyrolysis oil is not seen as a viable option as an alternative fuel for ships at this point. The issue remains of the responsibilities and ownership in the supply chain. All risks now lie with the ship owners, both for fuel quality as engine guarantees.

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FREIGHT PIPELINE AS AN ALTERNATIVE TO SECOND RAILWAY LINE DIVAČA - KOPER

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ABSTRACT

Cargo flow from port of Koper to Divača railway intersection is increasing every year. In order to guarantee the smooth transportation of goods from port of Luka Koper by railway it is essential to build the second track from Koper to Divača. Construction of the second railway line will take a long time and before it gets done, the cargo flow could change and the port of Luka Koper could lose its role of entry point into Central and Eastern Europe.
One of the alternatives to the second railway line is freight pipeline which is a new method of transporting goods in pipelines by capsules. Freight pipeline would resolve the current lack of rail capacity problem and establish faster and more regular transportation of all goods. Freight pipelines have specially designed transport units, named capsules that have standard dimensions such as containers, but are slightly changed by shape, which enables faster transportation by pipelines.
The article presents freight pipelines, its characteristic and possible geographical location in Slovenia.

Keywords: freight pipeline, capsules, railway, port of Luka Koper

1 INTRODUCTION

The geostrategic position of Slovenia on the crossroads of 5th in 10th Pan-European corridors represents a maritime gate for freight flows from Middle and Far East to the countries of central Europe - Austria, Germany, Czech Republic, Slovakia, and Hungary.

Connections between traffic infrastructure and economic growth are indisputable, which corroborates the importance of transport sector for each country. Good traffic connections enable quick and large movements of freight from point A to point B. On the other hand, inefficient connections cause slow movements and changing directions of cargo flows. All these facts indicate the need for having well organized and efficient infrastructure that is crucial for economic growth.

The European program of sustainable mobility and environmentally friendly transport moves freight from road to railway and vessels. In that way it encourages the development of new transport technologies. One of the new and widespread technologies is transport of cargo through pipelines, which is the fifth transport alternative to road, rail, water and air. Freight pipelines are designed in many ways. The most potential concepts are listed below (*Egbunike & Potter, 2011)*:

- Cargo Cap is the transport pipeline with its own transport units shaped in form of capsules. The capsules are designed for the transport of two Euro pallets.
- Subtrans is the transport pipeline using special transport units or special cars with wheels for carrying ISO containers.

2 TRANSPORT GROWTH

Transport modes develop very quickly. The main reason is the distance between resources and industry. The industry is usually located in one part of the world while resources are widely spread all over the world. The quick movement of freight from point A to point B requires good transport connections with powerful transport means and efficient transport infrastructure.

2.1 Pan-European Corridors

Pan-European corridors were formed whit the intention to connect the transport routes between Western and Eastern European countries. Today ten Pan-European corridors connect road, rail, air and water transport modes and enable intermodal transport all over the European continent.

Slovenia is positioned on the crossroads of 5th and 10th road and railway Pan-European corridors. The corridors cover the main transport infrastructure which includes the only Slovenian port – the port of Luka Koper (Figure 1).

The 5th corridor runs in the East-West direction and connects Venice with Trieste/Koper, Ljubljana, Maribor, Budapest, Uzhhorod and ends in Ukraine.

The 10th corridor runs in the North-South direction and connects Salzburg through Ljubljana, Zagreb, Beograd, Niš, Skopje, and finally Thessalonica in Greece.

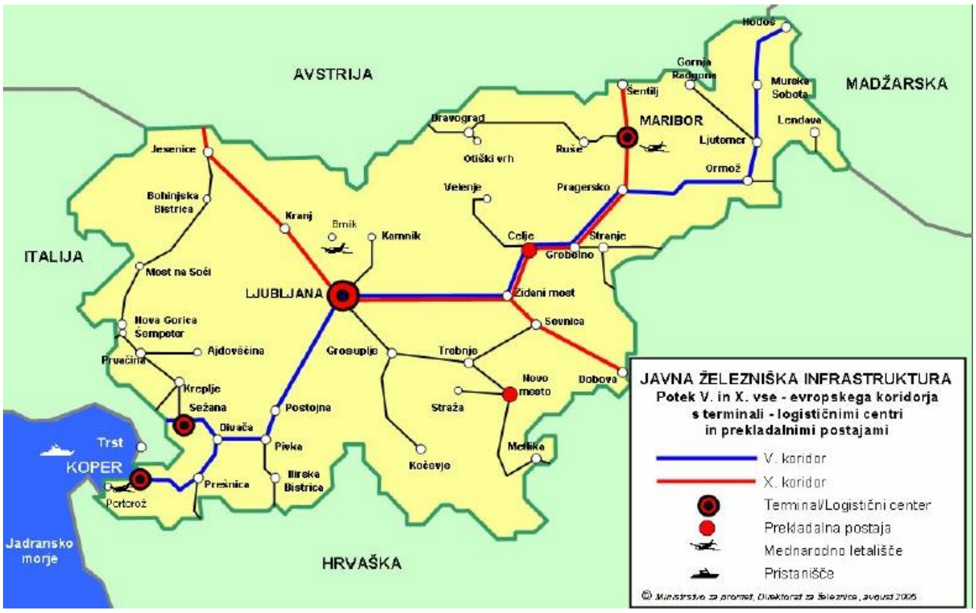

Figure 5: V. and X. corridor in Slovenia

Source: (Ministrstvo za infrastrukturo in prostor, 2005)

2.2 TEN-T Network

Pan-European Corridors are an integral part of the Trans-European Network for Transport (TEN-T), which provides guidelines for building a network of transport links including road, rail, and intermodal transport, and inland and sea waterways, with ports and airports. The main objectives of the TEN-T network are *(adopted to Godec & Jurše, 2010)*:

- Sustainable mobility of goods and people between European Union member states and neighbouring countries.
- Construction of missing links on main transport routes of the network.
- Elimination of bottlenecks to provide greater freight flow and people mobility in the network.
- Increased safety and reliability of transport.
- Freight shifting from road to the rail network and on inland waterways.

The main goal of TEN-T project is to improve network operability and productivity and strengthening the economic, social, and territorial powers of the European continent.

2.3 Road and rail transport in Slovenia

Traffic has a significant impact on the development of each country. This is also true for Slovenia. Corridors that are crossing the country bring together large amounts of freight. However, due to poor transport connections freight moves forward much more slowly than desired. Because of that, the road and rail network improvement is necessary. Otherwise freight flows might bypass the country. In this scenario, the country would lose a large part of the gross domestic product brought by transport activities.

In recent years Slovenia successfully completed the construction of the motorway network. In the last twenty years, construction and upgrading of the railway network is standing idle. European programs for sustainable mobility stress rail transport as an environmentally friendly and more powerful mode of transport compared to road transport. A comparison between road and rail transport is shown in Table 1.

Table 5: Comparison of road and rail transport

	Road transport	Rail transport
Energy consumption	Large.	Energy efficient.
Emissions	High.	Environmentally friendly.
Weather dependency	Yes.	No.
Safety	Rather low.	Quite high.
Spatial intervention	Construction on agricultural land.	Construction at the edge of the valley.

