THE EFFECTIVENESS OF A REGIONAL RAILWAY LINE - CASE STUDY ON THE TRACK HODONÍN - HOLÍČ NAD MORAVOU

Abstract. The effectiveness of regional railway lines has been a much discussed theme recently mainly in case of lines which are not sufficient per the capacity requirements of carriers, or vice-versa, which are utilised only to a minimum extent. The article deals with the assessment of options how to utilise the railway line Hodonín - Holíč nad Moravou with respect to its inclusion into Revision of Transport Expenses document. Based on the analysis of present operation situation in that border crossing as well as on the analysis of passenger and freight railway transport operation various options of utilising the line have been investigated with respect to operation and economic options of individual alternatives.

Keywords: regional railway transport, effectiveness, passenger transport, freight transport, manager of infrastructure

Adrián Šperka¹

¹ Faculty of Operation and Economics of Transport and Communications University of Žilina, Univerzitná 8215/1, 010 26 Žilina; +421/41 513 3434; adrian.sperka@fpedas.uniza.sk

Anna Dolinayová²

² Faculty of Operation and Economics of Transport and Communications University of Žilina, Univerzitná 8215/1, 010 26 Žilina; +421/41 513 3434; anna.dolinayova@fpedas.uniza.sk

Introduction

A regional line is of a local importance; it serves for public railway transport and it runs to a national or another regional line. Transport on such a line is usually characterised with a simplified control and operation of motor wagons, or electric units in passenger transport. In freight transport the fraction on regional lines is provided mostly with handling trains.

The issue of sustainability and operation on regional lines is dealt by Dolinayová et al. (Dolinayová et al., 2017). In their article they point out the importance of regional railway transport in context of an economic growth of regions. Regional railway transport has a non-substitutable place in regions with a higher standard of living, and in case of providing a quality service it leads to a significant improvement of performances (Masek & Kendra, 2013). Gašparík et al. investigated the provision of services in regional passenger railway transport and the interaction of a passenger with an order party of the transport service (Gašparík et al., 2015). An ecological aspect of regional railway and road transport is covered by Skrúčaný et al. (Skrúčaný et al., 2016) who studied the environmental burden caused with road and railway regional transport on the basis of simulating the fuel consumption of a bus and a train on Žilina - Rajec line with a certain amount of passengers. Seidenglanz et al. referred to a diversified organisation of regional public transport in three neighbouring Central European countries: the Czech Republic, Austria and Germany (Seidenglanz et al., 2015). Guihéry considered costs structure of operating regional railway passenger transport before and after competition and showed that the introduction of competition in Leipzig region had reduced the level of subsidy by 20 %, and improved productivity of the incumbent operator (Guihéry, 2014).

Advantages of regional railway transport mostly include a small negative environmental burden. However,

there are also railway lines where performances of railway transport drop from year to year and railway transport is replaced with other modes of transport, mostly the road one.

The railway line Hodonín (CZ) - Holíč nad Moravou (SK) is one of such lines. Passenger transport was stopped here in December 2004 and freight transport was stopped here even at the beginning of the 90s in the 20th century, in spite of the electrification (25 kV/50 Hz) which was finished in December 1987. Thus there in the Slovak section this line was listed in Revision of Transport Expenses document, which was prepared by the Ministry of Transport and Construction of the Slovak Republic in order to reduce costs expended on railway lines where railway transport was operated only in small extent or not at all. This document contains more than 25 railway lines in the territory of the Slovak Republic operated by Železnice Slovenskej republiky (ŽSR, in English: Railways of the Slovak Republic).

1. Methodology

A railway line creates a transport route for rail vehicles in order to provide railway transport. The railway infrastructure is built, maintained and operated by the government through ŽSR, a manager of the infrastructure (Ministerstvo dopravy a výstavby SR, 2011).

Whether the operation and maintenance of a railway line is effective or not, and to what extent, is observed using indicators anchored in the Contract for the Operation of Railway Infrastructure. It is a contract between the Ministry of Transport and Construction and ŽSR. The current contract has been concluded for the period 2017 - 2021. Usually it is made for 4 years and it contains rights and duties of both parties, as well as sanctions in case of not fulfilling conditions of the contract. Table 1 lists individual groups of indicators and their corresponding indicators (Železnice Slovenskej republiky, 2016).

