DETERMINE THE OPTIMAL ROUTE OF THE ROUTING OF THE SINGLE WAGONS METHOD CPM ON THE NETWORK ŽSR

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Abstract: *In the sector of railway freight transport is considerable part of performance carried out through the transportation of single wagons from the departure station to the destination station which show decreasing trend in the last period. Currently, the transportation of the single wagons is realized according to long term established procedures, which do not take into account its direction on the basis of the optimal costs for the individual carriers on the network of ŽSR. Transportation of single wagons is realized based on train formation, which is regularly analyzed and adjusted on the basis of strength of wagons lane and requirements of the Business Department. By the application of different optimization methods it is possible to achieve reengineering of these procedures and optimize costs. The paper deals with the reengineering of the single wagons routing by application Critical Path Method (CPM) on the selected particular traffic relation on the network of ŽSR. Through application of CPM method and by reengineering of technological processes it is possible to achieve cost savings for the customer as well as for the carrier for the carriage of goods and truncation the delivery time of shipment to the customer as well as to increase the competitiveness of the railway company.*

Keywords: SINGLE WAGON, CPM METHOD, NETWORK OF ŽSR, FREIGHT TRANSPORT,

1. Introduction

The railway transport is integral part of the transport sector of the European Union, and simultaneously, it is one of the ecological means of transport. The decreasing trend of the freight rail transport has coerced European community to strengthen its position and to adopt necessary legislative measures. The directive of the European parliament and the Council 2012/34 of the European Union through which regulates the unified European railway area emphasizes that the member states should adopt such measures which will support rail transport competitiveness and they will take into account individual characteristic features of the railways. [3]

Rail transport market in the Slovakia has constantly changed since 1993. There was only one company in the Slovakia until 2002 – Železnice Slovenskej republiky (ŽSR). This company had been divided into two companies since January 1st 2002 – ŽSR as an administrator and operator, and Železničná spoločnosť a.s. which provided operation of the transport and marketing activities (passenger and freight transport). Finally, three companies started to operate on the transport market after the transformation in 2005 – Železnice Slovenskej republiky, as a manager of the infrastructure, Železničná spoločnosť Slovensko a.s., for passenger transport, and Železničná spoločnosť Cargo Slovakia a.s., for freight transport. The transformation of the rail transport in the Slovak republic is depicted in Figure 1. [2,3]

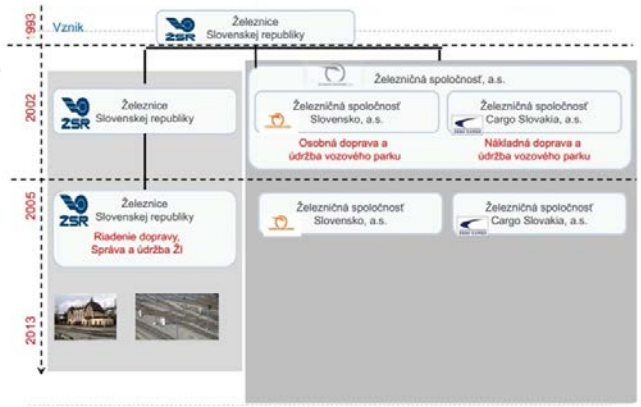

Fig. 1 *Transformation of the rail transport in the Slovak Republic*

Strong competition for customers currently takes place on the transport market among the carriers providing the transport services. The most important thing in the competition game is to best fulfill demands of the customers, which mostly are the delivery in time, at the required place, in the required quality and amount, and mainly for the optimal price.

The considerable part of the performances in the freight rail transport sector is carried out by transport of the single wagon consignments from the station of departure to the station of destination. This kind of transport has recently shown a downward trend. If the companies want this transport to be competitive, it is necessary, not only to adjust the legislation, but also to search the technological possibilities of the transport and shipping process optimization which will lead to better prices and quality of the provided services.

2. Current routing status of the wagon transportation

The contemporary model of the organization of the wagon currents on the Slovak railway network is not based on any freight train composition concept. It has been carried out on the basis of the long term established practices since 1995. The single wagon transport on the Slovak railway network is provided only by national carrier – ZSSK CARGO a.s. The private carriers operating on the Slovak railway market implement solely transport of the direct integrated trains.

