

THE CRITICAL PATH METHOD AS THE METHOD FOR EVALUATION AND IDENTIFICATION OF THE OPTIMAL CONTAINER TRADE ROUTE BETWEEN ASIA AND SLOVAKIA

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Abstract

Containers, as intermodal transport units, not only reduce loading time in sea ports; but they also help to protect cargo against its damage, loss and theft. Nowadays different types of containers are carried by cellular container ships among the continents. In maritime transport there are three main container trade routes that link the developed to developing countries located in Asia, Europe and America. One of these routes links top Asian and European container ports. Vessels, which operate on this route, have to sail through important maritime canals and straits. Some of these places are dangerous because of piracy or local war conflicts.

The goal of this paper is to choose an appropriate method of cargo transport between a selected Asian container port and the Slovak Republic. At the beginning we will describe the container trade route Asia and Europe, Asian and European container ports that handle containers. Then we would like to identify the criteria such as transport time, transport costs, risks during transport which be used for the an lysis of the proposed routes. At the end we will use the critical path method, one of the methods of Operation Analysis that will help to evaluate and identify the optimal container route between Asia and Slovakia.

Key words: containers, container trade routes, critical path method, evaluation and identification, maritime transport

1. INTRODUCTION

Most of consumer goods that are sold in the shopping malls come from Asia, especially from the Far East. The developed countries have moved their production subsidiaries to the developing countries of the Far East due to cheap labour force or tax benefits. Most of these goods are transported into containers due to the protection

of goods against their damage, loss or theft during transport, transshipment and storage and better manipulation of containers in the sea ports (Klapita, 2015; Tengler et al. 2015).

The basic goal of this paper is to focus on transport of containers between Asia and the Slovak Republic and compare it from the different points of view. In the research we have decided to use the critical path method that is one of the methods of operation analysis. Loading of containers will be carried out in the port of Singapore that belongs to the top 20 world container ports. Then, they will be transported by container vessels to four different European ports (Rotterdam, Hamburg, Koper and Constantza), where they will be loaded on the wagons and will be transported to the container terminal Dunajská Streda. We will compare these transport routes from the points of view such as transport time and price.

2. THE CURRENT CONTAINER TRANSPORT SYSTEM BETWEEN ASIA AND EUROPE

In 2015 about 175 million TEUs (over 1.69 billion tons of cargoes) were carried by container vessels in the world. In maritime transport there are three main container trade routes that link the continents:

- Transatlantic (North America - Europe),
- Transpacific (Far East – North America),
- Europe – Asia.

One of the busiest routes is the route that lies between Europe and Asia. It links Western Europe (the Netherlands, Belgium, Germany or France) with the Far East (West Malaysia, Singapore, Thailand, Hong Kong, the Philippines, Taiwan, South Korea, China and Japan). Vessels sail from the North Atlantic through the Mediterranean Sea, the Suez Canal, the Red Sea, the Indian Ocean, the Strait of Malacca, and the South China Sea to the North Pacific. On one hand this maritime route is the shortest route between Europe and Asia, on the other hand it is one of the busiest routes in maritime transport (Hanšút, 2015; Černá et al., 2017).

Table 1. Containerized cargo flows on major east-west (millions of teu)

	Trans-Pacific		Europe-Asia		Transatlantic	
	Eastern Asia-North America	North America-Eastern Asia	Asia-Europe	Europe-Asia	Europe-North America	North America-Europe
2014	15,8	7,4	15,2	6,8	3,9	2,8
2015	16,8	7,2	14,9	6,8	4,1	2,7
Percentage change 2014-2015	6,6	- 2,9	-2,2	0,0	5,4	-2,4

Source: (Review of Maritime Transport, 2016)

Most of containers are transhipped in the biggest European ports such as the port of Rotterdam or the port of Hamburg. For the countries of Central and Eastern Europe (also for the Slovak Republic) it is better to use the port of Koper or the port of Constantza because these ports are closer to the Asian markets than sea ports of the North Sea. After transshipment of containers in the sea ports they are transported to the container terminals located in hinterland by railway or road transport. We chose the container terminal Dunajská Streda for our comparison because this terminal belongs to the best built terminals in Slovakia. It was built according to the criteria of AGTC.

In spite of the fact containers can also be transported by railway transport from Asia to Europe through the Trans-Siberian railway (this transport route saves transport time about 50 %) most of containers are still transported by ultra large container vessels due to cheaper transport costs (Internal materials of the Ministry of Transport, 2016).

3. EUROPEAN MARITIME PORTS

These days there are about 400 world container ports that handle containers; the top 60 ports handle about 98 per cent of world container port throughput (Grobarčíková & Sosedová, 2014).