Source: (Jakomin, L., Zelenika, R. & Medeot, M., 2002)

Most freight comes into Slovenia through the port of Luka Koper. Freight is then distributed from there on to the end users through road and rail links. Delays on the rail network occur due to high saturation on the one and only railway track to and from the port. Therefore, cargo owners prefer to use road transport, which is faster and more efficient, but on the other hand, environmentally unfriendly. Because of increased use of the motorway, which connects the port with the hinterland, congestion on the motorway caused by increased use of heavy-goods vehicles is frequent.

The capacity of the existing single-track rail line, providing both freight and passenger traffic, to and from port is insufficient. As a result, freight stays in the port longer than desired, because the carriage of passengers has the right of way to the freight transport. At the same time the single electrified track between Koper and Divača is covered with problems which contribute to greater use of road transport *(Godec & Jurše, 2010)*:

- Uncertain and unreliable provision of traction power supply.
- Small line capacity according to rail transport demand.

- Overloading of line.
- Bottlenecks as a result of the combination of freight and passenger transport on the same route.
- Insufficient exploitation of the line.
- Longer transport time due to steep and long climbs (slope between 25 and 26 ‰).
- Shorter train sets due to steep climbs.
- Requirements for longer train sets because of changes in the structure of the freight on the railway.
- Organization and implementation of technical measures of traction required by track utilization at peak times.
- Safety problems (forest fires).

For a long time, the Slovenian government has been discussing the construction of the second track that would link the port with the hinterland because of problems that occur on the existing route. The second railway track would enable higher throughput, shorter travel time of goods, environmentally friendly transport, shifting of large amounts of freight from road to railroad, increased traffic safety, etc. *(Godec & Jurše, 2010).*

3 SECOND RAILWAY TRACK KOPER - DIVAČA

The rail section Koper - Divača is part of the railway axis Lyon - Trieste - Divača - Ljubljana - Budapest - Ukrainian border, which is defined as the 6th priority project of the European Union in the field of designing TEN-T network.

The development of port of Luka Koper and its promotion over the years has contributed to attracting and increasing freight flows. Increased freight flow established the need for further distribution of goods by road and rail which causes traffic jams and non-fluent distribution of cargo. Those are just a few reasons why there is a need for building the second railway track Koper - Divača. The track is situated in the region of Primorska and includes next cadastral units: Ocizla, Draga, Hrpelje, Lokev, Divača Plavje, Škofije, Dekani, Črni Kal, Rožar, Tinjan, Gabrovica, Osp and Bertoki (Figure 2). The total length of the new line would be 27.101 km, of which the longest sections, 20.322 km, would be built underground. The line would include eight tunnels and three viaducts, which would allow trains to achieve a maximum speed of 160 km/h *(Godec & Jurše, 2010).*

Figure 6: Track of the second railway line Koper - Divača

Source: (Stergar, A., 2012)

The second railway track would allow separate distribution of goods and increased rail safety. Moreover, it would increase the throughput and the fluidity of rail vehicles and related quantities of cargo. Increased capacity would also divert freight from road to rail and in this way contribute to a minor impact of pollution on the environment.

The second railway track combined with the existing railway track would provide more freight and passenger capacity, which has essential importance for the country. The demand for rail transport is so great that even the modernization of the existing line would not be sufficient to provide enough capacity. Table 2 presents throughput and transport capacity of the existing line, of possible modernization of existing line, and of new railway track.

Table 6: Throughput and transport capacity of railway track between Divača and Koper

Capacity	Existing railway track	Modernization of the existing railway track	New railway track
Throughput	72 trains per day	102 trains per day	129 trains per day
Transportability	9,2 mil net tonnes per year	14,2 mil net tonnes per year	27,48 mil net tonnes per year

Source: (Godec, A. and Jurše L., 2010)

4 FREIGHT PIPELINES

Because the outlined course of the second rail line is mostly designed through tunnels and viaducts a transport pipeline could be used instead. Projects of using pipelines for transporting various freight types and not only liquid freight are receiving much attention today. Various studies indicate that freight pipelines bring more advantages than disadvantages both for users and the environment *(Howgego & Roe, 1998)*. The advantages and disadvantages of transport by pipeline are shown in Table 3.

Table 3: Advantages and disadvantages of pipeline transport

ADVANTAGES	DISADVANTAGES
Relatively fast transport of large quantities of cargo.	High initial investment.
Low transport costs.	Aboveground pipelines spoil the appearance of the environment and increase the possibility of sabotage.
Safe, negligible risks of loss and damage of goods in transit.	Inflexible transportation route.
Cheap power energy.	Limited flexibility in transport, mainly in one direction.
Independent of weather and seasonal effects.	Not suitable for small amounts of freight.
No external effects on the environment.	A limited set of freight for transport.
Long life and low-cost maintenance.	Expensive control on operational safety.
The possibility of remote monitoring and control of transport.	Highly qualified workforce is required.

Source: (Jakomin, L. et all, 2002)

The ideas of introducing the different types of transport pipelines are very vivid today as people are becoming increasingly aware of the importance of a rapid and environmentally-friendly mode of transport. Transport pipelines would greatly reduce the number of road transport vehicles and thus relieve the roads, lower the number of traffic jams and accidents and decrease air pollution generated by exhaust fumes and noise. Fuel consumption would also be reduced, because pipelines use electricity to propel the transport substrate. Because of advanced technology, electricity would be acquired from renewable energy sources such as solar and wind power. By using the transport pipelines, delivery time should be announced even more precisely and thus further lead to a reduction of transport costs. In any event, the introduction of transport pipelines which connect ports with distribution centres in the hinterland as well as for the distribution of goods in urban areas makes sense, because it brings a lot of advantages that certainly outweigh the disadvantages of such a system.

4.1 Cargo Cap

Cargo Cap is a transportation system which uses special cargo capsules for the transport of freight that was invented by the German professor Dr. Dietrich Stein. It is an alternative to conventional transport systems - roads, railways, aviation and maritime routes, which in a fast, flexible, competitive and environmentally-friendly mode provide the carriage of goods. The system allows the delivery of goods according to the Just In Time concept, because of its continuous operation - 24 hours, 7 days a week *(Cargo Cap, 2013)*.

Figure 7: Cargo Cap capsule

Source: (Cargo Cap, 2013)

The technology consists of two parts: pipeline and capsule. The base is a capsule, which represents each individual and intelligent vehicle about the size of two Euro pallets. Each capsule has a built-in electro-motor, which drives the capsule with a maximum speed of 36 km/h. In addition, each capsule is also equipped with RFID technology, which connects the capsule with the computer and in this way ensures the smooth flow and automated loading and unloading of cargo. The second important element is the pipeline, which represents transport infrastructure. The pipeline system is located underground, so that the transport is not affected by weather and road conditions. The diameter of the pipeline is about 2 metres due to the small size of the capsules. As a result, the cost of construction of the pipeline in comparison with other transport sectors is very low (Table 4).

Table 7: Construction costs for different modes of transport

	Costs:
1 km of transport pipelines (track with one tube)	3,3 million €
1 km of transport pipelines (track with two tubes)	6,4 million €
1 km of highway expansion with two lane (depending on building and housing)	10 to 30 million €
1 km of tunnel in urban area	>100 million €

Source: (Stein, D., 2011)

Cargo Cap allows freight transport based on win-win mode (environment – transport), because there is no need for big constructions sites of the system. Not only the system itself does not cover large areas but it also takes place under the surface and in this way makes it possible to exploit the area for agricultural or industrial use. In addition, Cargo Cap is powered by electric motors which are environmentally-friendly and do not generate harmful emissions, noise and dust.

