The Possibilities of Increasing the Economic Efficiency of Regional Rail Passenger Transport—A Case Study in Slovakia

Anna Dolinayova and Lenka Cerna

Abstract Short-distance rail passenger transport is regarded as a service of public interest in almost all EU countries. With regard to European Transport Policy and measurements proposed in the Fourth Railway Package, it is necessary to improve the quality of rail passenger transport services, so it reflects customers' requirements, and the optimal utilisation of public resources. Opening the market of this rail passenger transport segment may, however, not bring expected results. The efforts to reduce a drain on public resources may induce a lower quality of services and lower performance of rail services. Public passenger transport represents only one quarter of the total share of passenger transport on the Slovak transport market where the share of rail passenger transport is approximately 9.4%. A separate issue is the impact of a zero fare, introduced in November 2014, on the attitude of the public on rail transport. As a result, the interest of the public in travelling by passenger trains has increased, but at the same time, the quality of provided services has been impacted significantly. This paper outlines how selected technical, technological and other factors influence the efficiency of providing services within a rail passenger transport segment in a selected urban agglomeration. The results suggest; applying a tariff system and setting quality standards of services for rail passenger transport.

Keywords Rail transport · Short-distance · Passengers · Efficiency · Tariff system · Quality

1 Introduction

The analysis of rail transport development in the EU and the Slovak Republic, in the context of strategic transport-political objectives, points to positive development in rail passenger transport. The declaration of a state transport policy in the Slovak Republic is similar to the principles of the EU. The emphasis is on utilising rail

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transport as a more environmentally friendly mode of transport (Strategy PPT 2020 2015).

The measurements of the Fourth Railway Package contribute to creating a more efficiently working industry which better responds to customer needs and improves the relative attractiveness of the rail transport industry concerning other modes of transport (Fourth railway package 2016). All measurements in the Fourth Railway Package make it easier for new rail operators to enter the rail transport market. Synergies will be achieved through a combined effect of individual initiatives. The efficiency of opening the market is dependent on the introduction and efficient application of certain "frame conditions", such as non-discriminatory access to infrastructure, access to appropriate rail locomotives, access to stations or assignment of a train route including the traffic management. Some of these frame conditions will be solved through initiatives related to the market opening with services of domestic rail passenger transport. The other ones will be solved through a proposal related to strengthening and empowering infrastructure management. To reduce obstacles for new participants entering the market, some synergies should be achieved by setting simplified procedures for issuing safety certificates for rail enterprises as well as permissions to put rail vehicles on the market (Strategy for DTI by 2020 and Fourth Railway Package 2016).

Liberalisation of the passenger transport market in the Slovak Republic has not resulted in a higher share of rail transport in the potential transport market. The increase of passengers on trains in the Slovak Republic has been evoked mainly due to subsidised fares as a result of Government regulations (free transport) as well as competitors entering the market with low prices. The increase of a rail transport share is based on a combination of a competition and commercial principles, orders for public services, and regulatory measurements (Strategy for DTI by 2020).

The methodology used in this paper is divided into several parts, and its primary goal is to study the possibilities of increasing economic efficiency of regional rail passenger transport through the optimal establishment of processes on the analysed part of the railway line in question. This will bring cost savings and ultimately increase economic efficiency while preserving quality standards of public passenger rail transport. In order to achieve this scientific method, individual steps will be used. The first part of the methodology describes the observed problem, which deals with the analysis of the development of public passenger railway transport in the Slovak Republic. We will examine selected factors influencing the efficiency of services provision in the railway passenger transport segment in the selected agglomeration. During the research, the number of passengers transported in individual modes of transport is analysed.

Passengers traveling free are also studied. Collected information, complexity and depth of examined indicators were the basis for creating a research plan which identified individual phases, methods and procedures. The following part of the methodology contains an analysis of the occupancy of the trains and the analysis of the timetable on the selected part of the railway line. On the basis of these analyses, the possibility of optimising the train journeys and the circuit of the rail vehicles need for the service operation on the selected part of the railway line is identified. The

conclusion of the methodology is supplemented by the calculation of the economic efficiency of rationalisation measures based on the monitoring of the cost of the proposed solution. The methodology represents a sequence of steps to ensure an increase in the economic efficiency of rail passenger transport in the monitored region.

2 Literature Review

Many authors have been dealing with the issue of economic efficiency of public passenger transport and associated influencing factors. Fitzová et al. (2018) identified factors impacting the efficiency of urban public transport systems in the Czech Republic. An innovative approach to the evaluation of public bus transport efficiency was introduced by Avenali et al. (2018) who tried to apply a hybrid model of costs in order to determine standard unit costs of local public bus transport. As the authors state, the results of such an evaluation may be a useful foundation for defining financial compensation of services within local public bus transport.

The economic efficiency of a railway system has recently been a topic discussed by economists in every European country as well as in countries out of Europe where rail transport works well (Catalano et al. 2019; Dolinayova et al. 2017). The productivity of the railway systems is constrained by the existing rail infrastructure (Marinov et al. 2013). Stoilova (2018) researched the development of rail passenger transport in the European Union countries by using criteria related to the transportation process and the level of economic development of the countries. In her study, she proposed a methodology based on a combination of multi-criteria methods with economic and social factors selected as primary criteria. Fraszczyk et al. (2016) studied various indicators impacting railway performance using available statistic data. This study identified the economic efficiency of regional railway transport could be increased by more effective utilisation. Simulation models can be used to analyse the use and productivity of railway lines (Singhania and Marinov 2016). On the other hand, the most critical factors in the use of railway transport relate to passenger behaviour (Rüger, 2017), travel time (Weerawat et al. 2017) and other quality factors.

The Fourth Railway Package (Fourth Railway Package 2016) proposes many measurements for increasing railway performance. Individual countries have been introducing some reforming measurements which contribute to stronger competitiveness of a rail transport system including a shift of modal split in favour of the railways. However, have the reforms brought an expected effect? Studies of single authors do not show precise results. Smith et al. (2018) studied the impact of reforms in rail transport on its efficiency with results suggesting that the cost reduction arising from a regulatory reform depends on the degree of the market opening (actual or desired), vertical structure and intensity of the network usage.

Reforms in individual EU countries may not always bring positive effects in the area of costs. Growitsch and Wetzel (2009) analysed 54 railway companies from 27 European countries. Their research showed that “integrated railway companies

are, on average, relatively more efficient than "virtually" integrated companies and that a majority (65 percent) of the railway companies observed indicate economies of scope" (Growitsch and Wetzel 2009). Bogart and Chaudhary (2015) studied the influence of state ownership on railway performance in India. Their results showed that state ownership was not worse than private ownership. Despite the majority of documents showing that introducing the competitiveness in rail transport (on a passenger and freight market) has had a positive impact from efficiency and productivity points of view, the study of the impact of vertical separation has brought various results (Cantos et al. 2012). Implementation of reforms may, however, increase the attractiveness of rail transport to customers and bring synergistic effects of the liberalisation of the railway transport market (Panak et al. 2017).

Considering that the economic efficiency of passenger rail transport is different in individual countries, the implementation of reforming measurements does not always increase efficiency. Therefore, we have decided to research the options of its increase, no matter if services are provided by the state or a private carrier. We performed an analysis of public passenger transport in the Slovak Republic using a case study in a selected agglomeration. We demonstrated how the costs of providing short-distance rail passenger services could be reduced based on non-investment measurements.