The top 20 container ports usually handle about half of the world's container port throughput. In 2015 the list of top 20 container ports included 15 ports from developing economies, all of them were located in Asia. The remaining five ports were from developed countries, three of which were located in Europe (the Netherlands, Belgium and Germany) and two in North America (Los Angeles and Long Beach, California) (Review of Maritime Transport, 2016).

In this part we focused on four European container ports that are important due to transport of containers from Asia to Slovakia.

3.1. Port of Rotterdam

The port of Rotterdam is the biggest port in Europe. It lies on the coast of the North Sea and the river Nieuwe Mass. Navigable network of this port is very dense with lots of canals.

The port is largely located in the city centre of Rotterdam, which was caused by historical development of the city. The total length of the port is 42 km. Nowadays, the total area of the port is 12.603 hectares (ha), of which land area is 7.793 ha and water area is 4.810 ha.

Ultra large container vessels and bulk carriers that carry iron ore from Brazil can enter the part called Maasvlakte. Water depth in this part is about 24 metres. The port of Rotterdam is connected with the other world ports through a large number of line companies. The port has got a very good connection with hinterland through road and railway transport (A 15 motorway and railway Betuweroute that links the Netherlands with Germany) (Port of Rotterdam, 2016).

Transshipment and storage of containers is carried out in the different parts of the port of Rotterdam (Maasvlakte, Europoort, Botlek, Eemhaven and Waalhaven).

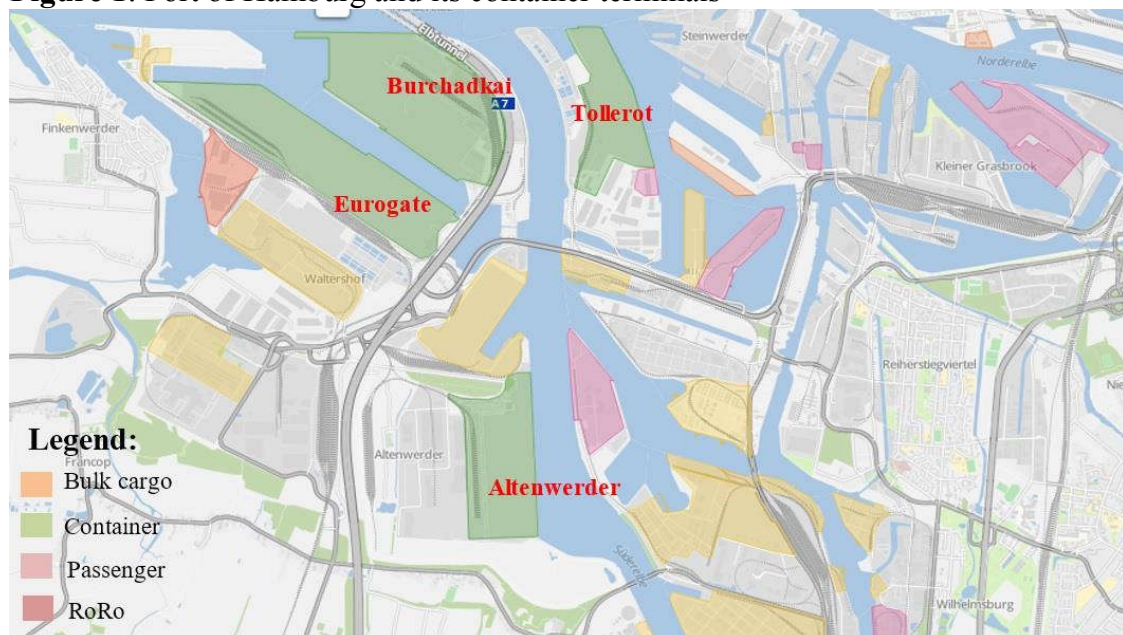
Container terminals are divided according to the size of container ships that anchor there. Ultra large container vessels are operated in the container terminals (ECT Delta and Euromax APM or APM 2) that are located in the parts Maasvlakte I and II.

Smaller container vessels are operated in the terminals such as ECT City, RST, Uniport and Barge Center Waalhaven that are situated in the parts Eemhaven and Waalhaven. These ships carry containers between the port of Rotterdam and the United Kingdom / Scandinavian states, respectively between the port and hinterland. The containers are stored in parts Botlek and Waalhaven (Dávid & Jurkovič, 2013).