Table 1. Indicators of Contract for the Operation of Railway Infrastructure

Group of Indicators	Indicator
Operation	Length of lines in km
	Categorisation of lines
	Number of transport points for passenger and freight transport
	Throughput of line sections
	The highest line speed
	Accidents caused by a manager of infrastructure by categories
Performance-related	Regular scope of train transport
	Utilisation of a forward performance of a line section
	Degree of occupancy of a line section with regular transport
	List of carriers
	Number of employees who guarantee the subject of the Contract for the Operation of Railway Infrastructure
Qualitative	Standards of railway lines and stations
	Fulfilling of a line timetable
	Full overviews of deviations from construction parameters of operated lines
Economic	Summary transport performances of a minimum access package and line access to facilities of passenger and freight transport, as well as to facilities of the carrier
	Proceeds out of the fee for railway infrastructure within the division into passenger and freight transport, and the carrier
	Cost rate
	Performances expressed in train kilometres and gross tonne-kilometres
	Total real revenues and costs per a line section

Individual indicators are observed by a manager of the infrastructure in more detail in the module Controlling within the SAP ECC System. Quarterly a qualitative indicator of a full overview of deviations from construction parameters of operated lines is evaluated. Half-yearly economic indicators of summary transport performances and proceeds out of the fee for railway transport route are evaluated. Other indicators are evaluated annually (Dolinayová & Nedeliaková, 2015).

To verify a forward performance in chapter 4 we will use the methodology of a theoretical forward performance of ŽSR which is characterised with the following steps (Gašparík & Šulko, 2016):

- in the first table there are multiples of number of trains N_1 and N_2 which represent the number of trains,
- in the second table there are times of occupancy of an interstation section with individual sequences of trains,
- total time of occupancy T'_{obs} is calculated as a sum of multiples of a product of the number of trains of a given sequence, and unit time of occupancy of the given sequence, i.e. matching cells of both tables are multiplied,

- value T'_{obs} will be increased in 10 %,
- time of occupancy is calculated as a share of increased time of occupancy and the number of trains,
- average time of occupancy t_{obs} and time of intervals t_{medz} is determined,
- required time of intervals is found per the regulation ŽSR D 24,
- actual time of intervals will be compared with the required one $t_{medz}^{poz} \leq t_{medz}^{sk}$,
- a prospective practical throughput as well as other qualitative indicators of a line timetable will be calculated.

The rate of occupancy is represented with an indicator of the degree of occupancy s_o . The degree of occupancy is a ratio of the total time of occupancy T_{obs} of the investigated operation facility and the total calculation time T (usually 24 hours) which is reduced with the time required for maintenance and repairs $T_{výl}$ and occupancy of permanent handlings $T_{stál}$ (Gašparík & Šulko, 2016).

$$s_o = \frac{T_{obs}}{T - (T_{výl} + T_{stál})} \quad (1)$$

A line timetable is considered sufficiently occupied when it shows a degree of occupancy from 0.5 to 0.67. The degree of occupancy is a dimensionless number (Gašparík & Šulko, 2016).

2. Operation-Technical Characteristics of the Line Section Hodonín - Holíč nad Moravou

After a dissolution of Czechoslovakia on January 1, 1993 and origin of two sovereign states of the Czech Republic and Slovak Republic the originally domestic line became one of the shortest interstate lines connecting two states.

The railway border crossing Hodonín - Holíč nad Moravou comprises (Železnice Slovenskej republiky, 2018):

- the frontier transitional station Hodonín,
- the frontier station Holíč nad Moravou,
- the frontier line.

2.1. The Frontier Transitional Station Hodonín

RS Hodonín was made available to public on May 1, 1841. Alongside on that date there was an operation on the line Břeclav - Uherské Hradiště initiated.

In 1999 - 2000 RS Hodonín underwent a complete reconstruction including the modernisation of a station interlocking plant and access for disabled passengers. Currently the interlocking plant is controlled from CDP Přerov. Table 2 contains the number and type of tracks located in RS Hodonín (Pagáč, 2018).

Table 2. The Number and Type of Tracks in RS Hodonín

Type of a Station Track	Number
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transport	19
handling	22
other	5

There passes the 2nd transit corridor of Správa železniční dopravné cesty (SŽDC, in English: Railway Infrastructure Administration) through RS Hodonín. There run 5 active sidings into RS Hodonín.