3 Analysis of Public Passenger Rail Transport in the Slovak Republic

A basic prerequisite for increasing the attractiveness of public passenger transport is the need to improve individual connections and links, by individual carriers, in all transport modes in the whole territory. Public passenger rail transport in Slovakia is a result of European Transport Policy, Principles of State Transport Policy of the Slovak Republic and the Transport Development Strategy of the Slovak Republic by 2020. It conforms to Regulation (EC) No 1370/2007, Act No 513/2009 Coll for the railways and amendments of some acts and Act No 514/2009 Coll on transport on the railways (Strategy for PPT by 2020 2015).

The Transport Development Strategy of the Slovak Republic by 2020 (a resolution of the Government of the Slovak Republic No 158 of 03 March 2010) is an underlying document which defines fundamental long-term goals, priorities of transport development in the Slovak Republic, and tools and resources required to achieve the goals. It represents a ground for preparing other conceptual ideas and vision of the Ministry of Transport and Construction of the Slovak Republic for formulating the position of the Slovak Republic towards a future European Transport Policy. The Transport Strategy complies with conceptual materials adopted at EU levels, such as the Lisbon Strategy, the Gothenburg Strategy and the Transport Policy of the EU.

Private carriers organise rail passenger transport in the territory of the Slovak Republic in cooperation with the Ministry of Transport and Construction of the Slovak Republic. In some relatively small areas of self-governing regions, central order-

ing of rail transport enables efficient operating of regional transport. Regional transport is currently provided by the following carriers: Železničná spoločnosť Slovensko ("ZSSK, a. s.") and RegioJet ("RJ"). The planning of regional transport is based on Economic and Social Development Plans, Territorial Plans, and (if worked out) Transport Operation Plans and Territorial Generals of Transport (Daniš et al. 2016).

3.1 Support of the European Transport Policy for the Development of Public Passenger Rail Transport

For more than 25 years transport policy of the EU has been oriented at building a sustainable and competitive transport system. Transport-political measurements, to support rail transport in order to increase its share on the transport market, have been integral parts of the EU policies for the long term. Rail transport has ambitions to significantly contribute to the fulfilment of the EU strategy which is mainly focused on increasing the competitiveness as well as durable economic, social, environmental and energetic sustainability, cohesion and safety (White Paper 2011).

In the White Paper 2011 on Transport the Commission, the EU introduced its vision for the provision of a Single European Rail Area (SERA), establishing an approach to ensure transport competitiveness in the EU in a long-term term. At the same time, the Commission dealt with issues of expected growth, fuel safety and CO^2 emissions reduction. An essential aspect of this policy is to strengthen rail transport role regarding difficulties of reducing the dependency on oil in other industries. This strategy can, however, be achieved only if rail transport provides efficient and attractive services. If failures in regulation and the market are eliminated, including obstacles to enter the market, and complicated administration procedures, efficiency and competitiveness of rail transport will proceed.

Building a single rail area represents one of the options to make use of rail transport potential. European Transport Policy for rail as a sustainable transport option, depends on wide-ranging tools. Regulation of the transport market and creation of conditions to favour rail and water transport are based on effects of such financial and non-financial tools which support transport liberalisation, do not infringe the competition and ensure the interoperability.

The EU transport policy aims to build an inner market with rail transport and thus to create a more efficiently working industry with better reactions to customer needs. Therefore, earlier EU legal regulations document some underlying principles. These principles regulate the improvement of rail transport efficiency through a progressive market opening, independent rail enterprises establishment, infrastructure managers and their accounts separation. The principles have progressively been applied since 2000. Lastly, adopting three subsequent packages of the EU legal regulations have made some impact, but the total share of rail transport in the EU within utilised transport modes remains low. Partially, it is due to issues with appropriateness (e.g. rail transport is not convenient from the point of view of many journeys for short

distances within a town, such as shopping in supermarkets), but also as a result of obstacles to enter the market which restrict competition and innovations (White Paper 2011).

Concurrently, with opening the rail transport market, other EU measurements have improved the interoperability and safety of domestic networks. A more European approach to rail transport should simplify cross-border movement so rail transport can utilise its competitive advantage for longer distances and ensure lower costs for a single market with suppliers of rail equipment.

The Fourth Railway Package was designed to complete a single European rail area and to improve interoperability. It aimed to enable the competition related to agreements on public services on domestic markets in order to improve the quality and efficiency of services in the area of domestic passenger transport.

There are the following specific measurements of the Fourth Railway Package (Fourth Railway Package 2016):

- infrastructure management,
- opening the market with services of domestic passenger rail transport,
- interoperability and safety, and
- social scale.

The Fourth Railway Package introduces an integrated approach which will create conditions for growth of the entire rail transport system. Through progressively increasing reliability and efficiency, it will also increase its share on the market, set up conditions for better quality services and enable rail transport to develop its unused potential, so it becomes a real and attractive alternative. The Fourth Package concentrated on finishing the single rail area and was adopted in April 2016 (a technical pillar) and in December 2016 (a market pillar) (Fourth Railway Package 2016).

3.2 Historical Development of Public Passenger Rail Transport in the Slovak Republic

Rail transport was the first means to provide mass public passenger transport in the territory of the Slovak Republic (Strategy for PPT by 2020 2015). In the inter-war period (years) rail carriers also provided services of public passenger transport by road (Strategy for PPT by 2020 2015). Since 1949, the company, Czechoslovak State Railways provided only rail transport services. Until the dissolution of the Czech and Slovak Federative Republic on 01 January 1993, Czechoslovak State Railways were controlled by the Transport Department (Strategy for PPT by 2020 2015).

After dissolving the company Czechoslovak State Railways into two entities, a state-owned company Železnice Slovenskej Republiky ("ŽSR") was formed in Slovakia. On 30 September 1993, the Act No 258/1993 on ŽSR was enacted. The adopted act defined ŽSR in Slovakia as a state-owned company applying elements of commercial and public service management, the only one of its kind. In connection with the economic recovery of the railways in Slovakia and integration of the ambitions

of Slovakia into the EU, the resolution of the Government of the Slovak Republic No 830 approved the "Transformation and Restructuring Project of ŽSR" in 2000. The Project proposed a physical and accounting separation of the management and operation of a railway from transport and business activities. On its grounds, the assets and activities of the carrier were separated from a railway operation, and on 1 January 2002, two railway companies were created—Železničná spoločnosť, a. s., as a provider of transport and business activities, and Železnice Slovenskej Republiky as an infrastructure manager. The founder and 100% shareholder of the new company Železničná spoločnosť, a. s., was the Slovak Republic, where the Ministry of Transport, Post and Telecommunications in the Slovak Republic acted on its behalf. At the turn of 2004 and 2005, in compliance with the resolution of the Government of the Slovak Republic No 662/2004, that company Železničná spoločnosť, a. s., was transformed into two independent companies, and at the same time, passenger and freight rail transport were separated. The role of a provider of passenger rail transport services was taken over by the newly created company Železničná spoločnosť Slovensko, a. s., ("ZSSK"), and the role of a provider of freight rail transport services was taken over by the newly created company Železničná spoločnosť CARGO Slovakia, a. s (Strategy for PPT by 2020 2015).

