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European Transport Corridors and North Adriatic Ports

Helena Bínová[1], Martin Jurkovič [2]

[1]Faculty of Transportation Sciences, CTU Prague, Konviktská 20, Prague 110 00, Czech Republic
[2]Faculty of Operation and Economics of Transport and Communication, University of Zilina, Univerzitná 1, 010 26 Žilina, Slovakia

Abstract From the ports in the northern Adriatic Sea (ports of Ravenna, Venezia, Trieste, Koper, Rijeka) a route from European ports of North Sea to the Far East is shorter by about 2000 nautical miles. It means a reduction of 6 to 8 days in shipping. These ports are reachable from commercial and industrial centers of Central and Eastern Europe. An assessment of the current situation and future development of the European transport corridors North - South, including possible interconnection by multimodal corridors Baltic ports in the north and Adriatic ports in the south, is included in this paper. This corridor is one of the ten basic corridors included in the new conception of the TEN-T European transport network with the assumption of financial support from the EU in the period of 2014-2020. Further, the paper also includes an analysis of a modal assessment (Modal Split) of transport connections of Central Europe with the Far East.
The heart of the paper is a proposal of connection of chosen seaports that serve as logistics terminals to current European multimodal corridors and further to proposed multimodal corridors.

Keywords North Adriatic Ports, European transport corridors, railway, multimodal transport corridors

JEL O33; R40; R41; R42

1. Introduction

Currently, the transportation of goods is performed mostly by maritime transport. For the future, options of land transport connections i.e. railway transport are considered and assessed. This includes connection of the Far East - Europe.

The opportunity of using railway connection between Asia and Europe depends on two essential facts. The first one is an adequate railway route through Asia up to Europe, the second one are sufficient railway corridors in Europe, including strategically located and adequately capacitated public logistics centers.

The Trans-Siberian Railway is a perspective possibility of rail connection (length more than 9,000 km) between Europe and Asia. It can be considered as a supplement of maritime route. The Trans-Siberian Railway can connect all the regions concerned, which may become part of the interconnected intermodal transportation system.

In the future, it is necessary to take into account planned canal Danube - Oder - Elbe. In the case of its implementation, it will be a multifunctional water work of major importance for the Czech Republic and Europe, which will connect a system of European waterways.

2. European Transport Corridors

When planning future transport corridors, it is necessary to use the Trans-European Transport Network (TEN-T), a network of road and rail corridors, international airports and waterways, and the Pan-European multimodal transport corridors (The Pan-European Traffic Networks), as the main transport axes between the EU and the countries of Central and Eastern Europe. It means nine rail and road corridors, the tenth, no. VII, is a water corridor – the river Danube.

These development corridors are currently different from the TEN-T network, which covers all the main routes within the European Union.

The concept of electronic freight transport (e-freight) - the electronic flow of information and tracking and tracing of goods during their journey, is also important. An essential precondition is the establishment of standard interfaces within the various transport modes and their interoperability across different transport modes. The implementation of information technologies in the freight logistics is in line with the document "Freight Transport Logistics in Europe - the key to sustainable mobility" (2006).

2.1. Association NAPA - North Adriatic Ports Association NAPA - Port of Ravenna, Port of Venice, Port of Trieste, Port of Koper, Port of Rijeka

The Association of ports in the northern Adriatic Sea – the NAPA was established in March 2010, the ports of Ravenna, Venice, Trieste and Koper. In November, Port of Rijeka became a full member of the Association. The North Adriatic Ports Association (NAPA) is an association of five North Adriatic seaports: Port of Koper, Port of Ravenna, Port of Rijeka, Port of Trieste and Port of Venice.

Port of Venice - key facts
- 2,200 ha surface area
- 30 km wharves
- 31 operating berthings

- 12/14 m depth
- 205 km internal railway network
- 70 km internal road network
- 24 terminals
- 1 dedicated cruise terminal + yacht facilities

Port of Trieste - key facts

- 2,300,000 m2, of which 1,800,000 m2 are a free zone
- 425,000 m2 of OPEN storage area
- 500,000 m2 of covered storage
- 12 km of quayside
- Berths with depths up to 18 m
- More than 20 well-equipped specialised terminals capable of handling every type of cargo
- Passenger terminals located in the heart of the historic city centre

Port of Koper - The Biggest Car Terminal in the Adriatic - key facts

- 2,800,000 m2 total port area
- 247,000 m2 of enclosed warehousing
- 76,000 m2 of covered storage areas
- 900,000 m2 of OPEN storage areas
- 3,300 m of quayside
- 143,000 m3 of shore tanks
- Max sea depth: 18 m

Port of Rijeka - Modernized Port of Competitiveness and High Efficiency - key facts

- 1,500,000 m2 total port area
- 335,000m2 m2 of enclosed warehousing
- 8,652 m of quayside
- 58 berths
- Sea depth at quays: 5.5 – 28 m
- Total reloading capacity 33,000,000 t
- Oil terminal: 2 berths (max. 20.000 m3/h)
- Port passenger terminal in the historic city centre

The five NAPA seaports are located at the northern tip of Adriatic sea, a natural waterway that penetrates deep into the middle of the European continent, thus providing the cheapest naval route from the Far East via Suez to Europe with a distance that is about 2,000 Nm shorter than other North-European ports.

More than 100 million tonnes of water-borne cargo are handled in the NAPA seaports every year. The cargo consists mainly of general cargo, containers, cars, ores and minerals, fossil fuels, chemicals and others types of cargo.

Due to huge variety of logistic services and the extensive traffic network, NAPA forms a perfect multimodal gateway to the key European markets. The near-by fifth Pan-European transport corridor provides a quick-link to 500 million European consumers. Large commercial and industrial hubs like Vienna, Munich and Milan are just few hours' drive away.

The four entities combine their strengths in order to promote the Northern Adriatic route and present themselves as an alternative to the North-European ports. In addition, the association anticipates cooperation in the development of maritime and hinterland connections, visits from cruise lines, environmental protection, safety and information technology. The ports of NAPA will also invest efforts into the coordinated planning of road, rail and maritime infrastructure, as well as the harmonisation of regulations and procedures in the field of port service provision.

On the Figure 1, there is a map of the connection of ports of the NAPA to the TEN-T and Pan-European corridors.

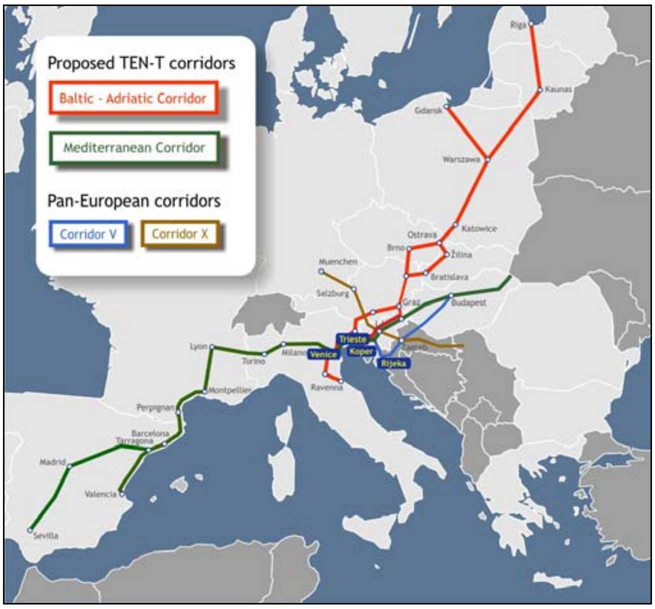

Figure 1. Connection of NAPA ports to the TEN-T and Pan-European corridors

From the ports, which are associated in the Association NAPA, the North Sea route towards the Far East (shorter by about 2,000 nautical miles, shorter navigation of 6-8 days) can also be used. The NAPA ports are easily accessible from the commercial and industrial centers of Central and Eastern Europe. The aim of the NAPA association's ports is to create significant competition from the North European ports. The maximum depth of the sea in these ports is 18 meters and ships of up to 6,500 TEUs can be dispatched there. Results of the NAPA in 2011 and 2013 of a total transhipment of cargo and container transport are shown in Table 1.

Table 1. The results of the NAPA in 2011, 2013 and 2014 of a total transhipment of cargo and container transport in comparison with other European ports

Total throughput of cargo in mil. tonnes			
Port	2011	2013	2014
Rotterdam	434,6	440,5	444,7
Antwerp	187,2	190,8	199,0
Hamburg	132,2	139,0	145,7
NAPA Ports	124,2	108,0	106,0
Marseille	88,1	80,0	78,5
Bremen	80,6	78,8	78,3

Transhipment of containers in mil. TEU

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Port	2011	2013	2014
Rotterdam	11,877	11,621	12,298
Hamburg	9,014	9,257	9,729
Antwerp	8,664	8,578	8,978
Bremen	5,916	5,831	5,796
NAPA Ports	1,8	1,6	1,8
Marseille	1,2	1,1	1,2

The important role of the NAPA for maritime transport to the Far East resulted from the first international conference on development of logistics in Central and Eastern Europe in the Austrian town of Villach (14 Dec. 2012).