In RS Hodonín there are the following services available for passengers (České Dráhy, 2018):

- international and domestic ticket office with the option to pay with a card or cash (also in € currency),
- integrated transport system with the option to validate the ticket in a stamping machine,
- bike rental service,
- waiting room,
- toilet for the disabled,
- exchange office operated by the company České Dráhy, a. s. (in English: Czech Railways),
- left-luggage office.

At the same time the RS is equipped with elevators and guide elements for visually handicapped passengers.

RS Hodonín does not provide any equipment (side or front ramp, customs clearance, derrick, etc.) for carriers in freight transport (ČD CARGO, 2017).

2.2. The Frontier Station Holíč nad Moravou

Railway station Holíč nad Moravou was made available to public on October 27, 1891. On that date there was also an operation on the line Hodonín - Holíč nad Moravou initiated.

The rail yard and dispatch shed have not undergone a considerable reconstruction. In RS there is a station interlocking plant of the 1st category activated - group light signals independent on the position of changes with manually reset changes. There in Table 3 is the type and number of tracks in RS Holíč nad Moravou listed (VLAKY.NET, 2004).

Table 3. The Number and Type of Tracks in RS Holíč

Type of a Station Track	Number
transport	8
handling	3
other	2

Through RS Holíč nad Moravou there also passes a line joining Kúty and Skalica in Slovakia. In RS Holíč nad Moravou there between the last and the first train in the line timetable a traffic closure of the transport service is introduced; its duration always changes to the date when the line timetable comes into force.

Passengers can wait in a waiting room, however, in the RS there is no ticket office. Tickets can be purchased via the Internet or another alternative selling channel, or at

a conductor on the train (Železničná spoločnosť Slovensko, 2016).

In freight transport there is a side ramp available to carriers; it is located on the track No. 4 and its surface area is 170 m². The station is not occupied by an employee of the carrier since handing of shipments in and out is performed during the stay of a handling train (Železničná spoločnosť Cargo Slovakia, 2018).

2.3. The Frontier Line

The interstation section Hodonín - Holíč nad Moravou is a single-track section and it is electrified with an alternate traction supply substation 25 kV/50 Hz (Železnice Slovenskej republiky, 2018). The electric operation began on December 3, 1987. Currently it is used only in case of a route deviation within passenger and freight transport, which happens only to a minimum extent (Tomančák, 2000). Table 4 lists a characteristics of the interstation section as it is introduced by Local convention for carriers in the given border crossing (Železnice Slovenskej republiky, 2018).

Table 4. The Characteristics of the Interstation Section

Position of the state border	km 3.009
Distance from axes of dispatch sheds of neighbouring RSs	6.543 km
Boundary of the frontier line	RS Hodonín - entry signal HS on km 0.990
	RS Holíč nad Moravou - entry signal HS on km 5.900
Stops on the line	Hodonín stop on km 2.100
The highest permissible line speed	60 km.h ⁻¹
Braking distance	400 m
The biggest length of the train including a railway tractive vehicle	665 m
The biggest admissible weight on axle	22.5 t (Hodonín - km 2.920)
	20.5 t (km 2.920 - Holíč)
The biggest admissible weight on a standard meter of a wagon	8 t/m (Hodonín - km 2.920)
	7.2 t/m (km 2.920 - Holíč)
Line class	D 4 (Hodonín - km 2.920)
	C 3 (km 2.920 - Holíč)
Line interlocking plant	a relay semi-automatic block with a check of the line freedom and axle counter

In the interstation section there is also Hodonín stop located. It is accessible for the disabled, however, in the stop there is no ticket office. The stop is plotted in Fig. 1.

Figure 1. Hodonín Stop

In the interstation section there are 6 bridges in total, out of which 5 are located in the territory of the Slovak Republic. One of bridges is built above Morava river; it connects the Slovak and Czech Republic. This bridge was reconstructed in 2008 (Železnice Slovenskej republiky, 2018).

3. The Analysis of the Current State of Railway Transport on the line Hodonín - Holíč nad Moravou

Despite a relatively high provision of train drive and electrification this line is utilised less and less from year to year.

The number of connections of passenger transport trains has been relatively stable during its operation, influenced only with historic events (World War II.). Table 5 contains numbers of individual trains in different periods of operation since 1938 up to 2004 when the operation of passenger transport was stopped (VLAKY.NET, 2017).