Thus, three independent railway companies have been acting in Slovakia since 1 January 2005: Železnice Slovenskej Republiky (ŽSR), Železničná spoločnosť Slovensko, a. s. (ZSSK), and Železničná spoločnosť Cargo Slovakia, a. s. (ZSSK Cargo), which emerged as a result of a progressive transformation of a joint-ventured enterprise. Since 4 March 2012, the operation of passenger rail transport on the Bratislava–Komárno track has been taken over by the private carrier RegioJet a. s. which replaced the company Železničná spoločnosť Slovensko, a. s. The market opening in the Slovak Republic caused the joining of new rail carriers as providers of transport services in public passenger transport—in 2014 Leo Express and in 2016 ARRIVA entered the market.

3.3 Operation of Public Passenger Rail Transport in the Slovak Republic

Rail passenger transport in the Slovak Republic is mainly provided by the state-owned company Železničná spoločnosť Slovensko, a. s., (transport performance of 94.4% (Statistical Office of SR 2018) and other private rail carriers [transport performance of 5.6% (Statistical Office of SR 2018)]. The transport performance is expressed using the number of carried passengers in the observed year of 2016. Železničná spoločnosť Slovensko, a. s., transported 65,606 thousand passengers in 2016 and the rest of carriers operating in rail passenger transport transported 3,919 thousand passengers. As a result of free transport, implemented in 2014, a significant growth of carried passengers was noticed in the following years (2015–2016). In 2014, public passenger rail transport was used by 49,272 thousand passengers, in 2015 it

was 60,566 thousand passengers, and in 2016 it was 69,525 thousand passengers (Statistical Office of SR, 2018).

Suburban rail transport is characterised with short transport distances and a high number of passengers. It provides daily transport of people from their legal residence or temporary address to work, school or somewhere else for personal purposes (doctor and/or office appointment, cultural events) from a subregion into big towns (Masek et al. 2015). ZSSK demonstrated that 30% of the population travel every workday and 17% travel several times a week which forms the greatest share in suburban transport (70%). This sector of passengers is susceptible to frequent changes in train schedules.

Regional transport is considered as transport among subregions of towns within a natural historical or administratively bounded region. Under conditions of the Slovak Republic, this transport is framed by regional boundaries, and according to ZSSK researchers, forms approximately 30% of all journeys. The segment responsible for passenger trains "Os" (the lowest category of passenger trains as mostly they provide transportation for short distances (regional services) and stop at all stations and stops) are in broader surroundings of the most important towns (Bratislava, Košice, Žilina, Prešov) with the most significant area of subregion. They also operate express trains, or trains of REX category (category of trains of the carrier Železničná spoločnosť Slovensko, a.s. and they usually have the same stops and go in line with an express train, but have a shortened route over them). The main groups of customers are those who commute daily to work or school, who attend health care institutions, offices or travel in their free time. Seasonal fluctuations account for transport of tourists and passengers travelling in their free time, reaching up to 20% (Strategy for PPT by 2020 2015). An increase in the number of passengers occurs mainly in tourist regions (a special position has the High Tatras Region of tourism) in the summer period (Strategy for PPT by 2020 2015).

Long-distance domestic transport has the function of transport to distant towns. In this segment, a significant share of travellers are students (20%) and weekly commuters travelling for a full fare, forming up to 25% out of the total number of passengers (Strategy for PPT by 2020 2015).

International long-distance transport includes transport of people to and from the territory of the Slovak Republic, and transit of people through the territory of the Slovak Republic to neighbouring or distant countries, and back. After the Slovak Republic's entry into the EU, international transport has been growing. International transport is provided with trains of IC (type of express train that operates in domestic traffic), EC (international trains higher category), EN (international night trains higher category), Ex (international or domestic trains higher category) and R categories (domestic day and night long-distance trains) in compliance with agreements with the relevant railways. International transport focuses on connecting regional centres and the capital of the Slovak Republic with capitals and industrial and urban agglomerations in neighbouring countries. During discussions with foreign railway management, efforts are on negotiating international trains which have reasonable occupancy in the territory of the Slovak Republic (Strategy for PPT by 2020 2015).

3.4 Regional Rail Transport in the Slovak Republic

On the market of domestic passenger transport in the Slovak Republic, there are currently two carriers: Železničná spoločnosť Slovensko, a. s., (ZSSK) and RegioJet a. s. (RJ). The state entered into agreements on transport services in the public interest with these two companies (Public service transport contracts in the operation of passenger transport on the track, 2018). The Ministry of Transport and Construction of the Slovak Republic orders transport performance in regional and long-distance rail passenger transport. Currently, the government allows a carrier to provide transport services at their own business risk on the tracks of Železnice Slovenskej Republiky (ŽSR). This principle is applied on rail links with sufficient volumes.

Funding for rail passenger transport is realised on the basis of the "Agreement on Transport Services in Public Interest" (pursuant to Act No 514/2009 Coll on the transport on the railways, pursuant to Act No 164/1996 Coll on the railways—Agreement on Performance in Public Interest until 31 December 2009), under which the state represented by the Ministry of Transport and Construction of the Slovak Republic, reimburses a provable loss from public rail passenger transport in the territory of the Slovak Republic. The agreement is binding for the state in terms of the obligation to reimburse the loss to the carrier. Such a loss in passenger transport means a difference between economically justifiable costs spent by the carrier in order to fulfil the commitment under the agreement including adequate profit and incomings gained through this commitment by the carrier.

As a result of free transport, more and more Slovaks have been travelling by train (Majerčák and Černá 2015). The state-owned carrier Železničná spoločnosť Slovensko (ZSSK) records an increasing number of passengers carried (Majerčák and Černá 2015). While many people utilise trains mainly for longer distances, transport for short distances and regional tracks not currently utilised, are also attractive. The state has partially reopened the operation on three of them in recent months. The Transport department, however, claims that it has finished with this initiative number for the time being (Majerčák and Černá 2015).

The possible reopening of passenger rail transport on tracks where transport is currently discontinued is contingent on having a sufficient flow of passengers. Such tracks will allow utilisation of the railways to their full extent during the entire day (Gasparik et al. 2018). Passenger rail transport operations are efficient in case of transporting significant passenger flows. In other cases, mobility gained by utilising bus transport.

Prices on rail passenger transport are regulated on the basis law by the Transport Authority. The exception is the price for commercial transport services; under the conditions of the Slovak Republic and to the current date we speak about IC trains of ZSSK, a. s. Until 2012, IC trains (definition in Sect. 3.3) were operated under the Agreement on Transport Services in Public Interest. Since 2012, IC trains of the state carrier have been of commercial interest.

Basic fares and special fares for transport services are set under the Agreement on Transport Services in the Public Interest of rail transport, and conditions of their

Fig. 1 The territory of the Slovak Republic divided into four functional regions. *Source* Strategy for PPT by 2020 (2015)

application are subject to regulation. Fare regulation is a decision of the Transport Authority on the proposal of a railway enterprise. After approval by the party ordering transport services, it is dependent on setting the maximum for basic fares and special fares. The Transport Authority determines the fare regulation with a general binding statute.

A fare which is not subject to regulation and prices of other services provided within transport services are set by a carrier in a fare tariff according to rules for price negotiation (the prices are without the intervention/treatment/guidance of the competent authority and in accordance with the valid law on prices in the Slovak Republic). The general regulation on prices, i.e. the act No 18/1996 on prices, does not apply to regulation of fares in rail transport, but it applies to regulation of the fare in urban transport (Fig. 1) (Strategy for PPT by 2020 2015).