2.2. The changing scenario

NAPA has been created to tackle several common issues that the ports are now facing. Changes in both the world economy (emerging economies' growing weight) and in the EU (the "eastward tilting" of the internal market) are modifying world freight routes, and will open new rooms of opportunities.

The growth of Europe-Asia trade will increase the traffic through the Suez Canal, modifying well-established routes, where Northern Range ports are nowadays handling the most part of the traffic.

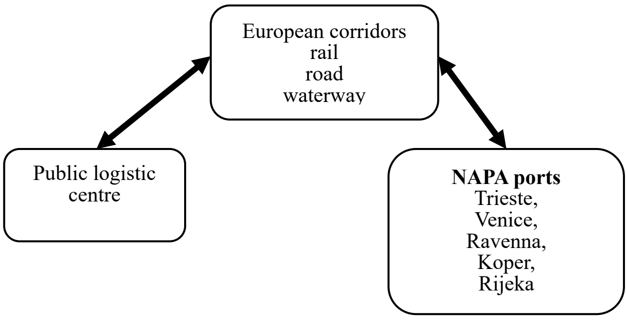

Figure 1. Scheme of connection NAPA ports to PLC and logistics terminals

The Northern Adriatic has a strategic and geographic advantage, being their closest Mediterranean seaport, but a critical mass must be achieved to cope with this challenge, and that is possible only if all the Northern Adriatic ports join their efforts.

The North Adriatic ports formally agreed to cooperate to create appropriate synergies in order:

- to have the North Adriatic ports assume the role as European logistics platform for traffic from the Far East to Europe and to and from Central and Eastern Europe;
- to promote coordinated planning of the development of road, rail, maritime, IT and telecommunications infrastructure at the service of the Northern Adriatic;

In particular, the Association promotes initiatives and actions to develop the following areas:

- tangible and intangible maritime and shore relationships with the foreland and hinterland of the ports, in order to expand their respective target markets; specific attention is given to the railway sector, seen as an essential way to improve competitiveness between port clusters as well as a key part of the sustainable development of land transport in Italy and Europe;
- cruise and passenger services;
- environmental protection and quality;
- safety and security;
- training;
- ITC services applied to the port sector.

The Association also promotes cooperation with logistics centres in their respective hinterlands.

At the logistic trade fair in Munich in 2012 an agreement was concluded between the association of NAPA and the BPA (Baltic Ports Association) in the cooperative support of implementation of a European transport corridor Adriatic - Baltic (one of ten basic corridors included in the new concept of TEN-T European transport network with the assumption of financial support from the EU for the period 2014-2020).

The ports of BPA shipped 800 million tons of cargo and 8.5 million TEUs in 2011, the ports of NAPA 124.2 million tons of cargo and 1.8 million tons of TEUs.

The port of Koper is also a member of the NAPA and its operational results are shown in the following Table 2.

Table 2. Operation results of the port of Koper in 2010, 2011 and 2012

Port of Koper			
Transhipment of cargo and containers in tons and TEU			
	2010	2011	2012
Cargo in total	1 445 631	1 383 354	1 438 833
Cargo in containers	4 276 137	5 309 346	5 292 047
Containers [TEU]	476 731	589 314	570 744

Direct sea routes to all major ports lead from the port of Koper. The Modal Split in the transportation of containers is: the railway transport up to 68 %, the road up to 32 % (according to Luka Koper Annual Report, 2011). The port of Koper is an important port for connecting with world's important seaports and European trade and industrial centers.

The basic activities performed in the Port of Koper are cargo handling and warehousing. They are conducted in 10 terminals specializing in handling and warehousing various types of goods, such as containers, general cargo, foodstuffs, light-perishable goods, livestock, RO-RO, timber, dry bulk and liquid cargoes.

Table 3. Distances from/to port of Koper

Distance in nm			
Koper - Alexandria	1.187	Koper - Malta	726
Koper – Buenos Aires	6.933	Koper - Montreal	4.824
Koper – Cape Town	6.634	Koper - Singapore	6.304
Koper - Haifa	1.359	Koper - Piraeus	835
Koper – Hong Kong	7.758	Koper - Sydney	9.584
Koper - Chicago	5.901	Koper - Vancouver	10.033

2.3. European Corridors in project A-B Landbridge

In a number of research projects other transportation corridors are examined - e.g. the European project Adriatic-Baltic Landbridge. It ran from 2006 - 2008 and a resulted in proposal of three European transport corridor areas, including related logistics centers. Three corridors of the A-B Landbridge project are shown in the Figure 4.

Figure 3. Transport corridors A-B Landbridge

The importance of these corridors is the possibility of shortening the European maritime route to the Far East by using southern European seaports and related European rail corridors in North-South direction for the collection and distribution to catching continental logistics centers.

- Western Corridor - Rostock - Berlin - Munich – Venice
- Central Corridor - Szczecin - Prague - Villach - Venice / Trieste
- Eastern Corridor - Gdansk - Ostrava - Vienna - Ljubljana-Trieste

An important aspect is the possibility of a future connection with a long-term planned project of interconnection of the waterways Danube - Oder - Elbe.

Designing of the Danube - Odra - Labe corridor takes into account the exceptional benefit of the Czech Republic area, which is the lowest point of the European water divide between the Danube and the Odra rivers (the Moravian Gate) whose length should be about 370 km at the current state of the implementation.

Waterway transport is particularly suitable:

- for transporting oversize cargo
- with regard to environmental protection
- for generating business activities along a watercourse

Multimodal transport is significant in terms of:

- interconnection of transport modes
- priority use of railways and inland waterways
- restrictions on road haulage
- environmental protection
- reduction of transport externalities
- reduction of traffic congestions

Realisation of infrastructure:

- financing
- environmental issues
- public participation
- institutional coordination

Policy issues for maritime sector:

- increasing connections with the Motorways
- coordinating planning and realisation activities with the rail sector
- planning adequate multimodal shift facilities

2.4. The possibility of connecting North Adriatic Ports by European corridors to the Trans-Siberian Railway or the Silk Road

For the opportunity of using railway connection between Asia and Europe it is necessary to assess two essential facts. The first one is a railway route through Asia up to Europe, the second one are sufficient railway corridors in Europe, including strategically located and adequately capacitated public logistics centers.

According to Eurostat statistics more than two-thirds of foreign trade in Europe in terms of value passes through seaports. It is likely that in connection with expected and by the statistics confirmed growth of container transportation, this number will grow. Cheu et al. (2013) state in their report at the conference of TRB (Transportation Research Board, Washington D.C., 13-17 January 2013), that the USA and the EU are two most important trading entities of the contemporary world. The second most important partner of the EU is China, which is also the EU's most important partner for import.

Trans-Siberian Railway - is a perspective option of rail connection (length of over 9,000 km) between Europe and Asia. It can connect all the regions concerned, which may become part of an interconnected intermodal transportation system. The company DB Schenker published in September 2011 a press release about connection Europe - China with a container train. China is also preparing a railway project, which should connect China's commercial metropolis such as Chongqing with Belgian Antwerp. This project, which is called New Silk Road or even Eurasian land bridge, should have a length of around 10,000 kilometers.

The sea route length is about 20,000 km; transportation time is 33-40 days.

The length of railway route is about 11,000 km; transportation time is 18-21 days.

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The Silk Road - first train to the Czech Republic arrived in November 2012 with fifty containers of computer components (duration 16 days). The advantage of this route, unlike the Trans-Siberian Railway, is more favorable weather conditions.

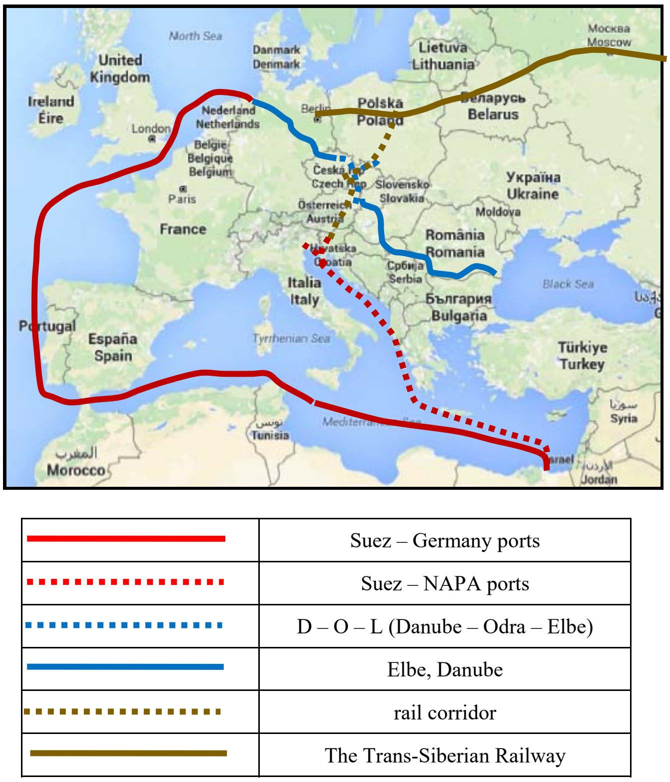

Figure 4. Comparison lengths of seaways with use the opportunity NAPA ports, D-O-L and The Trans-Siberian Railway

Assessment of the possibility of connecting the NAPA ports by using existing corridors and corridors proposed

Connection of the NAPA ports to existing European corridors is possible, but with regard to prognosis of maritime, rail and road transport. In particular with regard to the plans for reconstruction of the Trans-Siberian Railway, respectively the Silk Road we should consider connection of the NAPA ports to these corridors. It is possible to use the project "Adriatic - Baltic Landbridge" to plan these routes.