Table 5. The Number of Passenger Transport Trains During a Week

Line Timetable	Holíč nad Moravou - Hodonín	Hodonín - Holíč nad Moravou
1938/1939	7	7
1941/1942	3	3
1947/1948	10	10
1950/1951	10	10
1958/1959	14	13
1968/1969	13	12
1976/1977	12	12
1979/1980	12	12
1982/1983	13	13
1988/1989	12	12
1989/1990	12	12
1991/1992	12	12
1994/1995	12	12
1995/1996	10	10
1996/1997	9	9
1998/1999	5	5
2002/2003	4	4
2003/2004	4	4

The number of trains mostly achieved 10 trains in both ways. Most of trains were driving on the line within the line timetable 1958/1959, when there in the way Holíč nad Moravou - Hodonín almost 14 trains were driving on weekdays. A sharp decrease happened within the line timetable 1941/1942, when the operation on the line was affected by the World War II. Since the 90s in the 20th century the number of connections was gradually falling down.

On September 28, 1997, i.e. when the 1st change of the line timetable 1997/1998 occurred, the operation of passenger transport was stopped at the weekends and on holidays. This operation was provided by bus transport. Since the line timetable 1998/1999 there were only 5 trains driving on the line in both ways, and in the line timetable 2003/2004 the number was reduced to 4 trains only. On December 10, 2004 the operation of passenger transport was completely stopped on the line. Performances of passenger railway transport were taken over by bus transport (VLAKY.NET, 2017).

With respect to limiting elements described in the previous part the freight transport has never been too intensive. It was the electric operation which should have provided the deviation fraction of freight trains out of RS Břeclav, which was significantly overloaded already in the late 80s. In 1991 the operation of freight transport was stopped; even that minimum number of freight trains was returned back to their original route via RS Břeclav (Tomančák, 2000).

A low utilisation of this line is proved with statistic data obtained from the directorate of ŽSR from 2011 to 2018 introduced in Table 6.

Table 6. A Summary Comparison of Performances of Railway Transport

Line Timetable	Number	Train-Kilometre	Gross Tonne-Kilometre	Revenues
2010/2011	724	2,178.516	73,837.851	2,048.55€
2011/2012	726	2,184.534	91,771.491	1,990.42€
2012/2013	681	2,049.129	85,657.203	1,921.02€
2013/2014	2	6.018	433.296	6,- €
2014/2015	1	3.009	147.441	3.37 €
2015/2016	2	6.018	433.296	6,- €
2016/2017	0	0	0	0,- €
2017/2018	0	0	0	0,- €

Since the 1st change of the line timetable 2010/2011, i.e. March 6, 2011, there in the railway depot Hodonín armament of engine units, series 813/913, of the carrier ZSSK, a. s., took place which provided the fraction of passenger trains in the session Kúty - Skalica in Slovakia. Thanks to this the line was utilised. Every day the armament was provided with one pair of a train set. In December 2013 the cooperation was ended and performances on this line were reduced to minimum (Tomančák, 2012).

Freight transport was provided only with engine trains of freight transport which utilised the line in case of deviations.

Since the line timetable 2016/2017 the line has been utilised only to a minimum extent, occasionally for actions of railway enthusiasts and for drives organised with Railway Museum of the Slovak Republic

4. Results and Discussions

With respect to the analysis of the current state of railway transport on the given line we have focused our research on these three areas:

- utilisation of the line for deviations while reconstructing the IVth transit corridor, namely the section Kúty - Kúty, the state border,
- restoration of passenger transport on the given line based on requirements of passengers, arising from a questionnaire research,
- change of a route of freight trains in the direction Kúty - Břeclav - Přerov, and back via the border crossing Holíč nad Moravou - Hodonín.

4. 1. Utilisation of the Line for Deviations

The line section Kúty - Kúty, the state border, is part of the IVth transit corridor and at the same time it is part of the main line of the 7th RFC corridor. Due to these reasons a complex reconstruction of the section for the speed 160 km.h⁻¹ is planned.

The entire reconstruction project of the section will run simultaneously with the reconstruction of the section Devínska Nová Ves - Malacky. The whole reconstruction will be co-financed with the European Union through CEF, a tool for linking Europe (Železnice Slovenskej republiky, 2018). Figure 2 plots the site of realising the traffic closure works.

Figure 2. The Site of the Project Realisation

While realising the traffic closure works one of two line tracks will always be free. Since the traffic closure works will run on two sections simultaneously, some measures will be required in both passenger and freight transport (Šulko, 2019). Table 7 describes the traffic closure measures in passenger and freight transport as they

are scheduled by the manager of the infrastructure (Šulko, 2019).

