Transport technic and technology
Volume XVIII Issue 2 Year 2022
DOI: 10.2478/ttt-2022-0004

COVID MACHINE AND IMPLEMENTATION OF ANTI-PANDEMIC MEASURES IN RAILWAY PASSENGER TRANSPORT IN THE SLOVAK REPUBLIC

Abstract. The COVID-19 pandemic crisis has had a major impact on the supply, demand, and economic performance of rail transport. The largest impact was recorded in the second quarter of 2020, from April to June. Passenger transport was more affected than freight transport, with international transport falling by an average of 85% in the second quarter of 2020. The reduction in rail transport in the first months of the crisis was a direct consequence of the public authorities' response to the COVID-19 crisis (restrictions on passenger mobility) as well as the impact of the global economic slowdown, which generally led to a reduction in transport demand. The paper is focused on the impact of measures in railway passenger transport and subsequently on the implementation of new anti-pandemic measures in the next period. The paper describes the method of the Covid machine, which was introduced for a simple, concise, and comprehensible setting of the system of measures. The system for evaluating anti-pandemic measures is designed to inform about the current level of risk in relation to the measure in place.
Keywords: covid machine, covid-19 pandemic, railway passenger transport, measures

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Introduction

In 2020, the global health crisis due to the COVID-19 pandemic affected the entire EU and seriously affected passenger rail transport. Slowing down the spread of the COVID-19 pandemic was achieved by reducing population mobility. In connection with the declaration of a state of emergency in the Slovak Republic, international train traffic with all neighbouring countries was temporarily stopped, and the operation of IC trains was also stopped. The operation of all customer centres and the reservation workplace for personal equipment or selected points of sale was also suspended, the sale of national reservations was suspended, and the queuing of restaurant, sleeping and couchette wagons as well as car carrier wagon was also limited (Dedík, et al., 2022).

The decrease in mobility was reflected in the traffic performance in passenger transport. During the first wave of the pandemic, the number of passengers in national rail transport fell by up to 90% compared to the previous year. Several operators, especially new carriers, had to cease operation. The second wave of the pandemic in the fall of 2020 forced many countries to adopt further restrictive measures in connection with population mobility. The outbreak of the third wave of the pandemic prevented the rapid revival of rail transport, especially in the case of passenger rail transport services (Bulková, et al., 2022)

The introduction of individual measures, which gradually led to the restriction of mobility and the meeting of people, significantly contributed to the mentioned trend, as many people considered individual car transport to be not only more comfortable, but also significantly safer than public passenger transport. Although the gradual relaxation of measures has slightly increased its attractiveness, nothing has changed significantly in the mentioned trend (Marra, et al., 2022).

The impact of the Covid-19 pandemic was also addressed in their research by Vickerman, 2021; Gkiotsalitis & Cats, 2021; Zhang, et al., 2021; and many others.

1. Impacts of the corona crisis on transport performance in railway passenger transport in the Slovak Republic

In 2020, were transported about 46,657 thousand in passenger transport. persons, which was 30,700 thousand compared to last year. fewer passengers. This means that it is a year-on-year decrease of 39.69%, and of this (ZSSK, 2020a):

- A year-on-year decrease of 27,432 thousand passengers (-37.84%) was recorded in domestic transport, of which a decrease of 587 thousand passengers was recorded in commercial trains. persons (-71.76%).
- In international transportation, there was a year-on-year decrease of 3,338 thousand persons (-25.27%).

In 2021, were transported 45,672 thousand people in passenger transport, which was 984 thousand passengers less than last year. This means that it is a year-on-year decrease of 2.11%, of which (ZSSK, 2021):

- A year-on-year decrease of 1,548 thousand persons (-3.44%) was recorded in domestic transport, of which a decrease of 151 thousand persons (-66.46%) was recorded in commercial trains.
- An annual increase of 562 thousand persons (+35.50%) was recorded in international transport.

Significant changes occurred in the purchasing behaviour of customers who chose to travel by train only in the most necessary cases and for shorter distances. The year-on-year decrease in the number of transported passengers was also reflected in the decrease in transport performance in passenger kilometres, which in 2020 reached a total volume of 2,117,957 thousand passenger kilometres. Compared to 2019, it is 1,885,774 thousand passenger kilometres less (-47.10%).