Despite disadvantages that it might have, however the system still allows high-quality, flexible and reliable transport of freight. One of these disadvantages is the need for transhipment of cargo or additional manipulation operations because it has limited capacity (i.e., two pallets only). On the other hand, railways use special wagons for different freight types, and in that way they avoid additional manipulations. Another weakness of Cargo Cap is that the system is not the most appropriate modes for the transport of people. Capsules are small and travellers may suffer from feelings of anxiety.

Figure 8: Capsules for transport of passengers in pipeline

Source: (Garun, N., 2012)

4.2 Subtrans

Subtrans is a system of underground freight transport for long distances in two parallel pipes to allow transport in both directions. Special transport units or special cars with wheels for carrying ISO containers are used as means of transport. Cargo units or capsules are round on both ends and fit the pipe diameter. The core of the capsule is square to allow rapid unloading and loading (Figure 5).

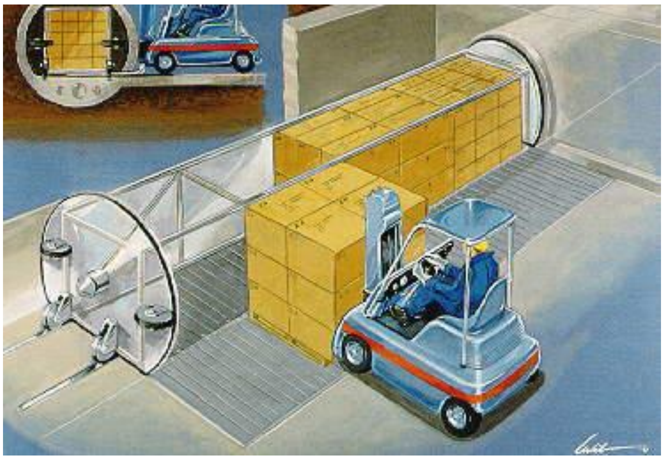

Figure 9: Subtrans capsule
Source: (Vance, L. & Mills, M.K., 1994)

The capsules are designed to accommodate up to four standard Euro pallets. There are also capsules for transporting bulk cargo. These transport capsules allow loading from the top. When full, the top cover closes and the transport process is ready to begin. The problem occurs at the unloading site because the capsules can only be unloaded from the top in an open area with cranes.

The Subtrans system is fully automated and provides operating speeds up to 100 km/h, which delivers maximum throughput to 1,875 capsules per hour, which is about 16,500 t/h *(Vance & Mills, 1994)*. Such a system also enables direct transport of standard containers (ISO). Before containers enter the pipeline they are equipped with special cars with wheels. This represents one unit which then travels along the pipeline (Figure 6). At the final destination the wheels on the container are removed and the container can continue its journey by other transport modes. This mode of transport allows rapid movements, because there is no need for additional manipulation operations.

.

Figure 10: Containers on cars with wheels

Source: (Vance, L. & Mills, M.K., 1994)

5 COMPARISON: SECOND RAILWAY TRACK VS FREIGHT PIPELINE

The second railway track is not only a need but essentially necessary for a further development of the port of Luka Koper. Consequently, the second railway track is marked as a priority in all important government documents (i.e., White Paper on Transport Policy). Despite the necessity of a second rail track, we need to take into account other technologies that have been developed in the last decades and have become a major competitor to the rail system. One of these technologies is freight pipelines. Their purpose is to shorten delivery times and reduce environmental pollution. The system is widely used in Dutch ports but the idea is rapidly expanding around the world (for example Foodtubes in London, in the USA the connection between the east and west coast etc.). A comparison between freight pipelines and the railway system is presented in Table 5.

Table 8: Comparison between using freight pipeline and railway system on the second line Divača-Koper

	FREIGHT PIPELINES	RAILWAY SYSTEM
Velocity	36 – 100 km/h.	Max. 160 km/h.
Reliability	Very reliable.	Quite reliable.
Ecology	Eco – friendly transport.	Quite eco-friendly.
Construction	Ecological building.	No control.
Limitation	2 pallets in one capsule (2 tons) or one ISO container.	Axle loads.
Engines	Each capsule has an electric motor.	Electric locomotive for each train set.
Control	RFID control.	No control.
Additional manipulation	Necessary.	Necessary.
Maintenance	As needed.	Regular.

Source: (adopted to Stein, D., 2011 & Godec, A. & Jurše, L., 2010)

Speed is one of the main current drawbacks of freight pipelines. Currently, capsules reach the speed of 36 km/h, which is very low compared to the railway system (which would allow speed to 160 km/h), but on the other hand a lot higher than the average speed of trucks bound for the city. However, there are already studies for freight pipeline systems where capsules would reach speed up to 300 km/h with a help of maglev technology *(Garun, 2012).*

Another characteristic for comparison is reliability. Freight pipelines are more reliable than the railway because they are equipped with RFID system, which enables better control and therefore simple anticipation of time of arrival at the end destination (JIT concept). The system is also more reliable than the railway because it has automatic loading and unloading of cargo. But on the other hand, when using the transport pipelines it is necessary to use additional manipulation operations for the transhipment of freight into transport capsules.

Freight pipelines have aerodynamically shaped transport units named capsules which are capable to carrying two pallets. This helps to reduce the cost of construction because the required diameter of pipeline is 2 metres. In fact, because of size, pipelines require less excavation and material for the construction of the network itself. Moreover, the company CargoCap developed a special building system under the surface named "pipe jacking" which is eco-friendly and fast (15 – 20 meters of pipeline per day). Since the route of the second track mostly (70%) takes place underground, the railway is not the best competitor. It is already known that the construction of large railway tunnels and the layout of the railway track runs very slowly, up to 10 metres per day.

A freight pipeline is great system for frequent conveyance of goods on pallets, but it requires additional manipulation operations which usually present extra costs. This can be a negative aspect because it takes time and more labour. But on the other hand, it is a positive aspect because it creates the need for new intermodal terminals which increases the multiplication factor in the development of the region (new jobs, the arrival of new trade flows, etc.).

One of the main reasons of comparison between freight pipeline and railway system is limitations. The transport unit of freight pipeline has a capacity limitation of 2 pallets. Another limitation is also that the capsules are not appropriate for transporting bulk and liquid cargoes. Meanwhile axle loads are the only railway limitations, which depend on different types of railway cars and railway capacity.

The European Union encourages countries to use environmental friendly modes of transport. Therefore, one of the important advantages of freight pipelines is the use of electric engines. These engines are eco-friendly and almost maintenance free. And even the electric power for this network could be produced by alternative way, by wind or solar power. On the other hand, the railway network needs the electrification of full railway track, which is very expensive, and needs regular maintenance.

6 CONCLUSION

The current railway line Koper – Divača is the main line of the railway infrastructure in Slovenia, but it does not meet today's traffic demands. Moreover, it represents a bottleneck in the Slovenian railway network. In order to provide required capacity, continuous transport, and shorter running times, the construction of the second track is a necessity. The second track is also essential for the further development of the port, since the proportion of cargo entering or leaving the port of Luka Koper by rail track exceeds 70 % *(Godec & Jurše, 2010)*. This is often one of the reasons that port has to refuse freight because it cannot guarantee that it would be delivered to the railway on time. Shifting freight from road to rail is also one of the key objectives of European Union transport policy.