Advantages of connection of the NAPA ports:
- shorter sea route, utilization of the route Suez - the NAPA ports
- use of European corridors, and increased use of railway transport
- implementation of public logistics centers of European importance in central Europe
- interconnection of European ports with railway Europe – China
- connection to the planned corridor Danube - Oder - Elbe, thereby connecting the Black Sea and Baltic Sea

In the graph below there are logistics terminals / inland ports, seaports identified as vertices (V).

Edges H1 to Hx are represented in length, transport modes, cost associated with the individual transport modes, capacity and reliability.

For a model of selection of transport mode in the transport network of the NAPA ports - Europe – Asia - USA, it is possible to take into account several variants of cargo transport.
- sea route via the Suez Canal – NAPA ports,
- sea route via the Suez Canal – Germany ports,
- NAPA ports – European Transport corridors - The Trans-Siberian Railway
- NAPA ports – European Transport corridors – D-O-L-inland waterway

There can be constructed a matrix of distances and transport modes for individual edges. In this graph, the transport network direct distance between individual vertices cannot be counted because these connections currently do not have adequate transport infrastructure.

Such transport network can be expressed mathematically as:

***D* = (*U*, *V*, *H*, *d*)**

where

***U* ……..** a set of vertices (nodes) in the starting area,

***V* ……..** a set of vertices (nodes) in the target areas,

***H* ……..** set of segments (edges),

***d* ……..** evaluation and choosing of transport modes of edges.

Individual edges can be implemented by several transport modes.

The solution is to search:
- the shortest (minimum) routes;
- the most reliable routes (routes in meeting the date of delivery);
- routes with highest (maximum) capacity;
- the fastest routes (excluding direct air transport);
- the cheapest routes;
- routes with minimal cost of transporting of excess goods.

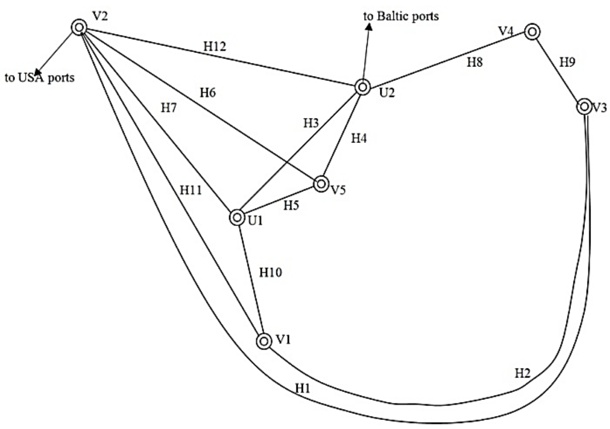

Figure 5. Graph of transport network of the NAPA ports – European Transport Corridors

V1……... NAPA ports
V2……... Germany ports
V3……... Shanghai
V4……... Vladivostok
V5………D-O-L
U1……... public logistic centre - Czech Republic
U2……... public logistic centre - Poland
H1……... seeway Europa (Germany ports) - China
H2………seeway Europa (NAPA ports) - China
H3……..._The Trans-Siberian Railway
H4……... D-O-L – PLC Poland
H5……... D-O-L – PLC Czech Republic
H6……... Germany ports - D-O-L
H7……... Germany ports – PLC Czech Republic
H8……... Vladivostok - PLC Poland
H9……... Shanghai – Vladivostok
H10……. NAPA ports - PLC Czech Republic
H11……. NAPA ports - Germany ports
H12……. Germany ports – PLC Poland

3. Assessment of individual risks when choosing options

The highest-risk factors:
- exceeding the investment costs
- implied investment costs
- failure to keep the design parameters
- failure to keep timetable of the construction
- no funding
- disapproval of the public
- demanding geographical circumstances;
- unresolved property circumstances;
- environmental protection
- rate of return
- coordination between individual states
- change of climatic circumstances

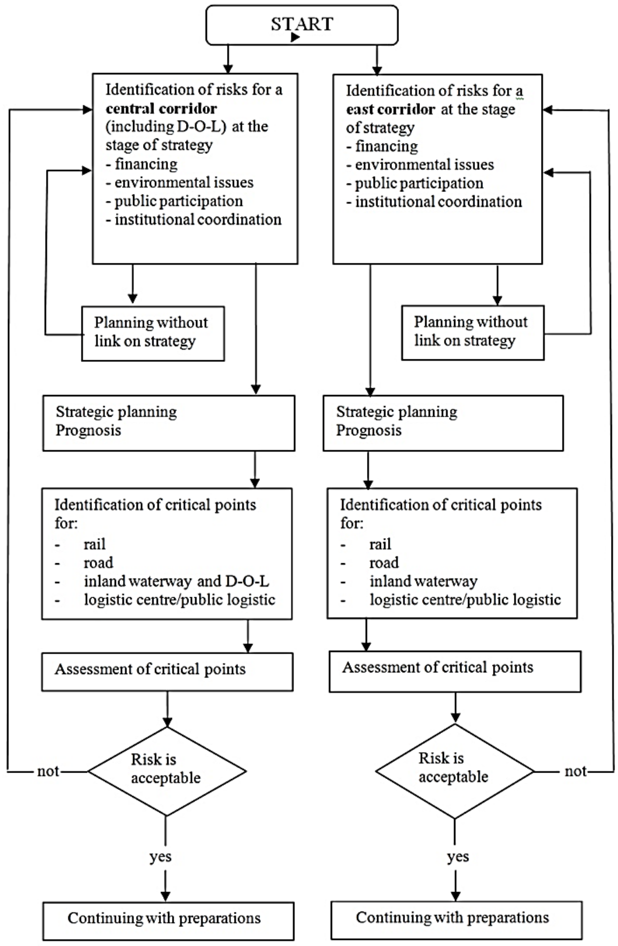

Figure 6. Risk assessment model

Crucial criteria for finding an optimal route are ordered by relevance as follows:
– transportation costs (in synergy with investment costs
– transportation time,
– transport reliability,
– transport safety,
– security measures to prevent illegal acts

Nowadays placed demands are on delivery times (e.g. in the automotive industry). It is even to expense of higher transport costs, respectively of lower reliability.

Table 4. Mathematical models of weights of criteria

Criterion	Importance/weight	Criterion name
K	Maximal	transportation costs
k – 1	…………	transportation time
k – 2	…………	transport reliability
1	Minimal	transport safety

It is necessary to determine:
– a set of criteria (criteria, wherein the higher values are preferred to lower)
– criteria weights (with using expert methods)
– sample Criteria

It is also necessary:

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– to assess results achieved (during the evaluation a reassessment of the weights of individual criteria or modifying of options, or extending number of variants can occur
– to assess risk - through risk analysis
– to assess and determine an optimal variant, to determine order of different options

When using a multi-criteria evaluation method the weight of individual criteria can be expressed through the vector of weights of criteria:

$$v = (v_1, v_2, \dots, v_x); \sum_{n=1}^{x} v_1 = 1; \quad v_1 \geq 0$$

4. Conclusions

In the recent past the Suez Canal has been a problematic point, so-called "bottleneck". After the recent expansion and increasing the capacity of the canal it changed the situation. Use frequently some of ports in the Adriatic and their well-capacitated connection to existing transport corridors of the TEN-T, of the Pan-European multimodal transport corridors (The Pan-European Traffic Networks) and the Trans-Siberian Railway came again to the fore.

The use of other multimodal transportation corridors that are prepared in the European area depends on completion of missing infrastructure, especially railways and inland waterways. Transfer of freight traffic from road to rail and waterways is an important factor.

Advantages:
- shorter route Suez - Gibraltar - German ports
- direct connection from the Mediterranean Sea to European rail corridors
- possibility of connection with the upcoming project Danube - Oder – Elbe
- use of railways for freight transport
- reduction of the operation of naval ships along the northern coast of Africa

Connection of the NAPA ports with ports in the Baltic Sea, thanks to use of new or reconstructed multimodal corridors can be another option.

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Laser scanning optimisation process in mountainous terrain

Mária Mrázová[1]

[1]Air Transport Department, University of Žilina, Žilina, 010 26, Slovakia

Abstract Digital terrain model is applicable for many possibilities related to aerial works by use of photogrammetry or laser scanning of the earth's surface. For the purpose of this research we consider just laser scanning used for work in difficult mountain terrain. The terrain of the Slovak Republic has many high hills and it signifies more complex flight planning, as laser scanning is usually flown in lower heights than photogrammetry. Moreover, as lower height is above terrain than the overlap between subsequent LIDAR strips is also lower. This situation can also lead towards the negative value in extreme instances.
This paper also describes the most effective way for flight planning during laser scanning of mountain terrain by comparison of two different technologies from operational and economical point of view.