The routing of the wagon currents on the Slovak railway network is carried out among the train formation stations. There were 31 formation stations in the network of ŽSR for the period of operating schedule 2014/2015. They are depicted in the figure 2. Some of the stations are enlisted among the main marshaling yards where the direct freight trains are composed; for example Bratislava východ, Zvolen freight station, Žilina – Teplička and Štúrovo. [2,5]

Fig. 2 *Current status of the train formation stations on the network of ŽSR*

The routing for each pair of the train formation stations and between the formation station and station in its yard area is arranged by service aid of ŽSR ***Routing data for the wagon loads***, which

contains regulations of the freight wagon transport routing. The wagon consignments transport is regulated by the directive of ŽSR SR 70 – Transport points classifier of the Slovak railway network according to attachment 1 and the directive D16. The cargo routing in the freight stations is based on the Routing book which is designed for every station.

The single wagon routing is based on the train formation plan of the freight transportation which analyzes and regulates every step according to the requirements of the commercial department. It is done on the basis of the part A – formation of the relational cargo from the routing stations according to cargo table depicted in figure 3.

114 Lisková	**101=101** **111=111** 122,124=**108** 5616=**120** 5680-5683=**108**	103-108=**108** 112=**108** 127-164=**120** 5635=**108** 5687-5696=**120**	110=**110** 120=**120** 165=**108** 5650=**101**
120 Žilina-Teplička	**101=101** **111=111** 122,124=**108** 134=**134** 146=**129** 160=**160** 164=**129** 5616=**152** 5680,5681=**108** 5689,5690=**152** 5696/1=**5696/1**	103-108=**108** 112=**108** 127,129=**129** 135=**135** 148-150=**149** 162=**129** 165=**108** 5635=**108** 5683=**129** 5695=**5695** 5696/2=**5696/2**	110=**110** 114=**114** 131=**131** 138=**138** 152-158=**152** 163=**163** 5650=**101** 5687,5688=**149** 5696 okr 1,2=**5696**

Fig. 3 *Cargo table example*

The transport may be carried out from and to all the stations with dispatching license on the network of ŽSR, from and to all the tariff transfer points, and from and to all the transport cities and points.

3. The characteristics of the Critical Path Method

The Critical Path Method (CPM) is classified among the optimization network models which help to plan the projects and to define the time of their duration on the basis of the length of the so-called critical route. It is possible to analyze and search for critical places or activities in the scheduling of the successive and interconnected activities with the help of this method. One factor is taken into an account in the method – time because the method is also called as the method of time planning. The simplicity and illustration of the solution are two the most important advantages of this analysis which are used in the practice. [4,6]

The critical route may be defined as the longest possible route from the point of time from the beginning point to the endpoint of the diagram. There is always at least one critical route which consists of successive and interconnected activities in every "project" solved by the CPM.

The practical application of this method is mainly used to estimate the total duration of the investigated "project". It is possible to estimate precise duration with the high level. The method may be used for researching in the area of logistics and transport.

It is necessary to follow the steps to fulfill the objective while realizing the "project" with this method: [4,6]

Step 1:

- Identification of the essential activities carried out in the specific "project",
- Division of the activities according to the importance, respectively the sequence of progression
- Specification of the tendering period of the activity,

Step 2:

- Outline the chart with the rim assessment based on the identified project activities and their duration, see figure 4.

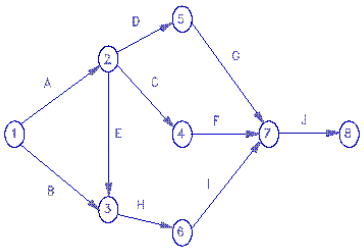

Fig. 4 *– The example of the rim assessment chart*

Step 3:

- Drawing a table for the "project" tendering period calculation itself by means of the calculation sheet, creation of the table in the Excel, or via software application,

Step 4:

- Calculation and allocation of the critical route

The application of the CPM on the specific "project" may help us to find out:

- The duration of the "project"
- Which activities are "critical", i.e. it discovers the activities that have to be done in time.

4. Results and discussion

The application of the CPM within the solving of the "project" of the wagon currents routing optimization among train formation stations on the rail network of ŽSR consists of the solution of their routing based on technical and technological activities which are carried out during the handling of the single wagon in the train formation stations or the service of the manipulation trains which are used for maintenance of the stations in their yard area. The duration of those activities is used to rim assessment.