Despite the necessity of a second rail track, we need to take into account other technologies that have been developed in the last decades and have become a major competitor to the rail system. One of them is different systems of freight pipelines, such as Cargo Cap and Subtrans. These two systems are the most promising technologies and a big competitor to the railway, because they enable quick and continuous cargo flow underground.

In the future it can be expected that freight pipelines will partly replace rail and road links and thus relive road and railway networks. Because such pipelines would be placed underground, degradation of the environment would be lower than today. It is true, however, that the current system with a cargo capsules might have certain drawbacks, which at this point outweigh all of its advantages. Being in its infancy, that kind of freight transport is expected to continue to evolve in the future.

It is difficult to predict whether the transport pipeline would be an appropriate alternative to the second rail track Koper - Divača, but it is wise to think in this direction, because a transport pipeline would allow quick transfer of large amounts of freight. With the development of the port of Luka Koper and transport corridors the quantity of freight that travels through Slovenia will probably continue to grow. However, if the transport network does not develop and there is no competition, trade flows would also change their direction to more efficient transport networks because today customers require delivery according to the JIT system.

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REVIEW OF FACTORS INFLUENCING AIRPORT COMPETITVENESS IN THE REGION: THE CASE OF JOŽE PUČNIK AIRPORT

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ABSTRACT

After the decline of air passenger transport in EU market in the year of 2009, last three years have been in sign of recuperation and the numbers have steadily been on the rise again. Although neighboring countries with their airports also recorded increase in numbers of transported passengers, Slovenian Jože Pučnik Ljubljana Airport recorded the opposite situation. In fact it recorded a 1.7% decrease of transported passengers in the last year.
When more than one airport is located on a relatively small geographical area their catchment areas often overlap each other creating competitiveness between these airports.
This paper will present basic analysis of elements influencing airport competitiveness in the multi airport regions and evaluate competitiveness of Jože Pučnik Airport using Airport competitiveness index.

Keywords: Air passenger transport, airport competitiveness, airport catchment area, airport competitiveness index

1 INTRODUCTION

Deregulation of European market airports meant the beginning of open competition between airports. Before the deregulation most countries owned their airports. Airlines operating at those airports in most cases had monopoly over the routes between countries which were formed via bilateral agreements. System of bilateral agreements where a route was normally served by only one airline per county was in place since Chicago conference which took place in 1944.

As there was no competition among airlines operating at most airports the airlines were free to set the prices as they seemed fit causing high fares, high cost and low productivity (Barrett, 2000), on the other hand deregulation of markets brought up to 70% decrease in fares on some routes by low-cost carriers.

However not only airlines were the ones facing competition. The airports were suddenly exposed to open competition and it soon became clear that airport competitiveness will be a major factor in determining the airport's strength on deregulated market.

In order to be able to evaluate the competitiveness or to evaluate the position of the airport on the open market it is necessary to determine the airport's catchment area and evaluate the factors that determine the size of its catchment area.

In this paper only the basic method of determining the catchment area will be mentioned, and the competitiveness of Airport Jože Pučnik Ljubljana will be evaluated through the use of airport competitiveness index method.

2 JOŽE PUČNIK AIRPORT

Jože Pučnik airport is the only Slovenian airport with regular international passenger lines. It is located about 25km northwest of Slovenian capital Ljubljana. In terms of total passenger volume in the year 2012 total passenger volume reached 1.198.911 passengers and 35.019 aircraft movements. The airport was officially opened on 1963.

At the moment there are 7 international airline operators offering flights at Jože Pučnik airport serving all together 26 destinations (majority being served by Adria Airways, which is the only national airline), with a single 3.300m long runway in direction 31/13 currently operating on one passenger terminal.

Last three years have been in sign of European passenger transport recuperating from the world-wide crisis and passenger numbers have gradually started to rise. As previously mentioned Slovenia through Jože Pučnik Airport did not follow that trend, even more the number of total transported passengers declined in the last 4 years. Passenger number variations can be seen in table 1.

Table 9: passenger movement at Jože Pučnik airport Ljubljana (LJU) for period between 2007 - 2011

	2007	2008	2009	2010	2011
Passengers	1.524.028	1.673.050	1.433.855	1.388.651	1.369.485
Public traffic	1.515.839	1.662.913	1.426.562	1.382.672	1.359.163
-domestic carriers	1.082.291	1.246.638	1.086.236	1.074.697	997.827
-foreign carriers	433.548	416.275	340.326	307.975	361.336
General aviation**	7.749	9.565	6.152	5.572	5.357
-domestic carriers	4.337	4.794	3.189	2.704	2.637
-foreign carriers	3.412	4.771	2.963	2.868	2.720
Other***	440	572	1.141	407	4.965

Source: http://www.lju-airport.si/eng/about-the-company/traffic-figures

Economic crisis hit Slovenia in 2009 and the effects can be clearly seen in passenger numbers from then on. It is expected that trend will be overturned in next few years providing proper measures will be put in place to help Slovenian economy.

3 JOŽE PUČNIK AIRPORT CATCHMENT AREA

Catchment area in essence is described by a geographical area within which there is a great probability that most of the passengers will choose the local airport (Strobach, 2006), however not rarely the catchment areas of airports are overlapping thus creating the effect of competitiveness among those airports. Therefore it is no longer clear which airport a passenger will choose since now he/she has a choice. The airports are in this case sharing the market or at least a part of it.

Standard simplified method of determining the airports catchment area is by determining the distance a car travels in two hours and then forming a concentric circle around airport at that distance. A slightly improved method is actual distance measured by 2h drive by car in any given direction thus creating non-equidistant area (fig.1).

Figure 12: Airport Ljubljana catchment area

Source: http://www.therouteshop.com/ljubljana-airport/images/ljubljana-catchment-large.png

For basic analysis this estimation suffices however for any more detailed evaluation a thorough research in passengers' origin is required to determine the real geographical market. At this point it is necessary to point out that airport´s catchment area is not a static matter, since the size varies in time, according to the type of the passenger, type of trip taken, change in services at the airport, access time and access cost to the airport and so on….

According to such simplified spatial analysis Airport Ljubljana has about 4 million potential passengers, not taking into consideration the neighboring airports.

There are several airports in the geographical vicinity for which we can safely assume that they share Airport Ljubljana catchment area. Those airports are Friuli Venezia Giulia Trst (TRS), Marco Polo airport Venezia (VCE) and airport Treviso (TSF). At similar distances also airport Maribor (BMX), airport Zagreb (ZAG) an airport Pula (PUY) can be found. We can safely assume that some of the fore mentioned airports share catchment area with airport Jože Pučnik Ljubljana however it faces the strongest competition from airports TRS and VCE.

Figure 13: Location and driving distance between airports LJU, FVG and VCE

Source: adapted from http://www.cei.int/content/adria-accessibility-and-development-re-launch-inner-adriatic-area

These three airports are located less than 3 hours car drive apart (LJU – TRS 1h38m, TRS – VCE 1h11m and LJU – VCE 2h40m) so it is safe to say that in most part no one of these airports has a unique catchment area.