3.2. Port of Hamburg

The port of Hamburg (Figure 1) was the third busiest European port in transshipment of containers in 2015. It is located on the banks of the river Elbe, about 115 km from its estuary into the North Sea. The total area of the port is 7.250 ha, of which land area is 4.331 ha. The maximum allowable draft of vessels is 12.8 metres. In the port bulk, general, liquid cargoes including containers are handled there. The port is directly connected with the hinterland of Germany by road and railway transport. Road transport has the most important role in transport of cargoes between the port and hinterland (about 40 million tons of cargoes are transported by trucks), railway transport links the port with 15 countries. The port area has three main railway stations; the length of railway tracks is about 375 km. The port fills the function of collecting place. The part of containers that are unloaded in the port of Hamburg are transhipped on smaller container vessels. They transport containers to the Scandinavian or Baltic States. It is called feeder service. In the port there are four container terminals (Altenwerder, Burchadkai, Eurogate and Tollerot), two of them use automated handling devices in their handling systems (Port of Hamburg, 2016).

Figure 1. Port of Hamburg and its container terminals



Source: (Port of Hamburg, 2016)

3.3. Port of Koper

The Slovenian port of Koper is located in the northern part of the Adriatic Sea. It links the countries of Central and Eastern Europe with the Asian and African countries. This port is intermodal centre; there are used different transport and loading systems such as RO-RO technology, handling devices for transshipment of different types of bulk, general and liquid cargoes (oversize cargo, containers, cars, livestock, and raw materials) (Port of Koper, 2016).

The port of Koper has got 11 special terminals (Figure 2) which carry out various functions such as transshipment and storage of cargoes, and different additional services. Each terminal is equipped by transshipment; shipping and storage technology. Container terminal that is located in the southern part of the port is equipped by cranes Panamax and Post Panamax. It has got four berths where vessels anchor during transshipment of containers. The port of Koper has got a good connection with other modes of transport. Rail transport conveys about 70 % of cargoes, the rest is transported by road transport (Port of Koper, 2016).

Figure 2. Port of Koper and its terminals



Source: (Port of Koper, 2016)

The Port of Koper has an important role for import of the spare parts located into the containers from South Korea to the automobile factories KIA and Hyundai located in Slovakia and the Czech Republic. About 140 000 TEUs (1 250 000 tons of cargoes) are imported by ships every year, twice a week (Twrđy et al., 2012).

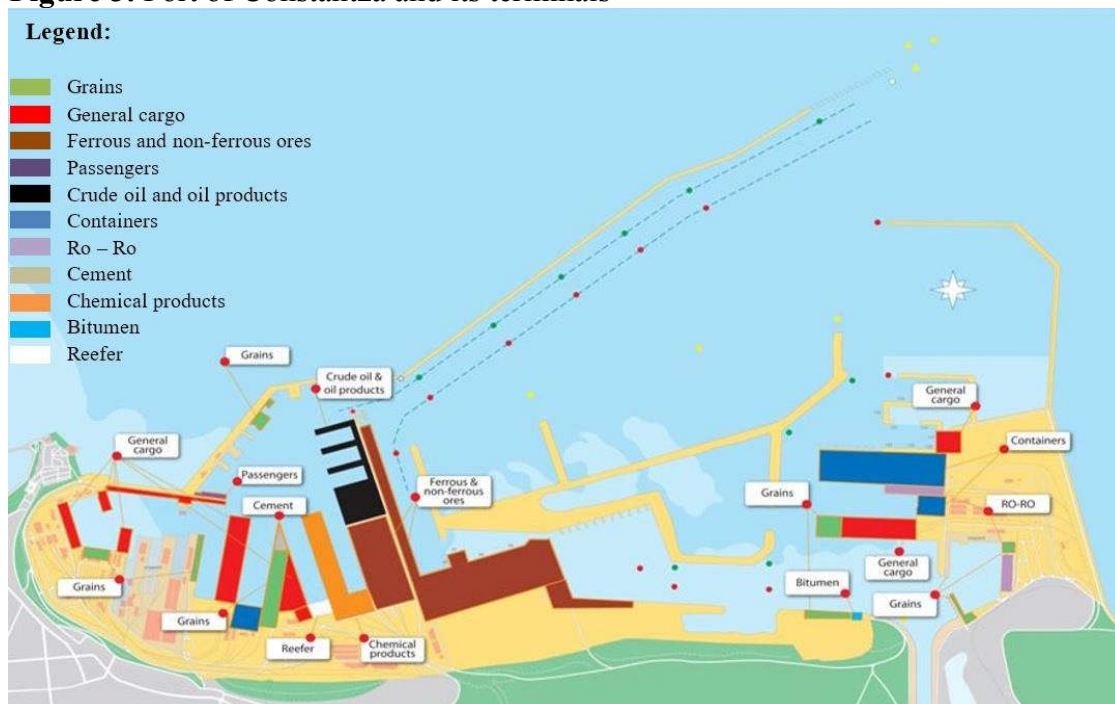
3.4. Port of Constantza

The Port of Constantza (Figure 3) that is the biggest Romanian port is located on the western coast of the Black Sea, 179 nautical miles (nm) from the Bosphorus Strait