Keywords laser scanning, LIDAR, optimisation, mountain terrain

JEL L93

1. Introduction

Optimisation process plays key role in any industry in order to find the most sufficient way to save costs and simplify the work process. Laser scanning is a method used for determination the spatial position of a large number of points on the Earth, such as buildings or vegetation. The result of points collection creates so called the point cloud that makes conditions for generation of needed digital terrain models in high definition resolution that cover all considerable detail.

Moreover, as was mentioned above, laser scanning process is executed at a relatively low flight level compared to the photogrammetry mainly due to the LIDAR's low range and consequently due to low level of radiant energy. Whereas the flights are made in low flight levels, it brings some kind of problems linked with overlaps adjacent LIDAR strips. As the altitude terrains is greater, then the greater strips overlap has to be done.

Briefly, in mountainous terrain the settings of the overlaps LIDAR strips has to be in close proximity due to the fact that if we make settings for 55% overlap and consequently difference of altitudes of the terrain will be less than 400 meters then the real overlap will drops to just 15 %. Whereas the resolution of LIDAR is higher, the overlap is smaller and also the flight level is lower due to the LIDAR and scanner operational efficiency.

2. Laser scanning technology

LIDAR – *Laser Instrument Distance and Range* - originally invented in the early 1960s short time after the laser invention and combined laser-focused imaging with radar's ability to calculate distances by measuring the time for a signal to return. [1]

LIDAR is a remote sensing technology based on the measurement of distance by illuminating a target with a laser and consequent analysis of the reflected light.

University of Zilina has also acquired photogrammetric technology for the purpose of applied research that is used in different fields of research, such as for the survey of localisation of damage forests caused by wind, or for the survey of the places with frequent landslides, etc.

The following paragraph will take closer look at the equipment that is used for the purpose of laser scanning.

The system that is bought for the purpose of University of Zilina use is called TRIMBLE HARRIER 68i that consists of the camera device and LIDAR technology. The Trimble Harrier 68i is an advanced corridor mapping system with a 400 kHz blasting pulse repetition rate and it ensures generation of extremely dense point clouds on one side and high quality geo-referenced ortho images on other one.

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Digital camera specifications are shown in Figure 1.

Model	Trimble AC P65 +
Operating altitude	0 – 10,000 ft AGL
Array size	60 MP
No. of channels	Three RGB
FMC	Fully integrated
Max. Exp. Rate	Down to 2.8 sec.
Image pixel size	Down to 0.03 m
Image scales	1:250 to 1:10,000
Calibration	Geometrical and Radiometrical

Figure 1. Trimble Camera's specifications [2]

The main disadvantage of this model is the absence of the NIR channel that is part of the alternative solutions. This channel absence partly limits the camera's use for the purpose of mapping of forest areas and tree's health whereas the temperature is one of the basic diagnostic tools for large forest areas. In addition, another limit represents the maximum exposure time down to 2.8 seconds.

Another camera's limitation is based on the fact that maximum exposure time is down to 2.8 seconds where this is limitation for the maximum longitudinal overlap scanning areas during flights in low flight levels and also with high resolution setting.

The laser scanner is the second part of technology. The laser ray is deflected by the rotating polygon at adjustable pulse repetition rate of 80 – 400 kHz what means that it is possible to scan about 400,000 points per second. FOV (field of view) is adjustable between 45 – 60 degrees whereas the camera has the FOV 56 ° setting. Therefore, for the planning of the FOV overlap the setting is done by another device. If the LIDAR set to 60 ° FOV, the camera is a limiting factor, and vice versa.

University of Zilina also use another technology for the purpose of aerial work– the Leica RCD30 system that offers high performance and makes digital multispectral photogrammetry at lower costs compared to another laser scanning technology.

Leica RCD30 single camera head CH62 provides co-registered RGBN imagery. It also offers 60 MP medium format with 8956 x 6708 pixels. Also this camera can be easily combined with other 3rd party sensors and LIDAR systems. Moreover, Mechanical Forward Motion Compensation along two axes and it also has ruggedized and thermal stabilized lens system with innovative bayonet mount and user replaceable central shutter with automatically controlled high precision aperture. [3]

3. Flight planning procedures in mountainous terrain

For the purpose of this paper we make comparison of two different technologies used for flight planning procedures in mountainous terrain. We make flight planning for the North part of Slovakia with choose of 3 polygons where both technologies – Trimble and Leica are used.

If customers do not require laser scan then we use Leica Frame Pro software. This software is designated for the downloading and consequent post-process image data acquired with the Leica RC30 medium format camera.

Moreover, after achieving files from the airplane, we use *Harrier Config v2.9* for flight planning procedures, where we make all needed settings related to requirements. For clearer understanding, use of Leica or Trimble depends on the customer's requirements - it means if customer also requires laser scan then we use Trimble.

The area that was planned for laser scanning is illustrated in Figure 2.

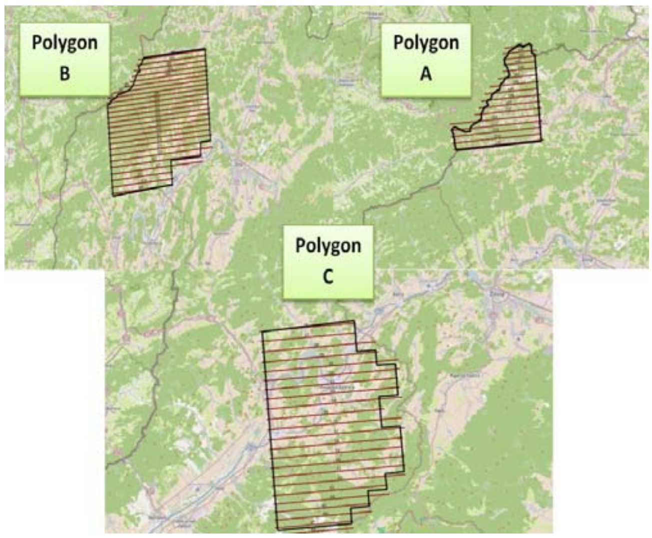

Figure 2. Illustration of the scanned polygons [author]

Following Figure 2, *Polygon A* lies around Korňa village close to Turzovka and Makov. From the geographical point of view this terrain is covered by altitude differences in the range from 150 to 400 meters.

Polygon B lies around the nearest towns as Bytča on southern part of the polygon and the northern part of polygon reached boundaries with Czech Republic. In this case altitude differences due to the hills were from 300 to 500 meters.

Polygon C is bordered by Udiča, Púchov and Považska Bystrica towns on northern part and southern part is bordered by Beluša, Domaniža and Pružina villages.

Following customer's requirements we made flight planning by use of both technologies. Due to the achieving many parameters we will consider just selected features in order to find out the best choice from operational and economical point of view.

LEICA OUTPUTS

Figure 3 illustrates the final mapping achieved by Leica MissionPro software.

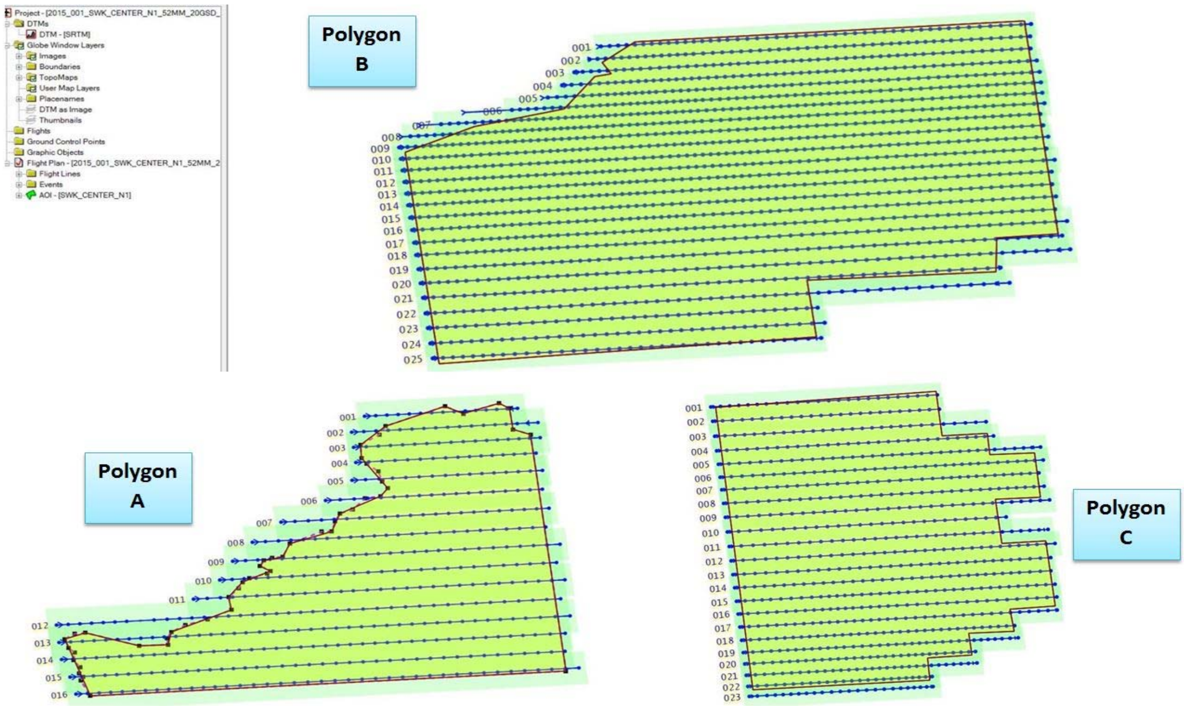

Figure 3. Illustration of the scanned polygons – Leica MissionPro software [author]

TRIMBLE OUTPUTS

Figure 4 illustrates the final mapping achieved by Trimble Harrier Config v2.9.