We will apply this method during the wagon current optimization on the rail network of the ŽSR during the wagon consignment transport from the station of a departure to the station of the destination. Regarding the number of the transport relations and the amount of the optimization possibilities of their routes, we will apply CPM on the chosen relation which will be carried out from the point of transport time from the station of departure to the station of the destination. [2]

To apply the method, we have randomly selected the single wagon consignment relation from the place of the departure to the place of the destination on the rail network of ŽSR: Plaveč – Štúrovo, where there are more varieties to perform the transport, as depicted in figure 5.

Fig. 5 *The variants of the single wagon consignment transport*

The individual variants of the single wagon consignment transport are characterized from the point of view of the transport route, route category and its traction, kilometers distance in the table 1.

Table 1: *The characteristic of the variants*

route direction		line categories	traction	distance (km)
variant 1				
Plaveč	Košice	A	E	88
Košice	Žilina	A	E	242
Žilina	Bratislava	A	E	198
Bratislava	Štúrovo	A	E	128
variant 2				
Plaveč	Košice	A	E	88
Košice	Lenártovce	A	E	115
Lenártovce	Zvolen	B	N	118
Zvolen	Levice	B	E	77
Levice	Štúrovo	C	N	52
variant 3				
Plaveč	Košice	A	E	88
Košice	Margecany	A	E	35
Margecany	Zvolen	93 - C 105 - B	N	198
Zvolen	Levice	B	E	77
Levice	Štúrovo	C	N	52

1st Variant

The wagon load transport route Plaveč - Košice – Žilina – Bratislava – Štúrovo is considered in the first variant. This wagon load will be revised in every train formation station on the route. The kilometer distance represents 656 km.

2nd Variant

The route Plaveč – Košice – Lenártovce – Zvolen – Levice – Štúrovo is considered in the second variant. The wagon consignment is recasted in two ways. Firstly, the wagon consignment is directly transported by a transversal freight train to Zvolen, and secondly, it is carried out by recasting in the railway station Košice. The distance is 450 km, and it represents the saving of 206 km in comparison to the first variant.

3rd Variant

The route Plaveč – Košice – Margecany – Zvolen – Levice – Štúrovo is considered in the third variant. The wagon consignment will be recasted in the each station. The distance is the same as in the second variant, 450 km, thus it also represents the saving of 206 km in comparison to the first variant.

Identification of the essential activities

Identification of the essential activities is the basic step for the calculation application of CPM on the network of ŽSR. Within the wagon current optimization, these activities consist of individual freight train routes which follow one after another after the wagon consignment is recasted in the train formation station or in the shunting yard. While we are solving the selected relation Plaveč – Štúrovo, the activities involve the transport by the transversal freight trains or manipulation freight trains. The activities are divided as follows: [5]

A. The single wagon transport Plaveč – Zvolen,
B. The single wagon transport Plaveč – Košice,
C. The single wagon transport Košice – Žilina,
D. The single wagon transport Košice – Zvolen,
E. The single wagon transport Košice – Margecany – Zvolen,
F. The single wagon transport Zvolen – Levice,
G. The single wagon transport Levice – Štúrovo,
H. The single wagon transport Žilina – Bratislava,
I. The single wagon transport Bratislava – Štúrovo.

The tendering period identification of the activity

All the activities, which help to carry out the single wagons routing from the place of departure to the place of the destination, must have their assessment that determine the chart rims during the CPM calculation. In this case, the individual activities are assessed by the tendering period in minutes.

A. The tendering period of the activity 678 min,
B. The tendering period of the activity 336 min,
C. The tendering period of the activity 967 min,
D. The tendering period of the activity 1 000 min,
E. The tendering period of the activity 573 min,
F. The tendering period of the activity 92 min,
G. The tendering period of the activity 69 min,
H. The tendering period of the activity 204 min,
I. The tendering period of the activity 302 min.

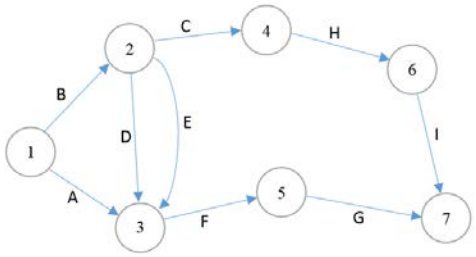

Fig. 6 The chart of the wagon consignment transport activity

The next step for the CPM calculation is to create the table of the activities which follow up one after another during the wagon consignment transport from the station of the departure to the station of the destination. The following up activities are depicted the table 2.