and 85 nm from the Sulina Branch. It covers 3.926 ha, of which land area is 1.313 ha and water area is 2.613 ha. The total quay length is 29, 83 km. The maximal allow draught for vessels is 19 metres. The port is part of the Romanian maritime port system under the coordination of Maritime SA Constantza. The south part of the port is linked with the Danube River by the Danube-Black Sea Canal. There are also located river port and Ro-Ro terminal and container terminal. In river port cargoes are loaded on inland vessels (barges, motor cargo vessels) that transport them to hinterland of Romania or other Danube countries. Constantza South Container Terminal was put in the operation in 2004. This terminal is equipped by container gantry cranes that tranship containers between the terminal and container vessels Panamax or Post Panamax. It provides the standard services such as other world container terminals (Port of Constantza, 2016).

The Port of Constantza has got a good connection. The rail network of the port that is about 300 km long, is connected with the Romanian and European rail network. The Port is an important part of TRACEA corridor that provides connection between Europe, Caucas and the Middle East. The Port of Constantza (Figure 3) became Free Zone in January 2007. It allows operating all types of cargoes.

Figure 3. Port of Constantza and its terminals



Source: (Port of Constantza, 2016)

4. THE POSSIBILITIES OF TRANSPORT CONTAINERS BETWEEN ASIA AND SLOVAKIA AND THEIR COMPARISON

During the proposal of a suitable way for transport of containers between the Slovak Republic and Asia (the Far East) we focused on the aspects which influenced mainly on transport processes that were carried out by sea and railway transport.

Containers are mainly transported by sea transport between the continents. In this part we analysed possible transport routes between Asia and Europe and four maritime ports that are important for Slovakia. After containers were unloaded in one of the ports they were transported by railway transport to the container terminal Dunajská Streda in Slovakia. We used the critical path method (CPM) for the comparison and selection of the optimal transport route (Hanšút, 2015).

The critical path method (CPM) is one of the basic deterministic methods of network analysis. Its goal is to determine the duration of a project based on the length of the so-called critical path, which is the sequence of interdependent activities with the least time reserve. CPM enables to facilitate effective time coordination of the partial inter-related activities of the project.

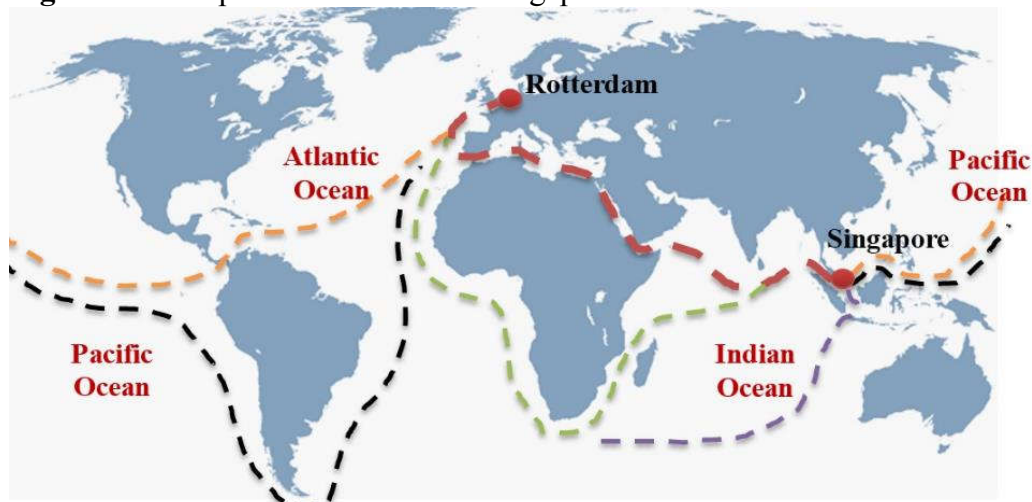
The critical path is defined as the longest possible path from the starting point to the endpoint of the graph. Each project has got at least one critical path. Each critical path consists of a list of activities which the project manager should focus on if he / she wants to ensure timely completion of the project. The end date of the last task on the critical path is also the completion date of the project.

If the duration of the activities is not known with certainty, the Program Evaluation and Review Technique (PERT) can be used to estimate the probability that the project will be completed by a given deadline (Winston, 2004; Fan et al., 2016).