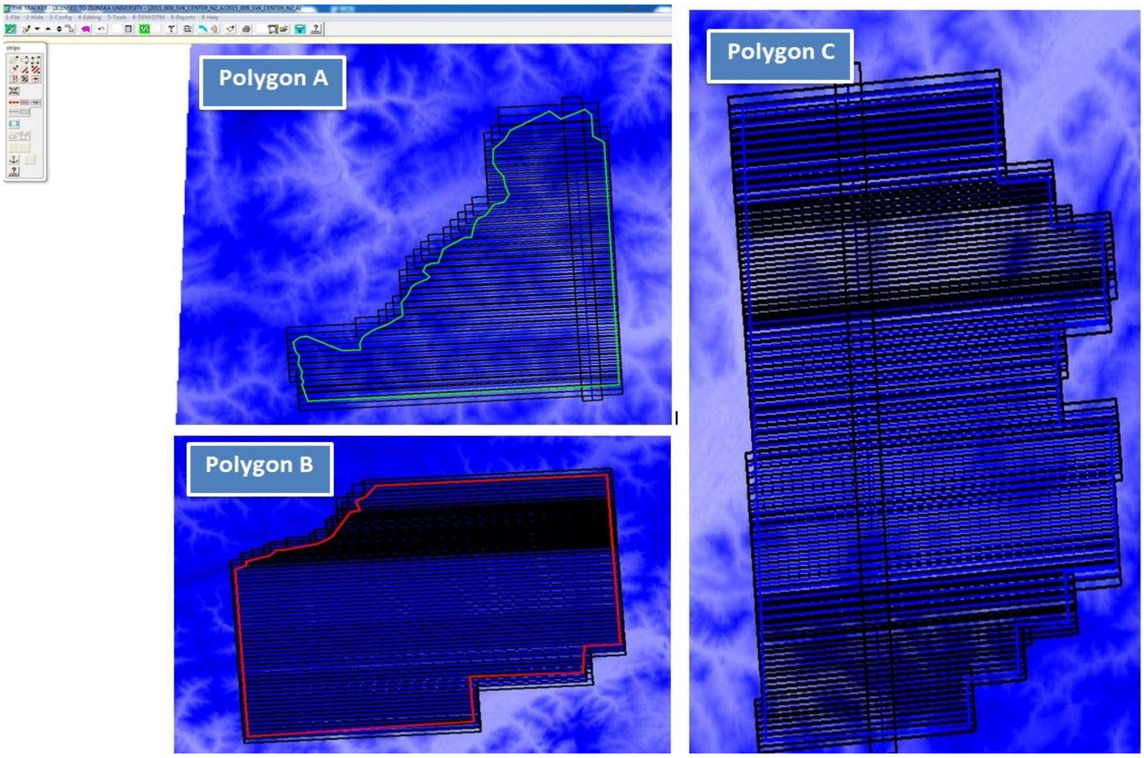

Figure 4. Illustration of the scanned polygons – The Tracker software [author]

4. Conclusions

Following results illustrated in Figure 5, we can see that from operational and economic point of view, the most effective way of flight planning in mountainous terrain showed the results achieved by *Leica MissionPro* Software.

LEICA	Lines	Photos	AGL Flying Height (ft)
Polygon A	16	432	7370
Polygon B	25	1528	6802
Polygon C	23	714	8083

TRIMBLE	Lines	Photos	AGL Flying Height (ft)
Polygon A	43	1245	12 657
Polygon B	65	3799	3858
Polygon C	88	3712	12657

Figure 5. Illustration of the scanned polygons – The Tracker software [author]

Moreover, in the case of *Polygon A*, by Leica Software we flew about 27 less lines as by Harrier software. From the photos point of view, Leica saves about 800 photos and the flight also was made in lower altitude (5200 feet).
In the case of *Polygon B*, Leica software planned 25 lines to fly while Trimble 65 lines. Also number of photos planned by Leica was 2271 less like in the case of Harrier software. The last *Polygon C* consists of 23 lines by Leica and it represents 65 less planned lines like in the case of Harrier software. In addition, the number of photos increased about 2998 photos in the case of Harrier software.

Briefly, *Leica Mission Pro software* flight planning procedures showed that save time needed to fly all lines about triple value and it produces triple times less number of photos that have to be processed what also safe work time.

ACKNOWLEDGEMENT

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Project is co-financ

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Value of Time Savings as a Factor in Deciding on Route Choice

Miloš Poliak[1], Štefánia Semanová[1], Lenka Komačková[1], Michaela Mrníková[1]

[1]Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina in Zilina, Univerzitná 1, Zilina, 010 26, Slovak Republic (University of Zilina in Zilina)

Abstract The paper deals with the definition of time savings as a factor in deciding on route choice of a carrier whether to use toll road network. The first part of the paper describes a history of road infrastructure charging in the EU Member States and the USA. Next part analyses the factors affecting decision-making process of a carrier when considering which road infrastructure to use – toll or non-tolled roads. The paper also identifies the value of time savings as a significant factor in route choice.

Keywords transport, toll, financing, factor, impact, decision-making

JEL R48, H40

1. Introduction

Method of road charging is significantly changing in Europe in recent years. Most states have substituted the method of road charging in the form of vignettes for the performance-based method of road charging. In the case of performance-based method of road charging, the fee amount does not depend on time validity of vignettes but it depends on actual distance travelled within toll road infrastructure (Poliak, 2012). Under such a changed method of road infrastructure charging, the approach of carriers to route choice has also changed, particularly in relation to the amount of fees for the use of road network which represents a considerable proportion of the total costs especially in the EU. Deciding on route choice is also more important depending on the extent of the performance-based road charging. Since 2005, the method of road network charging has been changed, for example, in Germany, Austria, the Czech Republic, the Slovak Republic, and Hungary. Changes in the system of road charging can be also observed in non-EU states (e.g. Belarus). Under performance-based method of road charging, the road transport operator – the carrier usually bears higher costs for using road network, and he can also consider a possibility to use non-tolled road infrastructure when planning transportation or to use roads with lower fees (Poliak and Konečný, 2008). Amount of fees for using road infrastructure is regulated by Directive 1999/62/EC in the European Union. The Directive provides a methodology for calculating the fee for using road infrastructure without consideration of the possibility of using the parallel non-tolled roads by the carrier (Poliak, 2008). When charging road infrastructure, there are also approaches that take into account a decision-making process from the position of the carrier. Such approaches are addressed by several authors, for example, Vadali et al. (2007). The objective of this paper is to express the value of time savings as a factor influencing the carriers when deciding on route choices during transport realization.

2. Development of Road Infrastructure Charging

Road charging has a long history. Many existing roads in the EU were originally built for the purpose of collecting toll fees in return for their use. Already in the 12th century, toll was collected for using roads, in particular bridges, in England (Albert, 1972). In 1830, the toll road network in England was comprised of 35,000 km of roads between London and other centres of regions. In the 19th century, between 2,500 and 3,200 companies financed, built and operated their toll roads successfully in the USA (Klein et al., 2008). Building of private roads was very widespread in the USA during that period of time. During 1850's, a considerable proportion of road infrastructure was operated by private turnpike companies in most states of the USA (Heminger, 2005). By the 1920's, construction of motorways in the USA began to take place with the help of the federal government. Noble (1941) described the feasibility and benefits of using toll roads. Based on estimation in 1937, there were estimated $3.7 million needed for construction and maintenance of the state road system in the USA. To meet the shortfalls in motorway budgets and also relieve the intense motorway congestion, the first government-owned toll motorways opened in several states of the USA, such as Pennsylvania and Massachusetts, between 1930's and 1950's (McNichol, 2006 and Aronott et al., 2005). In Europe, the first state-built motorway was charged in Italy in 1924. Subsequently, motorways were charged in Greece (1927), France, Spain, and Portugal (Jordi, Ph. 2008).

In the 1950's, the Federal-Aid Highway Act provided funding to construct the interstate system in the USA by running a fuel tax-based financing mechanism (Heminger, 2005). During the 1980's, states began to establish facility-based toll authorities to supplement their interstate motorway capacity. In the 1990's, toll-based congestion pricing and high occupancy toll lanes (HOT) were authorized and introduced in several states such as Texas, California and Minnesota. System of HOT charges motorists in single-occupant vehicles for the use of high occupancy lanes.