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Regional transport in the Slovak Republic is responsible for passenger trains (Os) (definition in Sect. 3.3). In the broader surrounding of the most important towns (Bratislava, Košice, Žilina, Prešov) there are also express trains "Zr" (accelerated train of the lower category and trains of REX category).

3.5 Development of Public Passenger Rail Transport in the Slovak Republic

To ensure further development of the public passenger transport system, it is necessary to identify negative aspects, bottlenecks and limitations which are related to organisation, operation and infrastructure.

Organisational: The most critical weakness of public passenger transport in the Slovak Republic is the absence of functional integrated transport systems. Currently, the Ministry of Transport and Construction of the Slovak Republic is the managing body for regional rail transport. Self-governing regions manage suburban bus transport, and relevant towns manage urban mass transport, with no mutual interconnection and coordination of individual transport modes (Strategy PPT and Strategy DTI by 2020, 2015). The timetable in rail transport is fixed with priority for long distance traffic and VÚC (autonomous region or higher territorial unit) not always able to influence the regional train times. VÚC often order bus services in partial collaboration with rail.

Operational: Rail transport has sufficient capacity to satisfy larger transport capacity across the whole network of ŽSR (Strategy for PPT and Strategy for DTI by 2020 2015). At the same time, operational costs have been increased, due to a required reconstruction of the fleet. The absence of harmonisation and integration of regional transport with other kinds of public passenger transport leads to high operational costs while part of the costs are spent on transport that is competitive for passenger rail transport. For coordination of rail and bus transport, the following is missing: change points between specific transport kinds, modern communication devices among vehicles and dispatching, and elements of transport systems integration (Strategy for PPT and Strategy for DTI by 2020 2015).

Infrastructural: Some examples of the identified infrastructural problems of regional rail transport about rail passenger transport are as follows. Insufficiently maintained and neglected character of railway stations and stops, less than optimal distribution of tariff points, infrastructure not adapted to population development and free transport in recent time, low speeds on perspective tracks which are suitable for taking line operation of their territory over (limited track speed, its transition and point restrictions) all contribute to a poor image and passenger experience (Strategy for PPT and Strategy for DTI by 2020 2015).

Identified infrastructure problems of regional rail transport for passengers include unattractive transport offerings, inconvenient travel times and long waiting times. These situations lead to passengers preferring other means of transport.

Measurements in Rail Transport for improving services

Measurements are activities by means of which strategic and specific goals are accomplished. They are fundamental for project definitions to achieve set goals. One measurement can be executed via more projects and vice versa, and one project can fulfil more measurements. The purpose of measurements are to determine the steps that must be taken at appropriate levels of the state, regional and local adminis-

tration. Each measurement can also be perceived as a programme involving mutually related projects. Selected measurements focused on the support for public passenger transport are as follows (Strategy for PPT and Strategy for DTI by 2020 2015):

- To establish a department at the state level which will deal with public passenger transport in a complex manner at the conceptual and legislative level.

Currently, competencies are relatively strictly divided into road and railway transport. The potential to solve single public passenger transport modes are not utilised as organisational and basic operational parameters are not well established.

- To create transport authority (authorities) in order to cooperatively organise and order services in public interest in rail transport, suburban bus transport and urban mass transport.

The process of managing performance in regional passenger transport is only partially coordinated. In places, rail transport enters into competition with suburban bus transport (concurrency of connections) and public passenger transport is managed by too many players (the Ministry of Transport and Construction of the Slovak Republic, self-governing regions, towns and municipalities). Individual managing parties do not have the expertise for qualified transport scheduling and evaluation. Therefore their decisions go directly into hands of carriers who determine a specific form of performance order in public interest and submit it for approval to the order party.

- To establish integrated transport systems, to integrate public passenger transport in the functional region Bratislava and south-western Slovakia.

Individual subjects managing public passenger transport communicate with each other at insufficient levels which results in frequent non-coordination of rail, suburban bus and urban mass transport. Currently, there exists only one full-featured integrated transport system in the territory of the Slovak Republic (integrated transport system of Bratislava), so the advantages of a common tariff and transport operation are utilised only to a minimum extent.

- To optimise the operation of a railway network and performances in it.

Based on the analysis of transport flows, it is necessary to operate train transport on those tracks where the railway has potential and can operate the territory more efficiently than bus transport.

- To ensure the reliability of rail transport operation.

There exists a potential to tighten criteria for measuring accuracy and reliability and for creating efficient sanction mechanisms in case of non-observing defined criteria.

- To improve the maintenance of vehicles in urban and regional railway public passenger transport.

There exists a potential to reduce the break-down rate of vehicles, to increase the reliability of transport and to improve the perception of public passenger transport by passengers.

- To implement a systematic and stable schedule in regional rail transport on the railways in cooperation with the Ministry of Transport and Construction of the Slovak Republic and self-governing regions.

So far there have been frequent and vast changes in the train diagram which has resulted in reluctance and impossibility to adapt connections within suburban bus transport to trains. From the passengers' point of view, the stability of the transport system is required.

- To improve the foreknowledge of passengers and to improve the information and notification system including elements needed for passengers with impaired hearing or for those visually impaired.

No carrier in the Slovak Republic offers a special acoustic notification for blind and visually handicapped people or even orientation audio beacons at entrances into vehicles or customer services. Some carriers continue buying new vehicles without an adequate information system. (Passengers miss information about the next stop, acoustic annunciators, etc.)

- To modernise a tariff, information and communication system in railway stations, stops and trains.

The existing information systems do not present information about all available transport types of public passenger transport; the volume of provided information may be increased. Some information systems do not provide sufficient volume of online data, or they do not provide them in a sufficient time span, or with adequate accuracy and reliability.

- To procure modern train units with barrier-free access from the platform level, to procure modern locomotives with a low energy intensity, to renew the fleet for regional rail transport.

Thanks to the unification of the fleet (mainly the concentration of modern vehicles) on specific, sufficiently perspective wagon tracks, it will be possible to make use of intended infrastructural measurements in full extent.

3.6 Development of Passenger Transport in the Slovak Republic

Population mobility, expressed by some journeys or transport performance per an inhabitant/year, had a slightly decreasing tendency from 1995 to 2015 (Harmanová

Table 1 Number of passengers carried in rail transport in Slovakia for the period 1995–2017

	1995	2000	2005	2010	2015	2016	2017
Total transport of passengers (thous. person)	89,471	66,806	50,458	46,583	60,566	69,525	75,370
of which transport of passengers by operators of transport with the number of employees 20 and more							
Total transport of passengers	89,471	66,806	50,415	46,583	60,566	69,525	75,327
International transport	3001	2474	2547	2858	3575	3718	3853
National transport	86,470	64,332	47,868	43,725	56,991	65,807	71,474

Source Statistical Office of the Slovak Republic 2018

and Štefancová 2017). Significant changes occurred in the transport division between public and non-public transport. The share of public transport on transport performance decreased from almost 50% in 1995 to 26.5% in 2015 in favour of non-public transport. The share of rail passenger transport stopped decreasing in 2013 (Harmanová and Štefancová 2017).

In the last three years (2016–2018), it increased from 1.8 to 2.3% in the case of all transport modes. The share of public rail passenger transport manifested positive development and increased from 6.2 to 8.7%. This interannual increase has been influenced by three factors, as follows (Daniš et al. 2016):

- the entry of competitors into the market,
- the introduction of free fare for selected categories of people on non-commercial trains,
- the extension of a train offer based on a higher order of train transport performances in public interest by the state.