4 COMPETITIVENESS INDEX EVALUATION FOR JOŽE PUČNIK AIRPORT

Airport competitiveness index is an index introduced by Grancay (2009) for evaluating airports according to their competitiveness level. Using certain indicators author suggested a competitiveness index assembled of index of Market potential, index of infrastructure, index of airport charges and index of previous results. Airport competitiveness index therefore presents an average of four indices multiplied by safety coefficient:

$$ACI = 0.25 * SAF * (I_m + I_i + I_{ch} + I_t) \qquad (1)$$

Each of the partial indexes has a number of indicators which serve in purpose of evaluating the index. Indicators are presented in table 2 where each index can have a maximum value of 1.

Table 10: Table of indicators for determining airport competitiveness index

Indicator	abbr.	Low value	High value
MARKET POTENTIAL			
Metropolitan area population	POP	0	3.000.000
Country GDP	GDP	0 USD	35.000 USD
Destination popularity	TRS	Neutral	Popular
Hub	HUB	Network carrier	None
Air transport liberalization	LIB	none	Both EU +US
INFRASTRUCTURE			
Road infrastructure	RDS	Poor	Developed
Public transportation system	PTS	Poor	Developed
departure delays	DEL	100%	0%
CHARGES			
Airport charges (per B737-800)	CHA	5000 USD	0 USD
Existence of curfews	CUR	Yes	No
RECENT TRAFFIC RESULTS			
Pax growth in the last 5 years	PAX	-100%	100%
Number of airlines currently serving airport	ARL	0	20
Number of destinations served	DES	0	200
SAFETY	SAF	Alert	Sustainable

Source 1: Grancay, 2009

4.1 Index of market potential

One of the most important parts of the index is determining airports market potential. As stated in the previous chapters market potential can be determined by its catchment area and the population residing in that area. By some estimates Jože Pučnik airport (LJU) has four million potential passengers in the catchment area which is comprised of Slovenia, South

Austria, North-East Italy and North-West Croatia. Even though we feel that this estimate is exaggerated the index sets the limit to three million for the highest mark.

The index also includes the country's GDP per capita. In 2012 Slovenian GDP per capita was equal to 17.244€ (roughly 22400$). Since the index sets the highest score to 35.000USD, on a scale from 0 to 1 we hit value of 0.64.

Third indicator within index of market potential takes into consideration the attractiveness of the destination. Value of this indicator is assessed according to popularity of tourism destinations in the region and since there are no top 50 world attractions in Slovenia this part of index is valued at 0 points.

Next indicator is a HUB indicator and it assesses the type of traffic on the airport. Airports that serve as HUBs get the highest score 1, while strong LCC presence at airport gets a score of 0.7 and airports that don't serve as HUBs or don't have LCCs are ranked at 0. According to this scale LJU gets a score of 0.7.

And the last indicator is an Air transport liberalization indicator. Since Slovenia is a part of deregulated European market thus LJU gets the highest score 1.

Through these indicators an Index of market potential is calculated using following formula:

$$\mathrm{I}_m = 0.2 * (POP + GDP + TRS + HUB + LIB) = 0.2 * (1 + 0.64 + 0 + 0.7 + 1) = 0.668 \quad (2)$$

4.2 Index of infrastructure

This index consists of three parts, development of road infrastructure (RDS), which connects the airport with the city, public transportation system (PTS) and delays (DEL) indicating the share of delayed flights.

LJU airport is connected to the nearby cities via highway therefore it scores a value of 1.

Unfortunately there is almost no existence of regular public transport with the exception of occasional bus service. For this LJU only gets a score of 0.25.

According to flightstats.com airliners operating at LJU airport have over 95% on-time flights so it scores value 1.

This index is calculated through the following formula:

$$\mathrm{I}_i = 1/3 * (RDS + PTS + DEL) = 1/3 * (1 + 0.25 + 1) = 0.75 \quad (3)$$

4.3 Index of airport charges

This index is composed of only two parts, first part is airport charges (CHA) applicable to a B737 with 189 seats and second part is curfews (CUR). If airport has a policy of no night flights during certain hours the value of this index is 0 and if charges go over 5000USD the value of CHA index is 0. At this point it is necessary to point out that the index was first introduced in 2009 so this value should be revised to more accurately show the true value of this indicator. For our purposes we will keep the original value therefore with charges exceeding 5000USD it is valued at 0.

Calculation is as follows:

$$\mathrm{I}_{ch} = 0.5 * (CHA + CUR) = 0.5 * (0 + 0) = 0 \quad (4)$$

4.4 Index of previous results

This part of the index includes three indicators. First indicator evaluates the trend of passenger transport (PAX). Value of PAX is 0 provided that in the last 5 years passenger trend was negative. As we concluded in the second chapter passenger numbers have been falling in the last few years hence the value of PAX for LJU airport is 0.

Second part of this index is ARL, indicating the number of airlines operating from/to airport. If number is greater than 20 airlines than ARL is 1. Since at LJU airport at the moment only 7 airlines operate at the airport value of ARL is 0.35.

The last part (DES) represents the number of destinations served by an airport and the limit for value 1 was set at 200 destinations. Airport Ljubljana only serves 26destinations therefore value of DES equals 0.13 and the calculation for index of previous results equals:

$$\mathrm{I}_t = 1/3*(PAX + ARL + DES) = 1/3*(0 + 0.35 + 0.13) = 0.16 \tag{5}$$

4.5 Index of safety

According to the Fund for peace organization Slovenia is classified into a list of ″Very stable″ countries and so deserves a score of 1.

4.6 Final evaluation of ACI for airport LJU

Combining all of the partial indexes into Airport competitiveness index bring us to following:

$$ACI = 0.25*SAF*(I_m + I_i + I_{ch} + I_t) = 0.25*1*(0.668 + 0.75 + 0 + 0.16) = 0.395 \tag{6}$$

The total score of ACI for Jože Pučnik Airport competitiveness index equals 0,395. In comparison to some of the biggest airports of the world like Singapore (ACI = 0.85), New York JFK (ACI = 0.85), London LGW (ACI = 0.69), Munich (MUC) (ACI = 0.63), which were determined by the author of ACI index, airport LJU is classified rather low on the ACI scale.

5 CONCLUSIONS

Airport competitiveness index evaluation of Jože Pučnik airport shows us that there is room for improvement in order to become more competitive on a global scale and also offers us a review of some indicators that form a competitive strength of a certain airport. At this point it is necessary to note that even more important than comparing ACI index to the rest of the world airports, airport LJU should be compared to local airports which are in direct competition within their joint catchment area like Airport Marco Polo Venezia and Airport Friuli Venezia Giulia Trieste. Using same methodology on Airport Marco Polo Venice it scores a result of 0.725 and Airport Friuli Venezia Giulia Trieste scores 0.44. Therefore we can safely conclude that the score of 0.395 reached by Jože Pučnik airport (LJU) puts it side by side with airport Trieste (TRS), but way behind airport Venice (VCE).

Due to its development, geographical position and vicinity to one of the world most known tourist destinations Venice airport gets much higher score that both other airports. The proximity of Ljubljana airport to Trieste airport and very similar score they reach make it so much more important to be aware of the competition these two airports insert to each other.