4.1. Singapore – Rotterdam - Dunajská Streda

Between the port of Rotterdam (Europe) and Singapore (Asia) there are five transport routes (Figure 4). One of limiting elements for choosing the best transport route is transport time that depends on the length of transport route and the speed of vessel that is 15 knots (kn).

Figure 4. Transport routes between Singapore and Rotterdam



Source: Authors

The shortest route from the point of time is the route that passes through the Strait of Malacca, the Indian Ocean and the Red Sea, the Suez Canal, the Mediterranean Sea, the North Atlantic and the North Sea. Transport time is about 23

days (Table 2). The price for transport of one TEU is 612 EUR. This price also includes charges for bunker adjustment factor, terminal handling charge, seaway bill, seal and report of goods in advance. We chose APL, one of the world's leading ocean carriers, for transport of containers (Hanšút, 2015).

Table 2. Maritime transport between Singapore and Rotterdam

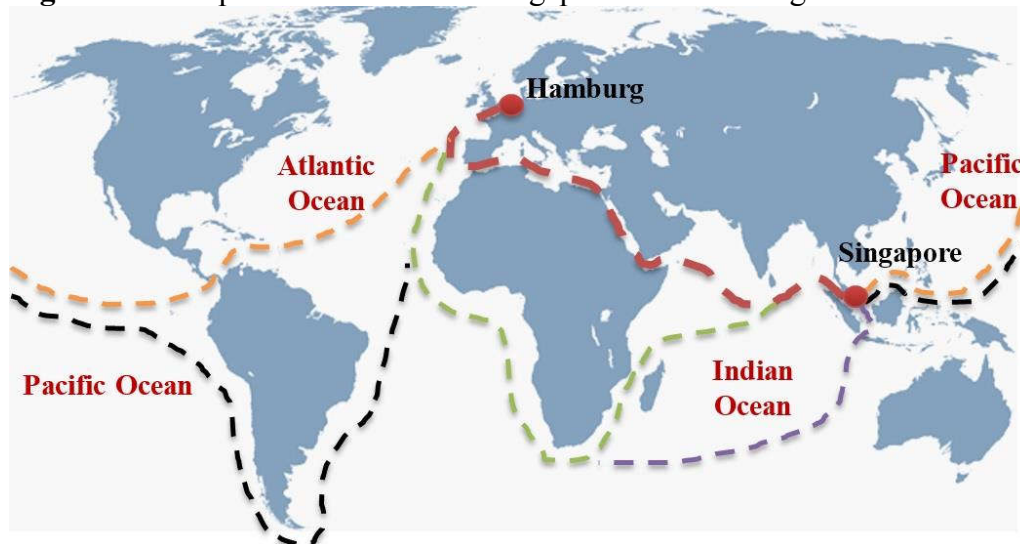
Route	Distance (km)	Vessel speed (nautical miles/hour)	Time (days / hours)
Suez Canal	15 349	15	23/1
Cape of Good Hope	21 770	15	32/16
Panama Canal	28 400	15	42/14
Strait of Magellan	31 295	15	46/23
Cape Horn	31 414	15	47/3

Source: (Sea Distances, 2016)

After arrival of the container ship in the port of Rotterdam containers are transhipped on railway wagons. The whole handling process takes about 36 hours. Then, they are transported by railway transport from the Netherlands through Germany, the Czech Republics to the terminal Dunajská Streda located in the Slovak Republic. The total length of this transport route is 1 515 km and takes about 32 hours and 9 minutes. The price for transport of one TEU is 800 EUR (Hanšút, 2015).

4.2 Singapore – Hamburg - Dunajská Streda

Figure 5. Transport routes between Singapore and Hamburg



Source: Authors

As in the previous case the shortest maritime route between Singapore and the port of Hamburg leads through the Strait of Malacca, the Indian Ocean and the Red Sea, the Suez Canal, the Mediterranean Sea, the North Atlantic and the North Sea (Figure 5). This voyage takes about 23 days 17 hours (Table 3); the speed of the vessel

is 15 kn. The price for transport of containers is 612 EUR and includes all charges as in the previous case. We chose the same carrier for transport of containers as in the previous case. In the case we chose another route transport time would be prolonged at least 10 days (Hansút, 2015).