The number of passengers carried by rail transport in the Slovak Republic in the period from 1995–2016 is shown in Table 1. A significant increase in the number of passengers carried was recorded in 2015 as a result of introducing a zero fare in rail transport (Annual Report ZSSK 2014–2017, Statistical Office of the Slovak Republic 2018).

The number of passengers carried by individual branches of public transport in the Slovak Republic is shown in Fig. 2. The introduction of free transport had a negative effect on transport performances in road transport (Annual Report ZSSK, 2014–2017, Statistical Office of the Slovak Republic 2018) (Table 2).

3.7 Public Passenger Transport Services by Rail Transport

Performance relating to the public interest include services which are the right of each citizen regardless of their financial situation and physical abilities wherever they

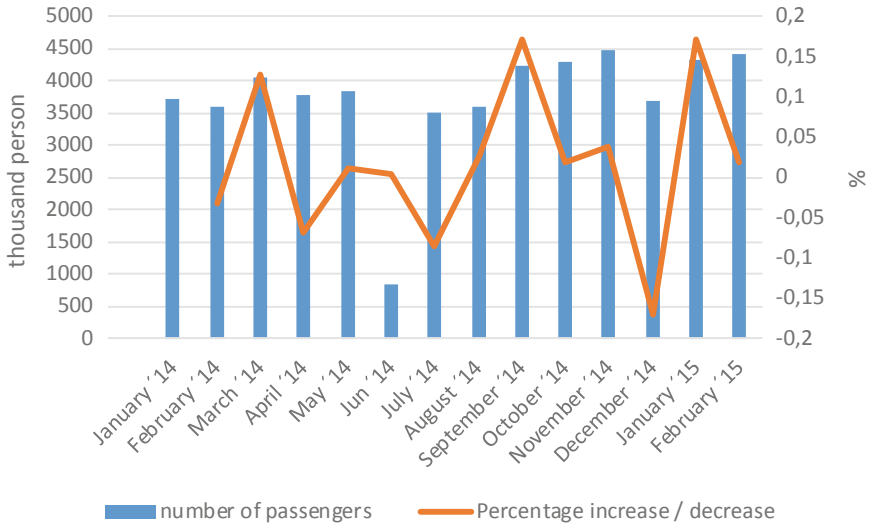

Fig. 2 Comparison of the Number of Carried Passengers before and after the Introduction of Free Transport, the Period of January 2014–February 2015. *Source* ZSSK, a.s

live. The public interest is vicariously realised through compensating the loss from the operation of non-profitable connections with the obligation to carry determined population groups in the context of relevant price legislation for free or for a set fare (i.e. social discounts) (Regulation No. 1370/2007, 2007).

The European Parliament and the Council adopted Regulation (EC) No 1370/2007 on public passenger transport services by rail and by road of 23 October 2007, repealing Council Regulations (EEC) No 1191/69 and No 1107/70 ("Regulation"). The regulation was published in the Official Journal of the European Union, L 315/1, 03 December 2007, p. 1, and it came into effect on 03 December 2009. This regulation was exerted with the Act No 488/2009 Coll, amending the Act No 168/1996 Coll on road transport subsequently amended and on amendments of some acts. This act came into effect on 03 December 2009. Currently, the issue of entering agreements on public services is treated in paragraph 21, art. 6 of the Act No 56/2012 Coll on road transport subsequently amended.

In the area of rail transport the application of the regulation has been reflected in the following acts:

- Act No 513/2009 Coll on railways and on amendments of some acts ("Act No 513/2009 Coll"),
- Act No 514/2009 Coll on railways ("Act No 514/2009 Coll").

Table 2 Number of passengers transported in each type of transport in Slovakia for the period 1995–2017

	1995	2000	2005	2010	2015	2016	2017
Total transport of passengers (thous. person)	2,669,335	2,745,442	2,669,382	2,606,149	2,608,160	2,632,582	2,630,731
of which by mode							
Railway public transport	89,471	66,806	50 458	46 583	60 566	69 525	75 370
Road public transport	722,510	604,249	449,456	312,717	252,175	259,194	245,731
Urban public transport	515,593	404,539	395,064	385,594	379,468	377,345	373,101
Inland waterway transport	138	80	134	120	132	136	12
Air transport	118	159	1716	554	583	350	411
Individual road transport	1,333,334	1,664,342	1,769,147	1,859,479	1,913,518	1,924,100	1,934,072
Public passenger transport	1,327,830	1,075,833	896,828	745,568	692,924	706,550	694,734
Non-public passenger transport	1,341,505	1,669,609	1,772,554	1,860,581	1,915,237	1,926,032	1,935,997

Source Statistical Office of the Slovak Republic 2018

3.7.1 Transport Services in the Public Interest in the Slovak Republic

Public Passenger Transport Services by Rail Transport (distant and regional) are currently ordered by the Ministry of Transport and Construction of the Slovak Republic ("Ministry") on the basis of the Agreement on Transport Services in Public Interest ("Agreement") for the period of validity 2011–2020. This Agreement is annually updated with an amendment containing the transport performance ordered for a given year where the required volume of transport performance is specified for distant and

regional rail passenger transport. The ministry assigned the currently valid Agreement, which covers performances in distant rail passenger transport, directly to the selected carrier Železničná spoločnosť Slovensko, a. s. Specifically, the determination of long-distance links in the network of Železnice Slovenskej Republiky is stated in a strategic document Development Strategy of Public Passenger and Non-Motor Transport in the Slovak Republic by 2020 (Majerčák and Černá 2015).

The ministry also entered into the Agreement in case of operating passenger transport on a regional track Bratislava–Dunajská Streda–Komárno with the carrier RegioJet, a. s. The purpose of the Agreement is to preserve transport operation by public passenger rail transport by a carrier on tracks No 132 Bratislava, main station—Bratislava, Nové Mesto, and No 131 Bratislava Nové Mesto–Dunajská Streda–Komárno.

Until 2012, the market of domestic passenger transport was almost closed, and all agreements on public transport services were concluded by the ministry with the only (state-owned) carrier ZSSK. All performance of ZSSK were realised as performance in the public interest, and thus the state reimbursed a provable loss to the transport company. The situation changed only in 2012 after the new carrier RJ entered the market of domestic passenger transport. The company started to operate regional passenger transport on the line Bratislava–Komárno by a direct order and entered into an Agreement to provide services.

3.7.2 Free Transport

Pursuant to the resolution of the Government of the Slovak Republic No 530/2014, in rail passenger transport, legislative changes were introduced within measurements of a financial, economic and social package of the Government of the Slovak Republic in 2014. As an example, the introduction of free transport for selected groups of passengers on trains operated under the Agreement (Majerčák and Černá 2015).

Following the decision of the Government of the Slovak Republic, the company ZSSK, a. s., which started free transport for pupils, students and pensioners. On 22 December, the company ZSSK, a. s., and the Ministry signed an amendment to a 10-year valid agreement on operating the transport in public interest for the period 2011–2020. The scope of ordered performance in 2015 was raised to 31.304 million train kilometres. The Ministry also concluded an amendment to a 9-year valid agreement with RegioJet (Public service transport contracts in the operation of passenger transport on the track, 2018). For 2015, it ordered 1.197 million train kilometres on Bratislava–Komárno track.