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PROBLEMS AT DETERMINING PRICE ELASTICITY OF DEMAND FOR BUS TRANSPORT IN WIDER AREA OF LJUBLJANA

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ABSTRACT

Public transport demand can be influenced in many ways, one of them being the price of travel. As fares increase, demand for transport service tends to drop. The phenomenon is described in a form of elasticity which in effect describes the ratio to which a change in price, effects the change in demand.
Recently a series of changes has been made to Ljubljana public bus transport service in a form of pre-pay tickets and implementation of zone travel.
This paper investigates the probable effects of these changes on demand for public bus transport in wider region of Ljubljana.

Keywords: Public transport, Transport demand, Demand elasticity, Fares

1 INTRODUCTION

Price sensitivity of demand is often measured as elasticity, where elasticity is defined as percentage change in demand at 1% price change. Demand for bus transport can be defined as a subset of public transport demand and refers to amount of travel by bus people would choose to take in certain conditions. Therefore it is safe to assume that increase in bus fares would have a negative effect on bus transport demand, which would in effect cause a mobility decline or even a partial modal shift to less favorable transport means, such as private car travel.

This paper will contribute to better understanding of what expected effects from changes being introduced into LPP fares zone model will have on short term and long term demand for bus transport through transport demand elasticity.

2 OVERVIEW OF BUS TRANPORT DEVELOPMENT IN WIDER LJUBLJANA REGION

In previous years Slovenia has mainly invested in development of road infrastructure thus creating perfect conditions for modal shift of passengers from public transport system to private car transportation. Even more, results of such unbalanced one-modality development resulted in above average numbers in private car ownership in Slovenia. With 521 cars registered per 1000 capita in 2011 (SURS, 2013) Slovenia is in the top 10 countries in the EU by the level of motorization. That being said, we can safely assume that we need to do more to enable a mode-shift from private car back to public transport use.

Numbers of passengers using public road transport has shown a steady decrease over the years (Tab.1)

Table 1: Passenger numbers in public road transport in Slovenia for years 2006-2010

Road passenger transport, Slovenia	2006	2007	2008	2009	2010
Public road transport	37964	38532	38751	36720	34769
City road transport	93953	90654	90024	83500	82789

Source: SURS

Any large policy changes in public transportation system should be in service of reversing the negative trend that is showing in the past years and not only in service of maximizing the net profit of service providers.

2.1 Ljubljanski potniški promet - LPP

LPP is the biggest Slovenian public transport bus company servicing urban Ljubljana region bus lines. The company's beginnings reach far into previous century, but the true expansion and development of public transport in Ljubljana region began around the year 1971. In 1991 the LPP became a public enterprise and ever since it has strived in bettering the public transport service to passengers in wider urban area of Ljubljana.

Nowadays LPP services 28 inner-city lines, 33 lines connecting Ljubljana city suburbs and transports up to 200.000 passengers daily. Fore mentioned lines are being serviced by 214 buses on inner lines and further 61 buses for the rest of the lines. All of the buses are also equipped with Urbana prepay ticket system which has replaced cash fare payments on all of their lines. Urbana system (Figure 3) was initially introduced into LPP ticketing system in 2009 and has eventually entirely replaced all forms of cash payments on the buses.

Figure 1: URBANA contactless system used by LPP

Source: http://www.blog.uporabnastran.si and http://english.jhl.si/holding/urbana

Urbana tickets consist of two types of contactless cards, one being transferrable and other personal non-transferrable ticket. A passenger can credit the ticket by a certain amount through special machine called urbanomat or at specialized vendors.

In addition to regular tickets LPP also offers a series of monthly tickets which are divided into different categories like monthly school ticket (for elementary school, high school and students), monthly ticket for senior citizens, monthly discount ticket for employees of LPP, monthly adult ticket and annual ticket. Passengers using the monthly and yearly tickets may use unlimited number of rides within the zone for which their ticket is valid.

All of the tickets are time tickets where the ticket is valid for 90min from the moment the ticket has been registered into the system on the bus. In this 90min a passenger may change buses within certain zones for which his/her ticket is valid.

2.2 Zone travel

Urban region of Ljubljana covers area with over 500.000 inhabitants in central part of Slovenia and within this region LPP is the main provider of Public bus transport. LPP bus lines are sorted into 3 zones in which Urbana prepay ticket is the main mean of payment.

Depending on the number of zones a passenger travels through, the price of fare varies. Latest change in price of fares set prices to following values: when traveling in one zone the fare price is 1.20 € and passenger may travel (interchange buses) in this zone for 90min. When traveling through two zones the fare price increases to 1.60 €, and when traveling through three lines the fare price is 2.50 € (a passenger can also pay using Moneta payment system based on GSM technology).

Besides from regular tickets LPP also offers monthly tickets intended for students, adults and senior citizens, where monthly tickets cost from 20€ for student ticket, to 20-60€ for senior citizens and 37-63€ for adults. Unemployed citizens also have discounted ticket, costing them just 17€.

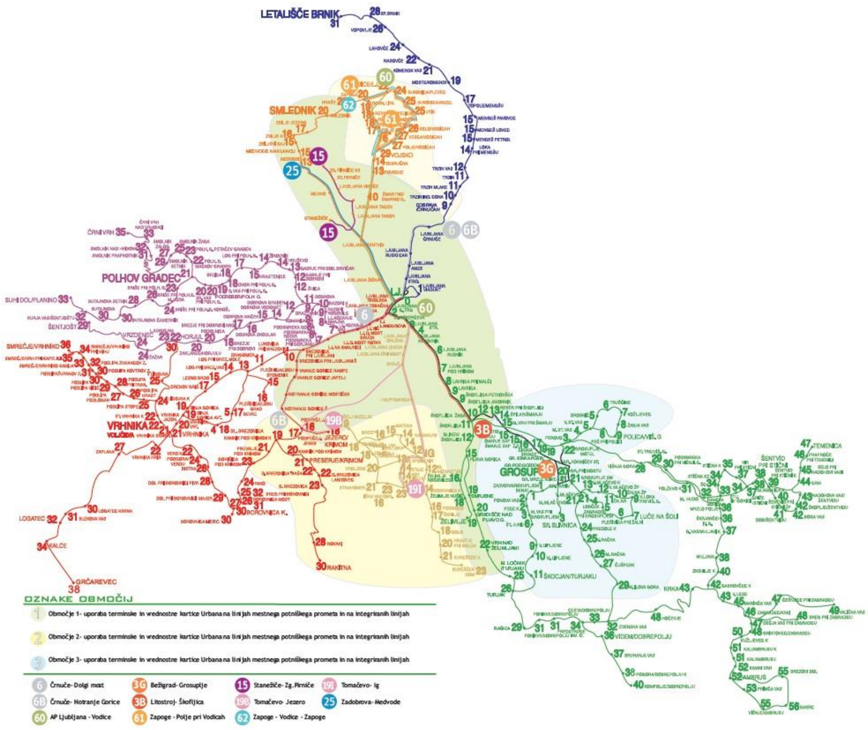

Figure 2: LPP zone travel scheme

Source: LPP web site (www.lpp.si)

It is important to take note of the situation before any change was taken to be able to determine the effects of implemented changes in the fare system of public bus transport in the wider region of Ljubljana. Main alterations to existing fare system took place on 1.1.2012, when new price list was issued. Prior to this change price of a single ticket was set to 0.8€, so the increase of price was 50%. The explanation behind this massive increase was that LPP hasn't changed the price of fare in years and also to achieve another effect, which is a transition to monthly tickets. In following section we will see that transition to monthly tickets actually increased. Similar price changes occurred also with monthly school tickets where price was previously set at 17€ and after the change at 20€ at a 17.65% increase. Regular adult monthly ticket was set at 34€ and the new price is set at 37€ at 8.82% increase.