When determining fees for using road infrastructure in the USA, the impact of possible diversion of vehicles from toll roads to non-tolled road infrastructure is taken into account. The adequacy of the fee for using road infrastructure is assessed particularly in relation to time savings of transport for the carrier who uses toll infrastructure (Zhou et al., 2009).

In the EU, a system of determining fees for using road infrastructure is regulated by Directive 1999/62/EC which sets out the main principles for toll calculation. Toll level in the EU is determined based on:

1. Infrastructure costs – which include:
    a) Investment costs – construction cost (including financing costs) and costs of infrastructure development. Investment costs also include costs of land acquisition, planning, designing, supervision of construction contracts and project management, costs of archaeological and ground investigations, as well as other relevant ancillary costs.
    b) Annual costs of maintenance and costs of construction repairs – these are annual costs of network maintenance and recurrent costs associated with repairing, firming and restoring of surface in order to ensure the operational functionality of network.
2. Costs of operation, management and collection of toll – these are particularly the costs of construction and maintenance of toll plazas and other payment systems, daily costs of operation, management and maintenance of the toll collection system, administrative fees and charges relating to concession contracts, costs of management, administration and services related to infrastructure operation.

A Member State is entitled not to include all costs into toll level. However, the possibility of using parallel non-tolled infrastructure or the factors affecting a routing decision of the carrier is not taken into account when determining fees for using road infrastructure.

3. Factors Affecting Carriers' Decisions When Planning Route of Transportation

A route choice in road freight transport is the result of various factors that were addressed by several authors. These factors include, for example, route attributes, level of congestion, toll fees, fuel costs, time of carriage (travel time), speed, and vehicle operating costs. Table 1 summarises the results of studies which deal with the factors affecting a route choice.

Table 1. Factors Affecting a Route Choice Made by Transport Companies

Authors of studies	**Knor-ring et al (2005)**	**Golob and Regan (2001)**	**Bain (2002)**	**Yalcin et al (2005)**	**Zyl and Raza (2006)**	**Vadali et al (2007)**
Region	**USA**	**Los Angles (USA)**	**Interna-tional experience**	**Japan**	**India, South Africa**	**USA**
Driver's decision				✓	✓	
Manager's decision					✓	
Driver wage / income			✓			
Route attributes	✓				✓	
Congestion		✓			✓	✓
Toll					✓	✓
Fuel costs		✓			✓	✓
Speed	✓	✓				
Travel time (reliability /uncertainty)		✓		✓	✓	✓
Vehicle operating costs			✓			

Source: Korring et al. (2005), Golob and Regan (2001), Bain (2002), Yalcin et al. (2005), Zyl and Raza (2006), Vadali et al. (2007)

Based on the results of processed studies, it can be stated that the most important factors are:

- Travel time – congestion and maximum speed for individual roads are also related to the travel time
- Fuel costs
- Toll

These results can be confirmed by the survey outcomes that were published by Vadali et al. (2007). The survey was focused on a route choice while deciding between toll and non-tolled road infrastructure. Carriers quantified individual factors. Factors were ranked from 1 (most important) to 5 (least important) according to their importance to the carriers. The survey outcomes are shown in Figure 1. Based on the survey, travel time, fuel costs and toll achieved the highest rating.

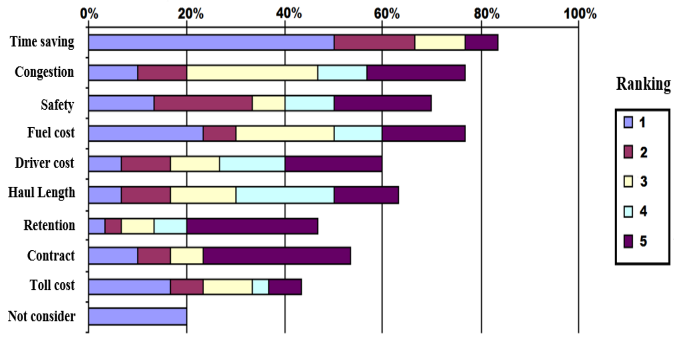

Figure 1 Importance of Factors Affecting the Use of Toll Road; *Source: Vadali et al. (2007)*

Travel time is the most important factor while deciding on transport route, particularly because legislation stipulates the maximum driving time of drivers within a given period. Table 2 provides a comparison of the stipulated working hours of drivers in individual countries. Maximum daily driving time in individual countries is regulated in the interval from 9 hours in the EU to 15 hours in Canada (northern part of the country, maximum daily driving time in southern part of the country is 13 hours). Similarly, maximum weekly driving time or maximum driving time within two consecutive weeks is also regulated. Moreover, minimum daily and weekly rest period are stipulated in the analysed countries. Drivers cannot drive during mentioned rest periods and vehicle must be stationary if a driver draws the rest period in the vehicle.

Table 2. Regulation of Driving Time and Rest Period in Individual Analysed Countries

Requirement	EU	USA	Canada[1]	Australia	New Zealand
Continuous driving time	4.5 h	8 h	13/15 h	5.25 h	5.5 h
Break	45 min	30 min	-	15 min	30 min
Daily driving time	9 h	11 h	13/15 h	12 h	13 h
Daily rest period	11 h	10 h	10/8 h	7 h	10 h
Weekly driving time	56 h	70 h	70/80 h	72 h	70 h
Weekly rest period	45 h	34 h	36 h	24 h	24 h
Fortnightly driving time	90 h	148 h	147 h	144 h	166 h

Source: Authors based on: [2], [3], [4], [5], [6]

When taking into account the mentioned restrictions, the carrier prefers the shortest travel time due to possibility to deliver the greatest number of shipments within limited period of time, and from the reason of realization of maximum vehicle performance that is possible within limited period of time. The mentioned statement was also stated by Vadali et al. (2007) and Geiselbrechtet et al. (2008). This means that the carrier will prefer a superior road infrastructure (toll roads) in terms of higher vehicle utilization and he will be willing to pay the fees for its use unless the amount of fees is higher than benefits associated with faster transport performed on that infrastructure.

4. Value of Time Savings from the Perspective of Carrier

Main factors that affect the decision of the carrier to use toll roads were identified in the previous chapter. Travel time is one of the most important factors. Value of time savings plays a key role related to the use of toll roads by the carrier. When considering the construction of toll infrastructure, public authorities should estimate how the carriers value their time savings associated with the use of toll infrastructure in terms of money. Only then it is possible to make a proper and efficient pricing policy.

Knorring and Kornhauser (2005) dealt with the value of time savings from the perspective of carriers. They concluded that value of time savings is a key factor in decision-making process of the carriers. They stated that the carriers, or drivers, do not just make a decision on which route to take when facing parallel routes, but every single transport route is planned with regard to the factor of time savings.

Several authors tried to estimate the value of time savings. Kawamura (2000) estimated this value based on preference data collected in California. Firstly, he summarized that value of time savings ranged from $14.50/hour to $35.60/hour according to the results of previous studies. Then, he estimated the mean value of time savings as $26.8/hour based on own collected preference data. He also defined dependence of the likelihood of using a particular infrastructure on the value of time savings when using alternative transport route (Figure 2). Likelihood of using a particular route is increasing with increasing value of time. At value of time savings of $100/h, only low percentage of the carriers would not use a given infrastructure.

[1] Southern part of Canada / Northern part of Canada

[2] Ministry of Transport of the USA: https://cms.fmcsa.dot.gov/regulations/hours-service/summary-hours-service-regulations (12.10.2013)

[3] Ministry of Transport of Canada: http://laws-lois.justice.gc.ca/eng/regulations/SOR-2005-313/ (12.10.2013)

[4] Ministry of Transport of New Zealand: http://www.nzta.govt.nz/resources/rules/work-time-and-logbooks-2007-index.html (15.10.2013)

[5] Ministry of Transport of Australia: http://www.ntc.gov.au/filemedia/Publications/HVDF_Basic_July08.pdf (16.10.2013)

[6] Regulation (EC) No 561/2006 of the European Parliament and of the Council of 15 March 2006 on the harmonisation of certain social legislation relating to road transport and amending Council Regulations (EEC) No 3821/85 and (EC) No 2135/98 and repealing Council Regulation (EEC) No 3820/85

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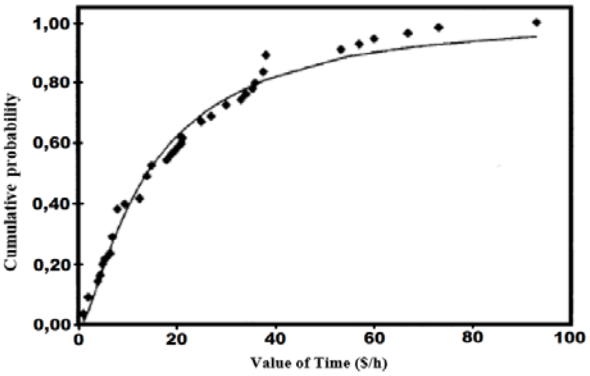

Figure 2 Value of Travel Time Savings for Road Transport Companies in the USA*; Source: Kawamura (2000)*

Before introducing toll in the SR, Poliak and Konečný (2008) addressed an issue of the use of parallel non-tolled road infrastructure in connection with definition of the methodology for determining the extent of road network pricing. In conditions of the SR, they processed dependence of the proportion of carriers willing to avoid toll roads depending on the level of toll; for two values of time savings – 600 SK/hour (€19.92/hour) and 400 SK (€13.28/hour). The dependence of vehicle diversions from toll infrastructure is depicted in Figure 3. About 30 % of vehicles had bypassed toll road infrastructure in 2008 if value of time savings would have been at the level of €19.92 when assuming the toll rate of 21 SK/km (€0.697/km). If value of time savings would have decreased to the level of €13.28 while keeping the same toll rate, about 37 % of vehicles had bypassed toll road infrastructure. Mentioned approach was not reflected in SR in the determination of toll rates and the rates were processed only based on the requirements of EU legislation.