Another amendment modified the formula for a new calculation of reimbursement for one train kilometre by an updated analysis of revenues and costs which would be valid from September 2015 until the end of the contractual period in December 2020.

During the first day of free transport, introduced by the company ZSSK, a. s., 104 thousand tickets were sold for that day, with 48 thousand tickets available for free transport. A significant number of paying passengers, however, bought their

tickets in advance and these passengers were not included in that number. In total, the number of tickets sold was 30% higher than the number of tickets sold on Sunday 17 November 2013, a year before free transport introduction. The development of the number of passengers carried increased in this period. A more detailed overview of the number of passengers carried as well as a percentage increase/decrease within the observed months is shown in Fig. 2 (Annual Report ZSSK, 2014–2017, Statistical Office of SR 2018).

On the ground of those statistical and accounting outcomes, it is possible to state that the introduction of free transport on trains operated within the Agreement (domestic transport) led to the following development of selected indicators (Majerčák and Černá 2015):

- 18% increase in passengers,
- 11 thousand passengers more in trains under the Agreement per day,
- 42.65% non-paying passengers in domestic trains under the Agreement,
- drop in incomings in trains under the Agreement,
- an increase of 4.3 km in average transport distance on trains under the Agreement,
- an increase in seat reservation ticket sale.

The introduction of free transport led to unavoidable steps in maintaining quality standards of travelling for paying passengers, at the same time fulfilling resolutions of the Government mentioned above. Therefore, in the first phase there were set one- and more segmental limits in SC, EC, Ex and R trains. The application of limits, however, has made the travel documents issuing longer.

In the case of trains of suburban transport, there were no limits set but the capacity was increased, and transport performances in traffic peak were strengthened. As a subsequent result of the above mentioned, in the period of regular changes of the train diagram, it came to an optimisation of single trains line regarding their actual utilisation—depending on the passengers' demand for transport. At the same time, the company ZSSK operatively streamlined the capacity strength of individual trains of suburban transport.

Besides a social aspect the Government's decision to make mass transport more ecologically sound, at the same time it should evoke negotiation on rail and bus transport harmonisation. The need to harmonise schedules have been discussed for more than ten years, and there has been done almost nothing done about it. Bus carriers still act as if they are their competitors with railways and they are not willing to agree on a reasonable schedule creation. Half-empty trains and half-empty buses on the same routes next to each other are still the norm.

4 Case Study—Regional Passenger Transport in North-Eastern Slovakia

For this case study, we chose passenger transport on those regional tracks where there was low intensity of passenger transport, i.e. Humenné–Medzilaborce and

Table 3 Rail passenger transport in the direction from Humenné to Medzilaborce

No	Category of train	Number of train	HE	ML	ML–M	DMU
1	Os	8953	4:35	5:52	5:57	861
2	Os	8955	6:37	7:47	7:50	861
3	Os	8957	8:37	9:47	9:50	861
4	Os	8959	10:37	11:47	11:50	861
5	Os	8963	12:37	13:47	13:50	861
6	Os	8965	14:37	15:47	15:50	861
7	Os	8967	15:29	16:23		861
8	Interfering	8969	16:37	17:47	17:50	861
9	Os	8971	18:37	19:47	19:50	861
10	Os	8973	20:37	21:47		861
11	Os	8975	22:44	23:41		861
12	Os	8977	13:29	14:23		861
13	Os	8981	4:03	4:05		861

Legend DMU—Diesel multiple unit
Source By Schedule Booklet for the Track No 103

Humenné–Stakčín tracks. These tracks can be found in the north-eastern part of Slovakia. They serve as a good representation for studying the efficiency of rail passenger transport services in regions where there is a lack of job opportunities, educational institutions, etc. (Jaros 2018). We were looking at options to rationalise trains deployment on the basis of an analysis of their occupancy providing that transport service administration of a given region is maintained, i.e. the schedule remains unchanged.

4.1 Analysis of the Current State

To implement rationalisation measurements in the area of trains utilisation, it is necessary to start with a deep analysis of the schedule including the deployment of locomotives and their use by passengers. Tables 3 and 4 show the schedules on the track No 103 Humenné (HE)–Medzilaborce (ML) according to the current train timetable (Schedule Booklet for the Track No 103).

During a 24 h period, 12 trains travelled in the direction Humenné–Medzilaborce and ten trains in the opposite direction. The train No 8972 is an interfering train, and it overrules the ride of the train No 8962 on Sundays. All trains in this track section are trains of Os (passenger train) category; in all cases, diesel units of 861 series are planned for their transportation. The trains are organised so the connection to/from REX trains to/from Košice station and to Os trains from/to Prešov station is assured.

Table 4 Rail passenger transport in the direction from Medzilaborce to Humenné

No	Category of train	Number of train	ML-M	ML	HE	DMU
1	Os	8952	4:18	4:28	5:24	861
2	Os	8954		5:05	5:59	860
3	Os	8956	6:18	6:29	7:24	861
4	Os	8958	8:18	8:29	9:24	861
5	Os	8960	10:18	10:29	11:24	861
6	Os	8962	12:23	12:29	13:34	861
7	Os	8964	14:17	14:29	15:24	861
8	Os	8966	16:17	16:29	17:24	861
9	Os	8968	18:18	18:29	19:24	861
10	Os	8970	20:18	20:29	21:24	861
11	Loc. train	8972	12:06	12:11	13:07	861

Source By Schedule Booklet for the Track No 103

Table 5 Rail passenger transport in the direction from Humenné to Stakčín

No	Category of train	Number of trains	Departure	Arrive	DMU/Locomotion
1	Os	9401	4:37	5:24	861
2	Os	9403	5:31	6:18	757
3	Os	9405	6:37	7:24	861
4	Os	9407	8:37	9:24	861
5	Os	9409	10:37	11:24	812
6	Os	9411	12:37	13:24	861
7	Os	9413	13:37	14:24	861
8	Os	9415	14:37	15:24	757
9	Os	9417	15:37	16:24	861
10	Os	9419	16:37	17:24	861
11	Os	9421	17:37	18:24	861
12	Os	9423	18:37	19:24	861
13	Os	9425	20:37	21:24	861
14	Os	9427	22:44	23:31	861

Source By Schedule Booklet for the Track No 104

Tables 5 and 6 show the schedules on the track No 104 Humenné–Stakčín according to the current train timetable (Schedule Booklet for the Track No 104).

During a 24 h period, 14 trains travelled in the direction of Humenné–Stakčín and 15 trains in the opposite direction. The train No 9462 is an interfering train (extra train whose driving eliminates or interferes driving of regular train), and it overrules the ride of the train No 9412 on Sundays. All trains are of Os category, and they drive in an hour cycle on this track. In the case of the majority of trains, the unit of 861

Table 6 Rail passenger transport in the direction from Stakčín to Humenné

No	Category of train	Number of trains	Departure	Arrive	DMU/Locomotion
1	Os	9400	4:35	5:24	861
2	Os	9402	5:28	6:17	861
3	Os	9404	6:35	7:24	757
4	Os	9406	7:35	8:24	861
5	Os	9408	8:35	9:24	861
6	Os	9410	10:35	11:24	861
7	Os	9412	12:35	13:24	812
8	Os	9414	13:35	14:24	861
9	Os	9416	14:35	15:24	861
10	Os	9418	15:35	16:24	757
11	Os	9420	16:35	17:24	861
12	Os	9422	17:35	18:24	861
13	Os	9424	18:35	19:24	861
14	Os	9426	20:35	21:24	861
15	Os	9428	22:42	23:31	861
16	Interfering	9462	12:18	13:04	812

Source By Schedule Booklet for the Track No 104

series is used for transportation; only in the case of trains 9409 and 9412 (or in case of the interfering train 9462), a motor wagon of 812 series is used for transportation and a connection of wagons of 011 series. In the case of trains 9403, 9415, 9404 and 9418, a motor wagon of 757 series is planned to serve as a locomotive. The reason is that the principle of the running may be as follows: a train 9403 leaves Humenné for Stakčín, it returns back to Humenné as a train 9404 and continues in its drive as a train REX 1904 to Košice station. The other trains are connections of trains from/to Košice or Prešov station. Train changes happen in Humenné station which serves as a changing station.