Transport performance in train kilometres, including alternative bus transport, for 2020 reached a total of 32,455 thousand train kilometres. Compared to last year, transport performance decreased by 2,048 thousand train kilometres (-5.94%). In 2021, they reached a total volume of transport performance of 1,966,146 thousand passenger kilometres. Compared to 2020, this is 151,811 thousand passenger kilometres less (-7.17%).

Transport performance in train kilometres, including alternative bus transport, for the year 2021 reached a total of 34,069 thousand train kilometres. Compared to last year, transport performance increased by 1,614 thousand train kilometres (+4.97%). Table 1 shows the development of traffic performance before and during the pandemic (ZSSK, 2020b).

Table 1. Overview of transport performance of Železničná spoločnosť Slovensko (Source: authors, according to ZSSK, 2020a, ZSSK, 2021)

Total rail passenger transport	Transport performance (mld. Passenger kilometres)	Passengers (mld. Passengers)	Transport performance (mld. Train kilometres)
2006	2,194.20	47.021	32.068
2007	2,147.96	45.598	32.060
2008	2,278.66	47.184	32.002
2009	2,249.07	45.342	31.980
2010	2,291.27	45.004	32.048
2011	2,431.72	45.959	31.331
2012	2,413.49	43.445	30.559
2013	2,421.95	44.287	30.438
2014	2,503.13	47.286	30.791
2015	3,081.25	57.275	31.856
2016	3,193.72	65.606	31.477
2017	3,759.92	72.473	32.641
2018	3,815.15	73.808	33.649
2019	4,003.73	77.357	34.503
2020	2,117.96	46.657	32.455
2021	1,966.15	45.670	34.070

The COVID-19 pandemic crisis had a major impact on the supply, demand, and economic performance of rail transport. The biggest impact was seen in the 2nd quarter of 2020, from April to June. Passenger transport was more affected than freight, with international transport down an average of 85% in Q2 2020, domestic transport down 18% in Q2 of 2020. Figure 1 shows a comparison of the total transport performance in rail passenger transport in 2019 and 2020.

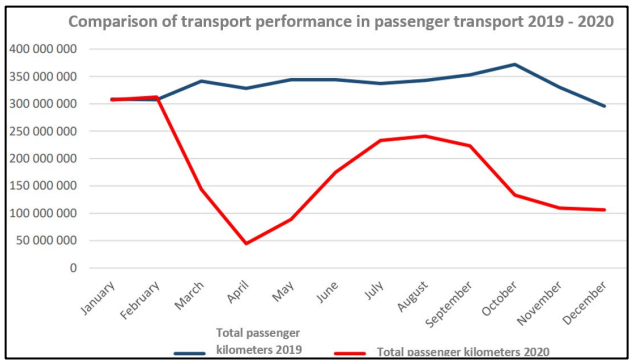

Fig. 1. Development of total transport performance in passenger transport in passenger kilometres in 2019 and 2020 (Source: SR, 2021)

Overall, the performance of passenger transport in 2020 in the mentioned indicator decreased by up to 47.10% compared to the previous year 2019. The development of the number of transported passengers in domestic transport is shown in Figure 2.

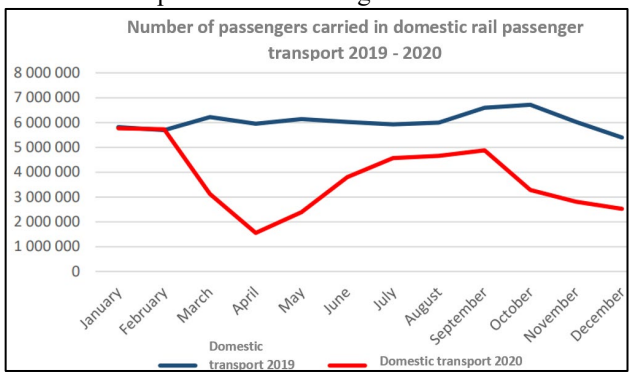

Fig. 2. Development of transport performance in the number of carried passengers in domestic transport in Slovakia (Source: SR, 2021)

During the first wave of the pandemic, passenger transport recorded significant decreases in the number of transported persons as well as in international transport. The number of transported persons in domestic transport decreased by 60.90% compared to 2019 and in international transport by 67.32% (Figure no. 3). Figure 3 shows the development of the number of transported persons in international transport.