Table 3. Maritime transport between Singapore and Hamburg

Route	Distance (km)	Vessel speed (nautical miles/hour)	Time (days / hours)
Suez Canal	15 818	15	23/17
Cape of Good Hope	22 239	15	33/9
Panama Canal	28 869	15	43/7
Strait of Magellan	31 764	15	47/15
Cape Horn	31 882	15 </td <td>47/20</td>	47/20

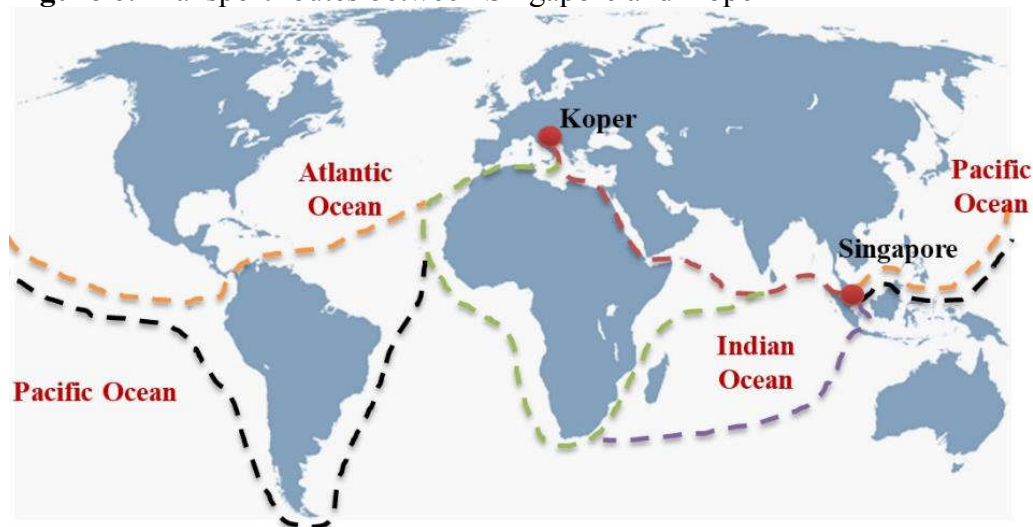
Source: (Sea Distances, 2016)

After arrival of the container ship in the port of Hamburg containers are transhipped on railway wagons. The whole handling process takes about 22 hours. Then, they are transported by railway transport from Germany through the Czech Republics to the terminal Dunajská Streda located in the Slovak Republic. The total length of this transport route is 1.053 km and takes about 30 hours and 9 minutes. The price for transport of one TEU is 650 EUR. (Hansút, L., 2015)

4.3 Singapore - Koper - Dunajská Streda

In this case we also chose the shortest transport route between the ports. It leads through the Strait of Malacca, the Indian Ocean, the Red Sea, the Suez Canal, the Mediterranean and Adriatic Sea (Figure 6).

Figure 6. Transport routes between Singapore and Koper



Source: Authors

The port of Koper that is the part of NAPA (North Adriatic Ports Association) has got a very good position. Transport time (Table 4) between this port and the ports of the Far East is at least one week shorter than between the ports of the North Sea (the port of Rotterdam, the port of Hamburg) and the ports of the Far East. The price for transport of containers is 1.236 EUR on this route. We chose the maritime carrier Evergreen for this transport (Hanšút, 2015).

Table 4. Maritime transport between Singapore and Koper

Route	Distance (km)	Vessel speed (nautical miles/hour)	Time (days / hours)
Suez Canal	11 675	15	17/12
Cape of Good Hope	22 832	15	34/6
Panama Canal	30 564	15	45/20
Strait of Magellan	32 388	15	48/14
Cape Horn	32 503	15	48/18

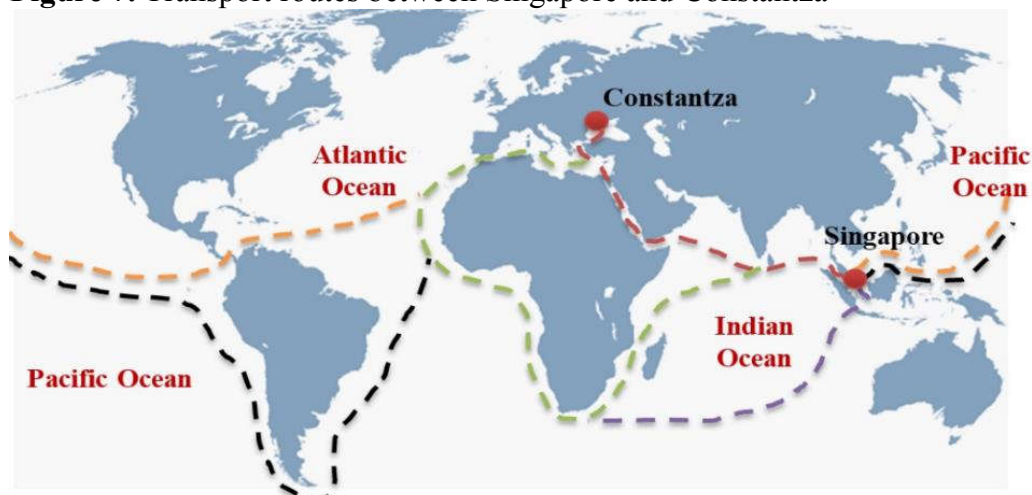
Source: (Sea Distances, 2016)