At the beginning of 2013 LPP announced another set of changes to fare system where monthly school ticket price was separated according to the number of zones passenger would travel through. Price for one zone was 20€ and for 2 and 3 zones 40€. Last change thus far happened when current pricelist was applied on 1.2.2013. In this version the price of monthly student ticket for 2 and 3 zones was decreased to 25€.

2.3 P&R system

Important part of the cities transport policies in the world has been an introduction of park-and-ride (P&R) system, which enables passengers from sub-urban regions to acces the city bus network by traveling to the P&R facilities on the edge of the city and transferring to bus service and so proving to be succesfull in mitigating congestion and difficulty of finding parking space in the urban centers (Baohong He et all.,2012).

Similarly LPP has a P&R system in place in order to compensate for the lack of parking space in the city and to attract new passengers to use the public transport system. Currently there are two working P&R facilities included in the LPP scheme (P&R Stožice and P&R dolgi most). Car users are charged 2,4€ per day and the fare is payable by Urbana ticket which grants every user with two bus tickets. Therefore by parking at a P&R facility car user gets a daily parking and two bus tickets. This way a car user doesn't have to worry about finding a parking place in the center of the city, avoids congestion and gets two ″free″ tickets to acces the city centre and return to P&R facility.

It is known fact that closer to the center of the city you get the higher are the prices for parking. Just for example the parking at garage Kongresni trg, which is in very centre of Ljubljana, parking fee reach from 1,20€/h up to 3 hours stay to 2,40€/h for every hour longer than 3 hours of parking. Obviously the P&R system is expected to attract more and more car users just due to the fact of high prices of parking in the centre of the city.

In respect to elasticity of demand for bus transport P&R effect should be taken into consideration in order to determine to what extent P&R influences the number of passengers using bus transport.

2.4 Trends in public bus transport in wider Ljubljana region

Public passenger transport usually has a very distinctive seasonal fluctuation. Passenger numbers for Slovenia in the last five years are represented in Figure4. Specifically a major downswing in passenger numbers is notable during the summer vacations period, there we can see the decrease in the months of July and August (note that data for 2011 and 2012 differ due to new data reporting system). At the time of writing this paper only statistical data for first nine months of 2012 were available.

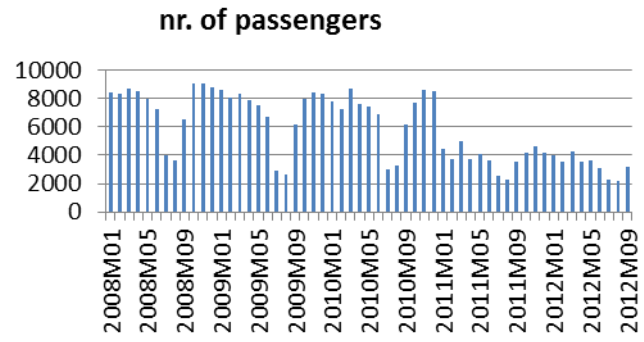

Figure 3: Public transport passenger numbers (1000) through years 2008-12 for Slovenia

Source: SURS data

Same tendencies have been recorded in the LPP passenger numbers (Figure 5), where we can also determine the decrease of passenger numbers in the year 2012. Where 41.050.121 passengers were transported in 2011 (33.088.431 in first 10 months), in the same time period of first 10 months of 2012, only 31.726.474 passengers have been transported, marking more than a 4% drop in passenger trips.

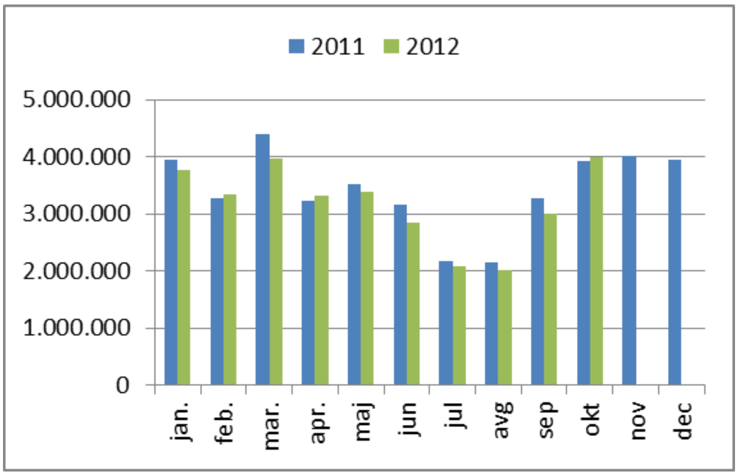

Figure 3: Total nr. of bus trips in LPP area for 2011-2012

Source: LPP internal statistic data

Further analysis shows that majority of trips in 2011 have been made using monthly tickets (21.456.429) as oposed to using prepay tickets (18.013.247), which is a 56% share. The ratio increased in 2012 where almost 61% of passenger trips were made using monthly ticket. Comparing the data from 2011 and 2012 we can make an interesting observation. Not only was there an increase in number of trips using monthly tickets, but also the amount of monthly tickets has increased considerably, for almost 23% in first ten months of 2012 after the price increase in ticket scheme which had the biggest effect on single ticket passengers (see table 2).

Table 2: Nr. of trips using monthly ticket and nr. of monthly tickets for LPP in 2011-2012

	2011		**2012**	
	nr.of trips	**nr. of mon.tickets**	**nr.of trips**	**nr. of mon.tickets**
jan.	2.195.095	42.612	2.317.972	47.305
feb.	1.605.529	34.277	1.976.577	44.925
mar.	2.491.552	42.199	2.588.756	48.846
apr.	1.734.587	36.642	2.065.171	44.744
maj	1.899.119	35.350	2.079.985	43.209
jun	1.589.658	33.509	1.705.166	40.018
jul	1.014.342	10.788	1.156.222	13.203
avg	979.544	9.791	1.091.924	12.533
sep	1.635.655	28.986	1.794.588	37.066
okt	2.046.512	38.898	2.533.615	53.116
nov	2.171.246	41.270		
dec	2.093.590	42.477		

Source: LPP internal statistic data

In order to determine probable effects of changes in price of fares with regards to demand it is necessary to look into price elasticity of demand.

3 PRICE ELASTICITY OF DEMAND

As demand or consumption is generally affected by prices any changes in price will have different effects on demand. When consumers, or in our case passengers, have no substitutes to choose from they will respond to price changes in accordance with the law of demand which states: if prices rise, demand will decline and if prices fall, demand will rise.

The same law applies to transportation demand. If fares increase mobility declines and if fares decrease, mobility increases (Litman, 2012). Operators of public transport in effort to increase their revenues use various techniques to optimize their fare models and ticket types. Knowledge of passenger response to changes is a key factor in maximizing revenue through system of fares. Hensher (2007) states, that knowledge of how various market segments respond to both the choice of the ticket type within a public transport mode and the choice between modes is crucial to the outcome.