There are three shift groups No 880, 881 and 885 for transport operation of Humenné–Stakčín and Humenné–Medzilaborce tracks. The shift group 880 operates Humenné–Prešov–Stakčín–Medzilaborce–Trebišov tracks. In this shift group, there are 5 units of 861 series set; the average daily run of a unit is 307 km. The shift group 881 operates tracks Humenné–Prešov–Bardejov–Stakčín–Medzilaborce. In this shift group, there are three units of 861 series set; the average daily run of a unit is 366 km. The shift group 885 operates tracks Humenné–Trebišov–Michaľany–Stakčín. In this shift group there are 2 motor wagons of 812 series set; the average daily run of a motor wagon is 261 km.

The analysis of a passenger frequency was conducted using an internal database of the company Železničná spoločnosť Slovensko, a. s., which regularly counts passengers in trains. Tables 7 and 8 record the occupancy of selected trains.

Table 7 Passenger frequencies in trains no. 8952 and 8953 on Humenné–Medzilaborce track

Train	Day	∑ P. in a train	Average number of P. in a train	Max. number of P. in a train	Train	Day	∑ P. in a train	Average number of P. in a train	Max. number of P. in a train
8952	Fri	816	49	99	8953	Fri	372	23	33
	Sat	371	22	45		Sat	224	14	16
	Sun	282	17	33		Sun	102	7	9
	Mon	709	42	93		Mon	428	26	40
	Tue	964	57	114		Tue	310	19	26
	Wed	553	33	69		Wed	295	18	22
	Thu	707	42	87		Thu	384	23	29
	Fri	453	27	60		Fri	333	20	30
	Sat	661	39	68		Sat	267	16	19
	Sun	303	18	37		Sun	131	9	12
Average		582	35	71	Average		285	18	24

Table 8 Passenger frequencies in trains no. 9400 and 9401 on Humenné–Stakčín track

Train	Day	∑ P. in a train	Average number of P. in a train	Max. number of P. in a train	Train	Day	∑ P. in a train	Average number of P. in a train	Max. number of P. in a train
9400	Fri	552	46	80	9401	Fri	277	24	50
	Sat	426	36	53		Sat	223	19	28
	Sun	252	22	32		Sun	95	9	13
	Mon	738	62	96		Mon	309	27	49
	Tue	702	59	98		Tue	319	27	52
	Wed	868	73	112		Wed	315	27	50
	Thu	611	51	83		Thu	296	25	54
	Fri	963	81	138		Fri	421	36	60
	Sat	304	26	39		Sat	250	22	33
	Sun	222	19	30		Sun	67	6	10
Average		564	48	77	Average		258	23	40

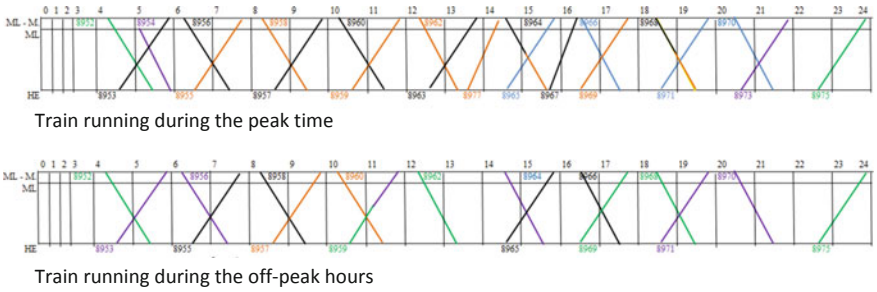

Fig. 3 Train running on Humenné–Medzilaborce Track

Similarly, frequencies of all train connections on studied tracks were processed. Table 9 summarises the percentage occupancy of all trains on given tracks.

The analysis identified that some train connections are not well utilised in terms of capacity. During rail passenger transport operations, it is inefficient to deploy trains with motor units of a high capacity when the number of passengers is very low.

4.2 Proposal for Rationalisation Measurements

In the analysis in the previous section for the track Humenné–Medzilaborce, it was proposed to substitute a motor unit 861 (with the capacity of 179 seats) with a motor wagon 812 with a trailer 011 (with the capacity of 114 seats) at those train connections where the capacity of a DMU 861 was not utilised. A new proposal of DMU deployment is shown in Table 10.

Figure 3 shows a train running during the peak time and off-peak hours.

The total shift need for the operation of this track section during the peak time and the off-peak hours are 2 motor wagons 812 + 2 connection wagons 011 and 3 motor units of 861 series.

Table 11 shows a proposal to deploy a locomotive and DMU on Humenné–Stakčín track and Fig. 4 shows the running of the train during the peak time and the off-peak hours.

The shift need for the operation of this track section at the given frequency of trains is 1 locomotive of 757 series, 3 units of 861 series and 2 motor wagons + 2 connection wagons of 011 series. Shift needs on both tracks were calculated by the proposed running of a locomotive and DMU for weekdays and weekends, so the passenger transport during the peak time is secured.

Table 9 Train connections occupancy

Train	50–100%		21–49%		0–20%		DMU/L
	PT	OP	PT	OP	PT	OP	
Track Humenné–Stakčín							
9400			x			x	861
9401					x	x	861
9402			x				861
9403					x		757
9404	x			x			757
9405			x			x	861
9406			x			x	861
9407			x	x			861
9408			x				861
9409	x			x			812
9410			x	x			861
9411			x	x			861
9412			x	x			812
9413			x				861
9414			x				861
9415	x			x			757
9416			x	x			861
9417			x				861
9418					x		757
9419	x	x					861
9420		x	x				861
9421			x				861
9422					x		861
9423	x			x			861
9424			x	x			861
9425			x	x			861
9426			x	x			861
9427					x	x	861
9428					x	x	861
9462				x			812
Track Humenné–Medzilaborce							
8952			x			x	861
8953					x	x	861
8954			x				861
8955			x	x			861
8956	x					x	861

(continued)

Table 9 (continued)

Train	50–100%		21–49%		0–20%		DMU/L
	PT	OP	PT	OP	PT	OP	
8957			x	x			861
8958	x					x	861
8959	x			x			861
8960			x	x			861
8962	x					x	861
8963	x						861
8964			x	x			861
8965	x			x			861
8966			x	x			861
8967			x				861
8968			x	x			861
8969	x			x			861
8970					x	x	861
8971	x			x			861
8973					x		861
8975					x	x	861
8977	x						861