After arrival of the container ship in the port of Koper containers are transhipped on railway wagons. The whole handling process takes 29 hours. Then, they are transported by railway transport from Slovenia through Hungary to the terminal Dunajská Streda located in the Slovak Republic. The total length of this transport route is 660 km and takes about 24 hours. The price for transport of one TEU is 350 EUR (Hanšút, 2015).

4.4 Singapore - Constantza - Dunajská Streda

In this case we also chose the shortest transport route that leads through the Strait of Malacca, the Indian Ocean, the Red Sea, the Suez Canal, the Mediterranean and Black Sea (Figure 7).

Figure 7. Transport routes between Singapore and Constantza



Source: Authors

The port of Constantza has a very good position due to saving of transport time. It is at least one week shorter than between the ports of the North Sea and the ports of the Far East (Table 5). The price for transport of containers is 723 EUR. We chose the maritime carrier Blue Anchor America Line for this transport. (Hanšút, 2015).

Table 5. Maritime transport between Singapore and Constantza

Route	Distance (km)	Vessel speed (nautical miles/hour)	Time (days / hours)
Suez Canal	11 105	15	16/16
Cape of Good Hope	23 483	15	32/5
Panama Canal	32 216	15	46/20
Strait of Magellan	33 040	15	49/13
Cape Horn	33 155	15	49/17

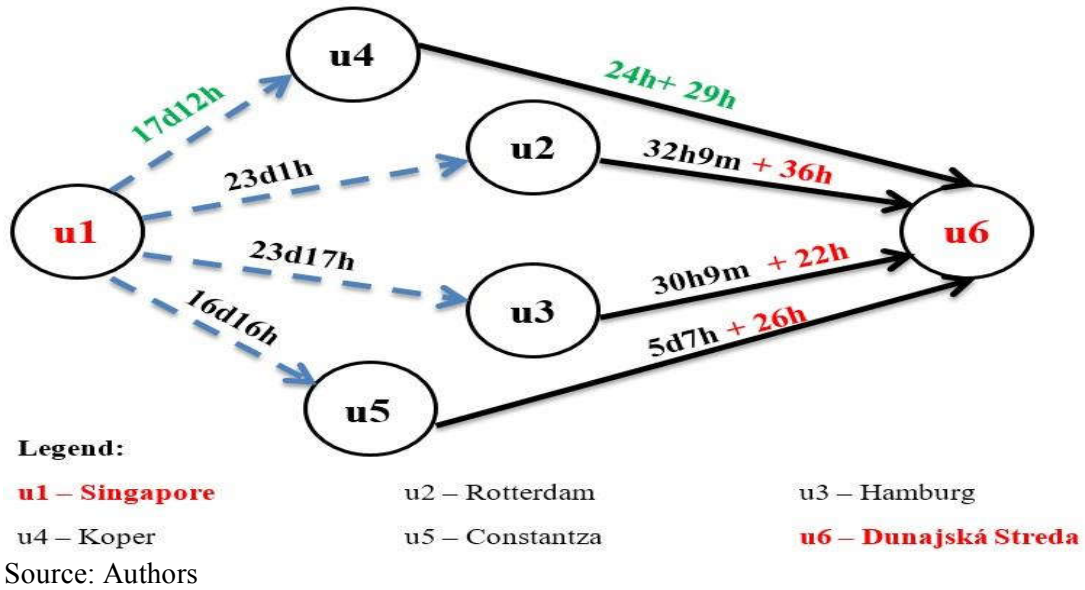
Source: (Sea Distances, 2016)

After arrival of the container ship in the port of Constantza containers are transhipped on railway wagons. The whole handling process takes 26 hours. Then, they are transported by railway transport from Romania through Hungary to the terminal Dunajská Streda located in the Slovak Republic. The total length of this transport route is 1.226 km and takes 5 days and 7 hours. The price for transport of one TEU is 1.000 EUR. (Hanšút, L., 2015)