Table 7. The Traffic Closure Measures

Measures in Passenger Transport	Measures in Freight Transport
Passenger trains will be cancelled in the section Kúty - Břeclav and they will be replaced with replacement bus transport	Nex and Pn trains in the branch Štúrovo - Kúty will be re-routed through Trnava and Jablonica
For other train categories their travelling time will be extended	Handling trains in the section Kúty - Kúty, the state border, do not drive

After reducing the number of passenger transport trains to 28 trains per day, the limiting section will not be the section Kúty - Kúty, the state border, but the section Sered' - Trnava, where only 24 trains can fit according to the Book of the Throughput of ŽSR. During the traffic closure there would 52 trains in the section Kúty - Kúty, the state border, drive.

To verify the forward performance the methodology of a theoretical forward performance of ŽSR was applied; it is characterised in more details in Chapter 1. It is plotted in Figures 3 and 4.

Sledy vlakov		Druhý vlak							
Názov podvozku		R pámy	R nepámy	Ox pámy	Ox nepámy	Pn pámy	Pn nepámy	Mn pámy	Mn nepámy
Prvý vlak	Pečet	7	7	*	*	6	6	*	*
R pámy	7	48	48			42	42		
R nepámy	7	48	48			42	42		
Ox pámy	*								
Ox nepámy	*								
Pn pámy	6	42	42			38	38		
Pn nepámy	6	42	42			38	38		
Mn pámy	*								
Mn nepámy	*								

Figure 3. Products of the Number of Trains Sequences

Time of occupancy (t_{obs}) for individual categories of trains is as follows (Železnice Slovenskej republiky, 2018):

- Ex trains share the same time of occupancy of the interstation section: 7 minutes,
- Pn train of an even direction features the longest time of occupancy of the interstation section: 12 minutes,
- Pn train of an odd direction features the longest time of occupancy of the interstation section: 11 minutes.

Sledý vlak		Druhý vlak							
	t_{obs}	R pájny	R nepájny	Os pájny	Os nepájny	Pn pájny	Pn nepájny	Mn pájny	Mn nepájny
Prvý vlak	Počet	7	7	.	.	6	6	.	.
R pájny	7	14	14			20	19		
R nepájny	7	14	14			20	19		
Os pájny	.								
Os nepájny	.								
Pn pájny	6	20	20			26	25		
Pn nepájny	6	19	19			25	24		
Mn pájny	.								
Mn nepájny	.								

Figure 4. Times of Occupancy with Individual Trains Sequences

The direct time t_{obs} must be added with the indirect time t_{obs} , which represents an interval of crossing in RS Kúty and RS Lanžhot. In both RSs the interval will be the same - 1 minute, with respect to matching types of a station interlocking plant (electronic interlockings). The calculation of the practical throughput (n_{prakt}) is to be added with 90 minutes of time of the traffic closures ($T_{výl}$). Table 8 summarises individual resultant values which are used to make a conclusion (Gašparík & Šulko, 2016).

Table 8. Resultant Values Required for the Calculation

Indicator	Value
$\sum T'_{obs}$	12,272 min.
T''_{obs}	13,499.2 min.
T_{obs}	259.6 min.
t_{obs}	4.99 min.
t_{medz}^{sk}	22.7 min.
t_{medz}^{poz} per the regulation D 24	9.4 min.
$t_{medz}^{poz} \leq t_{medz}^{sk}$	true
n_{prakt}	92 trains/24 hours

When one of two line tracks is excluded, the practical throughput is 92 trains per 24 hours, which is 40 trains more than expected 52 trains per 24 hours. This implies that re-routing under a favourable operation situation will not be required, however, with respect to a stochastic nature of the railway transport industry the necessity to re-route the trains cannot be ruled out. Therefore it would be appropriate to keep the line.

4.2. Restoration of Passenger Transport on the Basis of a Marketing Survey

Using a questionnaire survey realised in 2017 - 2019 inhabitants of towns Holíč nad Moravou and Hodonín were asked for their potential interest in restoring the

passenger transport. Table 9 represents places, dates and types of surveys which were realised in order to find out a potential of restoring the passenger transport.