Table 2: *Description of the activities during the goods transport*

Activity	Description of the activity	Tendering period [min.]	Previous activity
A	Single wagon transport	678	-
B	Single wagon transport	336	-
C	Single wagon transport	967	B
D	Single wagon transport	1 000	B
E	Single wagon transport	573	B
F	Single wagon transport	204	A,B,D,E,F,
G	Single wagon transport	369	A,B,D,E,F,G
H	Single wagon transport	204	B,C,
I	Single wagon transport	302	B,C,I,

The application calculation of the CPM was based on the definition of the essential activities and the table in the spreadsheet applicationExcel.

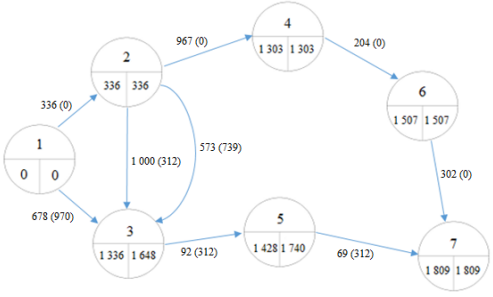

Fig. 7 The CPM calculation

The chart consists of the several parts. The circles represent individual stations on the transport route, where the variant of the transport route is depicted by the connection of the following activities. The circles are divided into three parts and their description is characterized in the following figure.

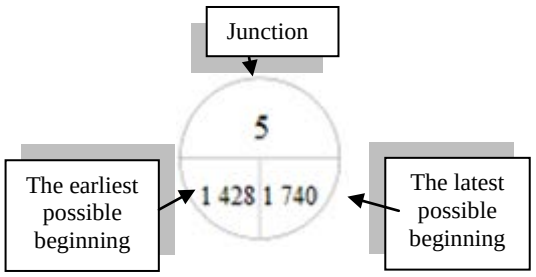

Fig. 8 The junction characteristic

The solution of the optimal route of the wagon consignment transport from the station of the departure to the station of the destination was carried out by three possible variants:

1st variant

Plaveč (1) – Košice (2) – Žilina (4) – Bratislava (6) – Štúrovo (7)

2nd variant

Plaveč (1) – Košice (2) – Lenártovce - Zvolen (3) – Levice (5) – Štúrovo (7)

3rd variant

Plaveč (1) – Košice (2) – Margecany - Zvolen (3) – Levice (5) – Štúrovo (7)

We saved the time of the transport by the comparison of all the variants after we identified critical route with the application of the CPM on the selected transport relation of the wagon consignment and possible transport routes available for the transport.

With the implementation of the CPM, the first variant emerged as the critical route whose tendering period is 1809 minutes without the time slack during the transport from the place of departure to the place of the destination.

The second variant has got two alternative solutions. Variant 2a – the wagon consignment will be directly transported by the freight train from Plaveč to Zvolen, and it will be carried out in Košice without the recast with 1594 minutes of the time slack. Variant 2b – The single wagon will be recasted in Košice and transport route will continue through Lenártovce with 936 minutes of the time-saving.

When we determined the assessment period in the third variant, it resulted in 1363 minutes of the time reserve.

The result of the CPM calculation in the selected relation Plaveč – Štúrovo is the identification of the critical route, which is represented by the first variant where all the activities must follow one another without any time reserve. The most appropriate variant of the transport is the variant 2a where we can save 1594 minutes during the same transport. [6]

5. Conclusion

There is a possibility to achieve time-saving of the single wagon delivery from the place of the departure to the place of the destination and also cost saving for the customers and the carrier. It may be achieved by the optimization of the wagon currents with the usage of the optimization methods and identification of the restrictive criteria.

Based on the calculations by means of the CPM, which is enlisted among the optimization methods, it is possible to achieve considerable time saving of the consignment delivery by the optimization of the single wagon consignment routing. We compared three variants of the transport on the selected relation and we found out that it is possible to achieve time saving of 1594 minutes and to decrease the running time of the wagon consignment by 206 km when all the activities follow one another.

To increase the competitiveness of the rail freight transport, it is necessary to create an effective system of the wagon currents organization, which will take into an account economic criteria of the carriers and simultaneously it will consider the capacity of the infrastructure manager.

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