Time savings – 600 SK/h (€19.92/h)

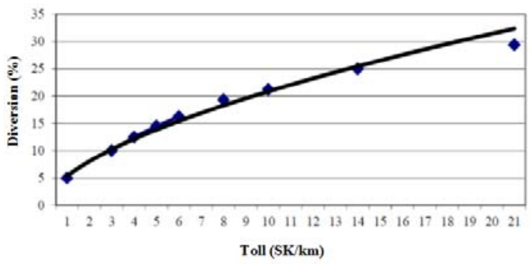

Figure 3 Dependence of Vehicle Diversions from Toll Road Infrastructure in Conditions of the SR; *Source: Poliak and Konečný (2008)*

Time savings – 400 Sk/h (€13.28/h)

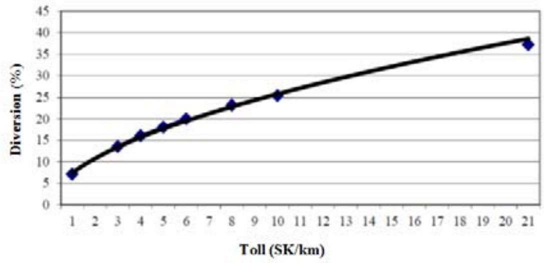

Figure 4 Dependence of Vehicle Diversions from Toll Road Infrastructure in Conditions of the SR*; Source: Poliak and Konečný (2008)*

4. Conclusion

The situation where freight vehicles which bypass toll road infrastructure and use non-tolled infrastructure of lower category still persists in EU countries. However, these non-tolled roads often lead across populated areas such as towns and villages. Operators of road freight transport (carriers) prefer non-tolled road infrastructure in order to reduce their costs related to vehicle operation in the case that costs of fees for using toll infrastructure exceed the effects associated with the use of this infrastructure, e.g. in the form of time savings or savings in fuel costs. Under EU legislation, the level of fee for using road infrastructure is dependent on the costs of its construction and maintenance without assessment of the impact of such determined fee on the demand of operators for the use of toll infrastructure. Public authorities then look for solutions of transit restrictions for road freight transport on parallel non-tolled roads. However, these solutions are often not effective without a thorough inspection. It is also difficult to ensure effective control between transport service of territory and transit of territory.

Therefore, a suitable solution is to set the level of fee for the use of road infrastructure so that carriers can use toll road infrastructure more efficient. This means that the amount of fee must be related to time savings of the carriers and cannot be higher than the value of time savings when using a particular section of toll road network.

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Airlines in Poland

Patrycja Rut[1], Tomasz Łusiak[2], Andrej Novák[3], Nikolas Žáčik[4]

[1]ERASMUS+ student, University of Zilina, Zilina Slovakia (first author's affiliation)
[2] PolitechnikaLubelska, Lublin, 20-093, Poland (second author's affiliation)
[3]Department of Air transport, University of Zilina, Zilina, 010 26 Slovakia (third author's affiliation)
[4]Department of Air transport, University of Zilina, Zilina, 010 26 Slovakia (forth author's affiliation)

Abstract In this article is described the concept of the airline. This article describes the different types of airline concepts which can occur in the airline market. The main topic of this research is description of all Polish airlines in detail. You can find in this topic description of each Polish airline also with a fleet and departures what were main attributes for this research and for determining of airline model of each Polish company

Keywords airlines, aviationin Poland, LOT, types ofairlines, Eurolot, Enter Air, Travel service Poland, Exin, SprintAir

JEL L93

1. Introduction

The airline - an airline providing scheduled or non-scheduled air transport services, including the carriage of passengers or cargo and has the appropriate civil aviation authority certificate issued by the State in which it was founded. In Poland, there are two types of airlines providing passenger services and cargo. [1]

1.1. Charter carriers

Tourist charter market was for many years dominated by airlines from countries bordering the Mediterranean. Until 2005,. The largest Polish player in this market was a LOT, and later a subsidiary Centralwings. In addition, from time to time they appeared and gone small airlines that operate on medium and long-haul routes. Polish airlines LOT, Enter Air, SprintAir, SkyTaxi, Travel Service.

1.2. Transportation of cargo

Transported by air freight consignments are two types: normal and requiring handling services. Supported special require, inter alia: hazardous materials, live animals, perishable goods, as well as shipping heavy and / or undersized, diplomatic and valuable. In 2010r.na board Polish aircraft carried a total of 45,1th. tons of cargo, the biggest share fell Airlines Cargo. Polish airlines LOT Cargo, Exin, Sky Taxi, Sprintair.[2]

Polish airlines offer both cruise calls, as well as charter flights and cheap domestic flights. The leading representative and symbol of Polish civil aviation are Polish Airlines LOT. These lines are one of the oldest airlines in the global aviation market - established in 1929, and today offer flights to over 100 destinations worldwide..

2. Polish AIRLINES

It's an air transport undertaking resulting from 1 January 1929 by the merger of all operating airlines in the country, the Polish company, owned by the treasury; LOT Charters owner of the company. It belongs to the Star Alliance. [3]

2.1. Fleet

Boeing 787 Dreamliner supports connections long distance Airlines. The Boeing 787 is a twin-engined, wide-jet. It is the latest model aircraft manufactured by the US Company of The Boeing Company. LOT was the first carrier in Europe, which started operating these aircraft to operate scheduled air services. The Boeing 787 Dreamliner is made of composite material, which has significantly lowered aircraft weight and consequently reduce fuel consumption by ten percent. The modern Rolls-Royce engines emit 60% less noise. The distinctive design of wings held high ends dramatically reduces the air resistance.

The aircraft version of the LOT terminal takes on board a total of 252 passengers in three classes of travel:
- LOT Business Class
- LOT Premium Economy
- Airlines Economy Class

Features and timetables sites are shown in the figure 1. [4]

Lenght	57 m
Height	17,0 m
Range	60,0 m
Diameter of fuselage	5,74 m
Max take-off weight	215 910 kg
Number of seats	250-290
Engine	General Electric GEnx lub Rollys Royce Trent 1000
Cruising speed	0,85 Mach
Reach	15 700 km
Max fuel	124 700 litrów
Operating ceiling	13 100 m
Number of pieces	6

Figure 1. Features and position of sites of Boeing 787.

Lenght	38,65m
Height	10.28 m
Range	28,72 m
Diameter of fuselage	3.01 m
Max take-off weight	52 290 kg
Number of seats	112
Engine	2× GE CF34-10E turbofans
Cruising speed	0,82 Mach (890 km/h)
Reach	3 990 km
Max fuel	12 971 litrów
Operating ceiling	12 500 m
Number of pieces	6

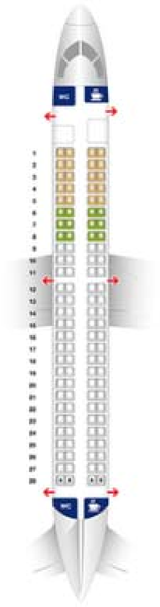

Figure 2. Features and position of sites of Embraer 195.

Embraer 195- The largest family of aircraft. It is the work of the Brazilian company Embraer - Empresa Brasileira de Aeronáutica. In our fleet to domestic and middle-distance. Characteristically floating end of the wing, called winglet, reduce air resistance. This allows for faster overcoming distances and lower fuel consumption. Performance and efficiency of engines Embraer 195 cause that it meets the rigorous standards of the noise-generating. Jet takes on board up to 112 passengers.

At your disposal spacious cabin, large lockers for luggage, and this will significantly improve comfort on flights to London.

The main advantages of the aircraft:

- Comfort seats with adjustable headrests

- Configuration of 2 + 2, no middle seats

Features and timetables sites are shown in the figure 2. [5]

The Boeing 737-400 is a twin-engine jet aircraft produced by the US company of The Boeing Company. It is produced in various versions since 1967. Boeing 737-400 in different versions, is the most popular jet airliner of all time.

In our fleet to domestic and middle-distance. Configured especially for us narrow hull, twin-engine model 400 takes on board from 148 to 162 passengers.