3.1 Determining price elasticity of demand

In general we have three basic types of elasticity of demand:

- Elastic demand
- Inelastic demand, and
- Unitary demand

All three are based on relationship of price and quantity and are mathematically defined as:

$$Elasticity\ of\ demand\ (E_d) = \frac{\%\ change\ in\ quantity\ demanded\ (\Delta Q)}{\%\ change\ in\ price\ (\Delta p)} \text{ or } E_d = \frac{\%\Delta q}{\%\Delta p} \quad (1)$$

Elastic demand is defined when a small change in price causes a large change in quantity demanded. Inelastic demand causes only small change even though prices may change drastically, whereas unitary elasticity describes a situation of linear change. When price changes for x% (for example 5%), quantity demanded will also change for the same percentage (in our case 5%), therefore unitary elasticity has value of 1.

In public transportation demand shows rather inelastic tendencies. As Fouquet (2012) emphasizes the importance of distinguishing between the overall market elasticity of demand for transport and the demand facing individual modes of transport, several researches have shown that demand elasticity of bus transport with regard to fare prices valued between -0.28 in the short run and -0.55 in the long run (Litman, 2012). According to Dargay and Gately (1997), short term elasticity is regarded for up to two years and typically last about one third of long term elasticity (up to ten years).

Public transport service providers desire to optimize their services in order to maximize income and since they often resort to changes in fares policy it is also imperative to understand what effects, if any, changes in fares will cause due to price elasticity of demand.

Recent research on public transport demand (Litman, 2012) suggests that main influential factor of demand is price of travel. However this is not limited only to fare cost, but also to all other expenses within the travel chain, such as price of time spent in travel, travel liking, risk of travel... Therefore level of demand can be defined as:

$$Q_d = f\left(C_x\right), \tag{2}$$

Where Qd is demand quantity and Cx is price for unit of transport service (including all added expenses).

It is safe to assume that each change in price causes a degree of response from a user affecting his choice on the public transport usage. In this case change in price can affect frequency of travel, destination, mode of travel, transportation used (car, bicycle, walking, train…), parking location and so on.

4 ANALYSIS OF DEMAND FOR PUBLIC BUS TRANSPORT IN THE LPP AREA

Given the data of bus transport usage in the past two years and under the assumption that price elasticity of bus demand is in fact equal to the value other researchers have determined (-0,28 for short term elasticity), we wanted to determine price elasticity of demand for bus transport in wider urban region of Ljubljana.

First we needed to determine the changes in fare prices and what affect each of changes has on demand in general:

Given the fact that a great variety of different fares exist within LPP fare scheme, we have encountered insurmountable obstacle in determining the bus demand elasticity in the LPP area. Although we are aware of the levels of price change (table 3) we were unable to obtain the segmented statistical data from LPP which would enable us to determine to what extent price changes on every ticket level had on combined elasticity. Data we were able to acquire allowed us to determine the number of monthly tickets sold by months for the last two years, however to be able to determine the effect of price changes in respect to elasticity of demand we would need data for each type of monthly tickets, otherwise the predicted elasticity can only be a speculation.

Table 3: price changes for main ticket types by LPP scheme

	price before change	price after change	% change
single ticket fare	0,80 €	1,20 €	50%
monthly school ticket fare	17 €	20 €	17,65%
monthly adult ticket fare	34 €	37 €	8,82%
monthly school ticket (2 and 3 zones) fare	40 €	25 €	-37,50%

Source: adapted from LPP internal data

Demand for public bus transport can be expressed in the following manner:

$$D = nr.of\ rides\ single\ ticket + nr.of\ rides\ monthly\ ticket \tag{3}$$

Analysis shows that amount of travel by bus in 2012, when using a single ticket decreased by 25.5% with regards to the amount of travels in 2011, at the same time traveling using some form of monthly tickets decreased by about 10% even though number of monthly tickets increased by 23% with regards to same period in 2011, indicating an average passenger now takes less trips.

Table 4: Relations among ticket type and nr. of trips for 2011-2012

	nr. of trips using tickets		
	2011	2012	change in %
	14612148	10882113	25,52
	all trips	trips using tickets	share in %
2011	41050121	18013247	43,88
2012	31726474	10882113	34,29
	nr. of monthly tickets		
	2011	2012	change in %
	313052	384965	23,00
	all trips	using monthly tickets	share in %
2011	41050121	21456429	52,27
2012	31726474	19309976	60,86

Source: adapted from LPP internal data

Most of fare prices increased in 2012, except fare for monthly school ticket which decreased in price.

In Theory a 50% price change at 0.28 price elasticity should decrease consumption by 14%, where the real effect was 25.53% with regards to previous year. It is hard to say whether this is due to change in fare price or due to continuation of decrease of public passenger transport. In addition there may have been some other incentives that caused the shift from single ticket use to monthly ticket.

Similar unexpected effect is noticeable at number of passengers using monthly tickets. Prices of all monthly tickets increased. Price increase of monthly school ticket (by 17.65%) and price of monthly adult ticket (by 8.82%) should have caused a minor decrease in demand. On the other hand the price of monthly school ticket for one zone travel was decreased by 37.5%, which should have increased the demand. Statistics show that actual demand increased by 12.32%. It is safe to assume that the difference can be found in increased gravitation of passengers from using single ticket to using monthly tickets.

Given the almost 23% increase in number of monthly tickets in 2012 with regards to 2011 it is expected that in 2013 even more monthly tickets would be used.

5 CONCLUSION

One of the priorities of national transport policies is creating conditions for mode shift of passengers from private car use to public transport use. Passenger numbers of Slovenian public bus transport have been dropping gradually for the last 10 years.

Public transport service providers have different tools to attract passengers to use means of public transport, one of them being changes in price of travel. Prepay tickets, P&R systems and implementation of zone travel showed positive effects in studies all over the world. However different models have resulted in different results. Understanding the effects that price changes through price elasticity of demand have on bus transport demand can prove to be essential in bettering the public transport services.

Perhaps more effort should be directed in promoting the P&R system so that even more car users would start using it and through additional incentives alleviate even more congestion from the city center.

Based on statistical data provided by LPP, recent changes had negative effects on bus transport demand. Regrettably the data was insufficient to enable us to do the calculations of elasticity of demand ourselves and therefore analysis isn't complete.

We were also unable to explore a very important aspect which is the structure of travel by purpose and by zones which has direct effect on elasticity since expected elasticity based on purpose of travel can be very different.

Given that researchers have proven that elasticity of bus transport demand is inelastic similar effect has also been observed in the case of LPP price change. Transport policies call to passengers to migrate to public transport use however most passengers don't respond positive to such calls since they care more about their own quality of travel than about greater good.

In order to migrate from private car use passengers need positive economic push. This push can be either in a form of significant decrease in travel price by bus or other public transport means, an increase in cost of travel by private car or some other incentives directed in bringing more passengers to public transport use.

Due to the result oriented service provider we can also conclude that public transport policy makers have different views on elasticity of demand for public transport than public transport service providers. While on one side government wishes to decrease the prices of public transport the service provider wishes to increase their profits. It is important to find a proper balance within these opposite poles.

Decrease in travel price by bus can be achieved in various ways, from optimization of service operator to governmental subsidies. Each and all of them must be carefully explored and implemented in a way to assure the biggest possible quality of transport at the lowest possible prices to attract passengers to return to public transport use.

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