Legend PT—peak time; OP—off-peak hours

Table 10 A Proposal of DMU deployment in the track section Humenné–Medzilaborce

Train	PT	OP	Train	PT	OP
8952	812 + 011	812 + 011	8964	861 + 861	812 + 011
8953	861	812 + 011	8965	861	861
8954	812 + 011	–	8966	861	861
8955	861	861	8967	861	–
8956	861	812 + 011	8968	861 + 861	812 + 011
8957	861	861	8969	861	812 + 011
8958	861	861	8970	861	812 + 011
8959	861	812 + 011 + 812 + 011	8971	861	812 + 011
8960	861	861	8973	812 + 011	–
8962	861	812 + 011	8975	812 + 011	812 + 011
8963	861	–	8977	861	–

Table 11 Proposal of a locomotive and DMU deployment in the track section Humenné–Stakčín

Train	PT	OP	Train	PT	OP
9400	812 + 011	812 + 012	9415	757	861
9401	812 + 011	757	9416	861	861 + 861
9402	812 + 011	–	9417	861	–
9403	757	–	9418	757	–
9404	757	757	9419	861	861
9405	2 × 812 + 011	812 + 011	9420	861	861
9406	812 + 011	812 + 011	9421	861	–
9407	861	861	9422	861	–
9408	812 + 011	–	9423	861	861
9409	861	861	9424	861	861
9410	861	861	9425	812 + 011	812 + 011
9411	861	861	9426	861	861
9412	861	–	9427	812 + 011	812 + 012
9413	861	–	9428	812 + 011	812 + 013
9414	861	–			

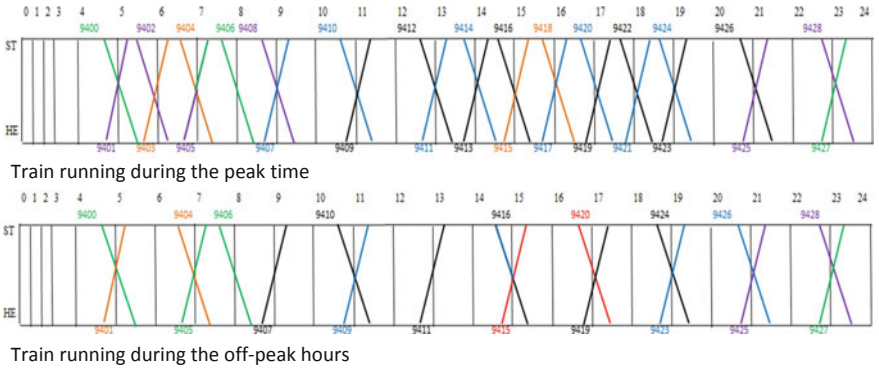

Fig. 4 Train Running on Humenné–Statkčín Track

4.3 Economic Efficiency and Proposed Measurements

When calculating the economic efficiency, we considered the following: the number of passengers will not change, and thus the efficiency may be increased thanks to saved costs. In the case of the proposal of changing the train running there does not occur a change of all costs. Since this is a rationalisation measurement where the train arrangement is changed the indirect costs, i.e. costs of operation and administration expenses, do not change. With this proposal there is no change of costs of locomotive and train crews because it does not matter if there is a set with DMU 861 or a set

Table 12 Input parameters for costs calculation

Type of train	Gross weight in tonnes	Capacity in person	Specific energy consumption in l of PHM per thousand grtkm
861	134.16	179	13.45
861 + tow	255.16	179	13.45
812 + 011 + 812	75.00	175	11.50
812 + 011	48.00	114	11.50
812 + 011 + tow	83.00	114	11.50
757 + wagons	326.40	162	12.00

with a motor wagon 812 and trailer 011 arranged; in either case, it is necessary to have a train driver and a guard on the train. Moreover, there occurs no change of costs of using the rail infrastructure in the area of costs of ordering and assigning the capacity and the fee for organising and arranging the traffic which is dependent on train kilometres. Likewise, the costs of accessing transport points are not changed.

Costs which are different are costs of transport means, costs of traction energy and part of the costs of using the rail infrastructure. Specifically, under conditions of the Slovak Republic, it is the fee for ensuring the operability of the rail infrastructure (U_3). A change of costs of rail locomotives is not taken into account since we did not examine their dislocation into another railway yard. Costs of traction energy depend on gross tonnage, distance and specific energy consumption in the given track section and for the given locomotive or DMU. The fee for using the rail infrastructure in the area of ensuring operability of the rail infrastructure depends on gross tonnage km (grtkm). Table 12 shows input parameters for the calculation of cost savings.

The calculation of cost savings was conducted as a product of a transport performance and its relevant rate (Dolinayova et al. 2015). As to the cost savings on energy, we considered the price 0.96€/l without VAT, and the fee for using the rail infrastructure U_3 is 1.261€/grtkm according to a valid revenue (a fee for the 2nd category of a track).

In the track section Humenné–Medzilaborce costs for all train connections are the same because the train formation does not change, i.e. costs of energy are 76.2293€ and the fee U_3 is 7.1054€. In the calculation of costs per year, we separately calculated costs during a work week and during the weekend because some train connections are not established at the weekends. Cost items mentioned above were similarly calculated for Humenné–Stakčín track. Costs of a single train are as follows:

- train formation—DMU 861
  - energy—50.2421 €
  - $U_{3–4}$.5677 €

Table 13 Costs of energies and U_3 per year

	HE-ML Current State		**HE-ST Current State**	
	Weekdays	**Weekends**	**Weekdays**	**Weekends**
U3/day	156.3184022	120.7914926	154.6169602	97.86333492
Energy/day	1677.045008	1295.898415	1669.847041	1061.01275
∑/day	1833.36341	1416.689908	1824.464002	1158.876084
∑/year	621,260.1918		589,386.7501	
	HE-ML Proposal State		**HE- ST Proposal State**	
	Weekdays	**Weekends**	**Weekdays**	**Weekends**
U3/day	150.7764586	72.44989752	133.4356405	86.36225832
Energy/day	1606.00031	743.2898312	1429.954766	929.2948379
∑/day	1756.776768	815.7397287	1563.390406	1015.657096
∑/year	533,004.2608		507,648.1676	

- train formation Locomotion 757 + wagons
  - energy—116.564 €
  - U_3—11.1129 €
- train formation—DMU 812
  - energy—24.012 €
  - U_3—2.5535 €

Cost savings quantification comes out of the current and proposed deployment of a locomotive and DMU in Tables 10 and 11.

Costs at the current state and in our proposal can be found in Table 13—they are listed separately for weekdays and weekends about a different number of connections. The calculation at the proposed state considers an optimal running of a locomotive and DMU shown in Figs. 3 and 4.

Total costs of the fee U_3 and energies at the current state on both tracks represent the sum 1,210,646.942 €. In our proposal, the amount of these costs is 1,040,652.428 € which represents the total difference of 169,994.514 €/year.

5 Conclusion

The future growth of the rail transport share on the passenger transport service market is based on a combination of: competition on a commercial principle, orders for public services, and regulatory measurements.

The economic efficiency of short-distance rail passenger transport is impacted by many factors. Some of them are of a social or economic character (such as the obligation to ensure transport service administration of a region, economic level of

a region, etc.) which a carrier cannot influence. This study shows that an optimal setting of processes may bring cost savings to rail transport operators which may ultimately increase the economic efficiency while preserving quality standards of public passenger rail transport. Though, the Government's interventions on prices may eliminate the benefits of new competitors' entry as well as realised investments into the infrastructure development and purchase of mobile resources for passenger transport (Regulation No. 1370/2007, 2007).

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