Embraer 175 is a slightly extended version of narrow hull jet Embraer 170. In our fleet it supports domestic connections, and middle distance. Thanks to the efficient and efective aircraft engines meet the stringent standards noises and floating completion wings - winglets, reduce air resistance, which reduces fuel consumption. On board can travel up to 82 passengers. In 2010, two Embreaers 175 of our fleet are chartered with crew to operate the flights most important people in country. Despite regional character, at your disposal spacious cabin, large lockers for luggage, and this will significantly improve travel comfort.[6]

Embraer 170 is a twin-engine jet aircraft narrow hull produced by the Brazilian company Embraer - Empresa Brasileira de Aeronáutica. Wings aircraft are equipped with a characteristically floating end of the wings called wingletami. They reduce air resistance and thus reduces fuel consumption. High performance and efficient engines comply with stringent standards while the noise-and thus the plane can fly to major airports in Europe and World. On board can travel up to 70 passengers.[7]

2.2. Departures

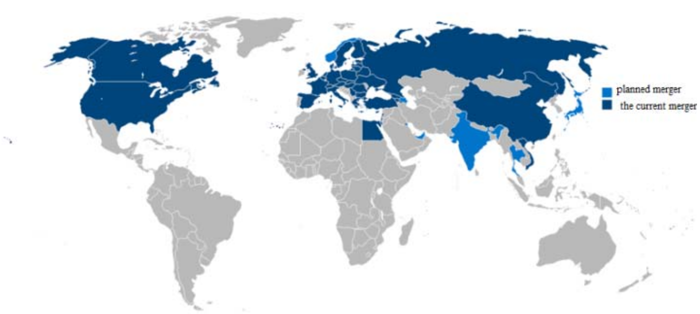

Figure 3. Planned and current merger [8].

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2.3. Eurolot

Operator providing transport services between major Polish airports, and connecting these ports to various foreign cities. The majority shareholder is the State Treasury (62% shares).

Eurolot has its own fleet of turboprop aircraft short-range ATR 72-200, as well as major medium-haul aircraft type Q400 NextGen Bombardier and Embraer 175.

Until recently, this line served as a feeder for domestic flights LOT Polish Airlines. However, in August 2012 the Board of LOT decided that domestic flights will operate a fleet which prevent the sale of part of the fleet. Therefore, the board decided to Eurolot expansions on European routes. Today, however, this line functions as feeder routes for foreign LOT.

Currently the CEO is Andrew Juszczyński, and his deputy - Bartlomiej Matusewicz.

Additional business of the company is Pilot Training Centre, in which courses are also offered to acquire licenses for the position of the Air dispatcher. The resort was established in 2003 and deals with training for individuals, as well as train crew Eurolot and LOT Polish Airlines and other entities in the world.

Carrier Eurolot SA whose majority shareholder is the State Treasury from 2012 struggling with major financial problems, according to data from the Ministry of Treasury. At the beginning of 2014, the situation of airlines was so bad that she had to sell two aircraft to repay their debt to the state entities. There is also plan for an orderly winding up or restructuring of the carrier. The main reason for poor financial performance was the start of commercial operations at its own risk, as well as misguided collaboration with 4You Airlines, and the company's development strategy diverges from market realities.

The last flight was made on the route Zurich - Krakow March 31, 2015 year.

Since April 1, the planes were included in the LOT fleet, which take over the commitment Eurolot in the form of operating lease. Airlines have already used the bombardiers leased with its crew of Eurolot in the formula ACMI. The transaction is in line with the restructuring plan LOT, which ends in October - it involves the use of regional aircraft. [9]

2.4. Enter Air

Polish charter airline. It has four permanent operational bases Chopin airport in Warsaw, Pyrzowice Airport, the airport in Poznan and Wroclaw airport. Enter Air aircraft also support other Polish cities such as Cracow, Gdansk, Rzeszow, Bydgoszcz and Lodz.

Enter Air was founded in November 2009, and its first season began in April 2010. Creation of a new airline conducive to good against Europe, the condition of the Polish economy and especially the condition of Polish charter market, which despite the crisis in the world grew by over 5% year on year. In the first period line benefited from two B737-400 type aircraft. The inaugural cruise was held on 25 April 2010 from Ataturk Airport. Warsaw's Frederic Chopin airport at the new Enfidha between Sousse and Tunis in Tunisia. The route from Warsaw to Tunisia and back made aircraft Enter Air with registration marks SP-ENB.

In the winter of 2011/2012, Enter Air launched its first scheduled flights to Sri Lanka and Bangkok. Cruises operate Boeing 737-800 aircraft. [10]

2.5. Fleet

At present fleet consists of 15 Boeing 737-400 and

- SP-ENA (B737 – 400)
- SP-ENB (B737 – 400)
- SP-ENC (B737 – 400)
- SP-ENE (B737 – 400)
- SP-ENF (B737 - 400)
- SP-ENH (B737 - 400)

- SP-ENI (B737 – 400)
- SP-ENK (B737 – 400)
- SP-ENY (B737 – 800)
- SP-ENZ (B737 – 800)
- SP-ENX (B737 - 800)
- SP-ENW (B737 - 800)
- SP-ENV (B737-800)
- SP-ENU (B737-800)
- SP-ENT (B737-800)

737-800.

Figure 4. City pairs and the most common used aircrafts [8].

2.6. Departures

- Bulgaria (Burgas, Varna)
- Czech Republic (Prague)
- Cyprus (Paphos)
- Croatia (Dubrovnik, Pool, Split, Zadar)
- Egypt (Hurgarda, Sharm El Sheikh, Marsa Alam, Taba)
- France (Lyons, Nantes, Paris, Toulouse)
- Greece (Chania, Heraklion, Kavala, Blackbird, Rhodes, Thessaloniki, Zakynthos, Araxos, Corfu, Athens, Airport Kefalonia)
- Spain (Almeria, Barcelona, Fuerteventura, Girona, Lanzarote, Madrid, Mallorca, Menorca, Malaga, Sevilla, Las Palmas de Gran Canaria, Tenerife)
- Kenya (Mombasa)
- Morocco (Agadir)
- Poland (Warsaw (base), Katowice (base), Gdańsk, Bydgoszcz, Poznan (base), Wroclaw (base), Łódź, Cracow, Rzeszow, Lublin)
- Portugal (Faro,Madeira)
- Sri Lanka (Colombo)
- Thailand (Phuket, Bangkok)
- Tunisia (Enfidha, Monastir, Djerba)
- Turkey (Antalya, Bodrum, Dalaman, Izmir)
- Israel (Tel Aviv ,Eilat)

- Italy (Catania, Lamezia Terme, Olbia)
- United Arab Emirates (Dubai)

2.7. SprintAir

The group brings together three companies SprintAir SA, SprintAir Cargo Sp. with o.o, and SprintAir Aviation School Sp. with o.o SprintAir Group companies provide services in the aviation market, specializing in both air freight, carrying out operations on behalf of partners such as UPS, TNT and Post Poland, as well as passenger flights in both types of operations scheduled flights as well as charter flights. From June 2011. SprintAir performs a scheduled passenger air service on the route Zielona Gora - Warszawa. From november 2011. As a subcontractor Polish Airlines LOT carrier performing daily flights from and to Bydgoszcz. In April of 2013. Began, also on behalf of LOT Polish Airlines, operate a daily flight Warsaw - Katowice, from November 2013 LOT resigned from the services SprintAir SA. In the operational base of the Warsaw Chopin Airport. In addition to air transportation group companies also carry out training activities conducted through operating in groups of two training centers: TRTO (training for pilots on the type SF340) and the Aviation Security training center (training of security screeners). [11]

2.8. Travel Service Poland

A charter airline based in Warsaw. It started May 9, 2012, following the first flight from Warsaw Chopin Airport. It is a subsidiary company which is the parent company Travel Service. All flights are made Boeing 737-800 aircraft.[12]

2.9. SkyTaxi

Polish charter airline based in Wroclaw. Performs passenger and cargo flights within the European Union, the Middle East and North Africa.

Since 2004 SkyTaxi is certified JAR-OPS 1 awarded by the Polish Civil Aviation Office in Poland [13]

2.10. Exin

Polish airline specializing in cargo transportation. The airline's headquarters in Lublin, and the base of operations is Katowice. [14]

3. Conclusions

2014 years was successful for LOT. Michael Leman, who in the company is responsible for the implementation of new products says the company for the first time in many years will have a so-called operating profit, which will make money on transporting passengers.

Since 2012, the company implemented a recovery plan. They released among other things, part of the administration, as amended agreements with certain employees. The carrier also received aid. In early December, he was paid the second tranche.[15]

More and more passengers are choosing LOT-class a higher standard. With Dreamliners, after three quarters of this year, the number of people traveling in Business Class and LOT Airlines Premium Class on long-haul routes grew by 48% compared to the same period last year.

The flagship carrier machines, Boeing 787 Dreamliner, attracting more and more passengers who value convenience and comfort. This is not only thanks to the most modern passenger aircraft, but mainly the result of continuous improvement of on-board product which offers Airlines.

Last year, the Polish aboard aircraft transported 5 million passengers and 45 thousand tons of cargo. In relation to the previous year's results transportation passenger increased by 16.7%, while cargo tonnage by 15.9%. The largest share the market had a Polish Airlines LOT.[16]

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