Table 9. Realisation of the Survey

Date	Town	Type
2. 2. 2017	Holíč nad Moravou and Hodonín	Direct address in a field
4. 3. 2017	Holíč nad Moravou	
11. 3. 2017	Hodonín	
24. 6. 2018 - 16. 4. 2019	-	Internet survey

Both questionnaires contained several open questions as well as multiple-choice questions. The purpose was to find out and analyse habits of passengers before and after stopping the passenger transport, as well as the option to transit to railway transport in case of restoring the passenger transport. Altogether there were 15 questions and some space for comments in both questionnaires. Moreover, preferred selling channels were investigated. Figure 5 plots results of individual surveys.

Figure 5. Interest in Restoring the Passenger Transport

The black colour is used to express the respondents' interest in restoring the passenger transport in 2017, and the blue colour is used to express the respondents' interest in restoring the passenger transport in 2018 and 2019. In 2017 the questionnaire was completed by 200 respondents, and in 2018 and 2019 the questionnaire was completed by 40 respondents. This second Internet questionnaire was only a supplementary one, serving to find out a change of the state when compared to 2017. The change in passengers' preferences was negligible.

Based on the results of the questionnaire survey there exists a potential to restore the passenger transport. A potential restoring should meet qualitative and quantitative requirements when creating the timetable. Table 10 lists some selected qualitative and quantitative requirements which are recommended to be met when creating the timetable. They should attract as many passengers as possible.

Table 10. Requirements of Timetable

Quantitative Requirements	Qualitative Requirements
Frequency of connections	Speed
Number of selling channels	Accessibility for the disabled
Number of seats	Easy-to-remember timing timetable
	Continuity of connections
	Integration

After meeting these basic requirements, the restoration of passenger railway transport would be an interesting alternative to current transport options between the towns Hodonín and Holíč nad Moravou.

4.3. Re-Routing of Selected Freight Trains

Selected freight trains driving on the route Kúty - Břeclav - Přerov could be re-routed via the border crossing Holíč nad Moravou - Hodonín after meeting the limiting conditions. There are the following limiting conditions:

- a standard of length,
- a standard of weight.

If a train passed without stopping through the section Kúty - Holíč nad Moravou - Hodonín, the standard of length would be irrelevant. With respect to the stochastic character of railway operation it would, however, be risky to ignore the standard of length. In Table 11 there are limiting conditions for the line section Kúty - Holíč nad Moravou and Holíč nad Moravou - Hodonín worked out (Železnice Slovenskej republiky, 2018).

Table 11. The Standard of Length of Limiting Sections

Section	Standard of length
Kúty - Holíč nad Moravou	530 m
Holíč nad Moravou - Hodonín	665 m

The limiting section is not the section Holíč nad Moravou - Hodonín, but the section Kúty - Holíč nad Moravou, a freight train would have to pass through. A limiting RS is Gbely, where the longest track is 530 m long. The following table contains examples of a standard of weight for selected railway tractive vehicles used most frequently by carriers (Železnice Slovenskej republiky, 2018).

Table 12. The Standard of Weight for Selected Locomotives

Section	Type of Resistance	Locomotive Series	Standard
Kúty - Holíč and back	S	230, 363	2,000 t
	T		2,200 t
	S	E 189	2,400 t
	T		2,600 t
Hodonín - Holíč	S	230	2,200 t
	T		2,500 t
	S	363	2,200 t

	T	363.5	2,500 t
	S		2,350 t
	T		2,800 t
Holíč - Hodonín	S	230	1,600 t
	T		1,800 t
	S	363	1,600 t
	T		1,800 t
	S	363.5	1,700 t
	T		2,000 t

The standard of weight was determined for locomotives, series 230 and 363, always with one active locomotive. These are the most often used types of locomotives by Slovak carriers. Besides, series 210, 740, 742, 753, 754 and others are also allowed to transit through the border crossing.

The biggest standard of weight is 2,800 t in the section Hodonín - Holíč when the locomotive, series 363.5, is used.

Conclusion

Regional railway transport is an important part of the national transport system. Despite some regional lines have been showing a low utilisation for longer time it is necessary to study their effectiveness with regard to synergic effects. Our research has shown that the line in question has its potential; moreover it is electrified with an alternate voltage system 25 kV/50 Hz, which increases its options of utilisation and at the same time it represents an environmental alternative to road transport.

Acknowledgment

The paper was supported by the VEGA Agency, Grant No. 1/0019/17 "Evaluation of regional rail transport in the context of regional economic potential with a view to effective use of public resources and social costs of transport", at Faculty of Operations and Economics of Transport and Communication, University of Žilina, Slovakia.

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