5. COMPARISON PROPOSED VARIANTS

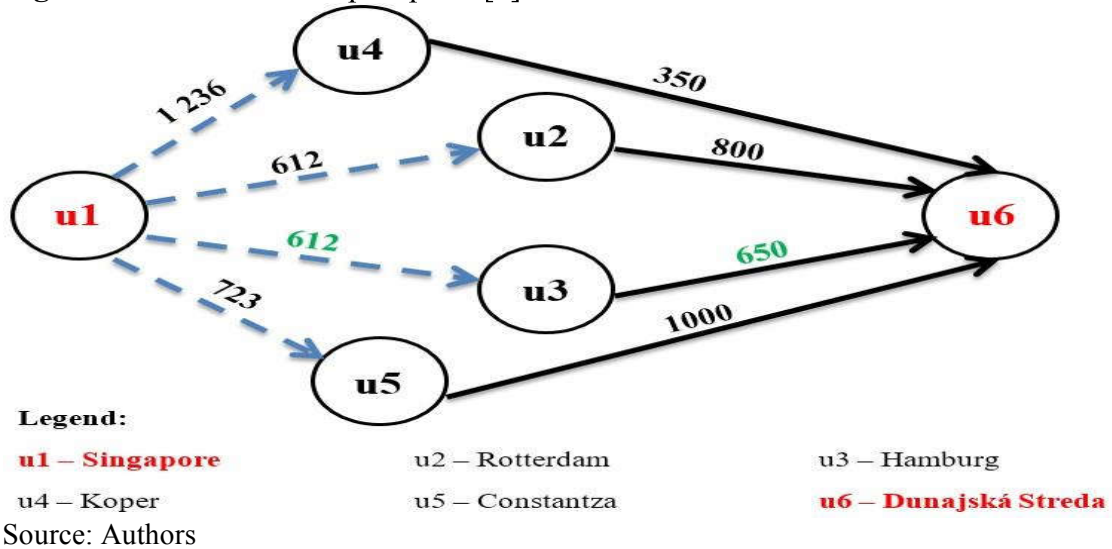
We decided to use the CPM for the determination of optimal transport route between Singapore and Dunajská Streda. Each transport route was evaluated according to total transport time. The shortest transport route would pass through the Suez Canal and the port of Koper and would take 19 days and 17 hours (Figure 8), (Table 6). On the other hand the longest one was the route that passed through the port of Rotterdam or the port of Hamburg. In both cases it was 25 days and 21 hours (Hanšút, 2015).

Figure 8. Criterion: Transport time [day/hour/minute]



For the part of customers transport price is sometimes more important than transport time. From the point of view of transport price the cheapest transport route passed through the port of Hamburg (Figure 9). The total price for this route was 1.262 EUR for 1 TEU. On the other hand the most expensive route was the route that passed through the port of Constantza that was 1.723 EUR for 1 TEU (Hanšút, 2015).

Figure 9. Criterion: Transport price [€]



The comparisons of transport routes from different points of view are presented in the table 6.

Table 6. Table of results

Criterion	Transport route of maritime transport	Value of criterion	Transport route of rail transport	Value of criterion	Total
Transport distance	SGP - RTM	15 349 km	RTM - DS	1 515 km	16 864km
	SGP - HAM	15 818 km	HAM - DS	1 053 km	16 871km
	SGP - Koper	11 675 km	Koper - DS	660 km	12 335km
	SGP - CT	11 105 km	CT - DS	1 226 km	12 331km
Transport time	SGP - RTM	23d 1h	RTM - DS	2d 2h 9m	25d21h9m
	SGP - HAM	23d 17h	HAM - DS	2d 4h 9m	25d21h9m
	SGP - Koper	17d 12h	Koper - DS	2d 5h	19d17h
	SGP - CT	16d 16h	CT - DS	6d 9h	23d 1h
Transport price	SGP - RTM	612 €	RTM - DS	800 €	1 412 €
	SGP - HAM	612 €	HAM - DS	650 €	1 262 €
	SGP - Koper	1 236 €	Koper - DS	350 €	1 586 €
	SGP - CT	723 €	CT - DS	1000 €	1 723 €

Source: Authors

6. CONCLUSION

The critical path method can be used as a tool for the estimation of the duration of a project. It is applied for the projects where durations can be estimated with a high degree of accuracy. The durations are usually known according to past experience and knowledge of the data of previous projects. It means that the durations are not statistically determined. This type of method can be used in logistics and transport.

In our research that was focused on the evaluation of the optimal transport route between the Singapore and Dunajská Streda from the point of duration we found out that the shortest route would go through the Suez Canal and the Slovenian port of Koper and it would take less than 20 days.

However, a lot of customers prefer transport price to transport time. According to our calculation that we did, the cheapest route was the route that led through the port of Hamburg.

At the end everything depends on the decision that the customer will make. If he / she prefers transport time to transport costs or vice versa.

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