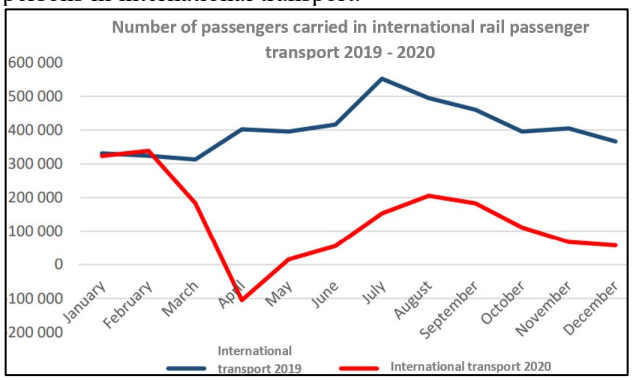

Fig. 3. Development of transport performance in the number of carried passengers in international transport (Source: SR, 2021)

The negative value in the month of April represents the return of fares.

2. Restrictions in rail passenger transport during the corona crisis

In passenger transport, performance was significantly affected by the pandemic, which results from the restriction of passenger trains, where the so-called Saturday's timetable of performances. The highest decrease in performance was recorded in the month of April 2020. Due to COVID-19, several measures were introduced in transport (ZSSK, 2020b).

March 2020:

- suspension of interstate train transport from/to Slovakia,
- national trains ran according to Saturday's timetable,
- restaurant cars were not queued,
- cancelled bus depots Košice – Bratislava and Humenné – Bratislava,
- restriction of sleeping and couchette wagons,
- cancellation of IC trains,
- restrictions on domestic long-distance trains (cancelled issuance of all reservations – seats, bicycles, luggage) (ZSSK, 2020b).

April 2020:

- suspended free transportation of students and children under 16 (ZSSK, 2020b).

September 2020:

- In the EN 477 and EN 476 trains, there were no sleeping and couchette wagons, seating wagons were unrestricted.
- Trains Ex 128, Ex 124, Ex 120 was not run in the section Púchov – Horní Lideč. Trains Ex 220, Ex 126, and Ex 122 were run without restrictions.
- Trains Ex 121, Ex 125, Ex 129 was not running in the section Horní Lideč - Púchov. Trains Ex 123, Ex 127, Ex 221, and Ex 122 were in operation without restrictions.
- In the section Břeclav – Bratislava main station was not run by RailJet 285.
- In the section Bratislava main station was not run by RailJet 284.
- SC 243 Pendolino reinforcement train was not run in the section Prague - Košice, Košičan only ran on Fridays.
- SC 242 Pendolino reinforcement train was not run in the section Košice – Prague, Košican ran only on Saturdays (ZSSK, 2020b).

October 2020:

- In train R 614 and R 615, car carrier wagon no. 23 (Košice – Bratislava main station and back).
- Established measures in restaurant wagons (ZSSK, 2020b).

November 2020:

- IC 44 and IC 45 were cancelled in the section Košice - Vienna.
- IC 523 and IC 524 were cancelled in the section Košice - Bratislava.
- Trains Ex 141 (Žilina – Prague) Ex 142 (Prague – Žilina) were run only on the domestic section Žilina – Čadca and back (without the possibility of seat reservation).
- Trains R 614 and R 615 have reduced train capacity.
- All customer centres were closed.
- ŽSR suspended the sale of ZSSK travel documents until further notice (ZSSK, 2020b).

After the first wave of the COVID-19 pandemic, the established measures were cancelled in the months of May and June 2020 as follows (ZSSK, 2020a):

- The offer of national trains has been expanded.
- The standard mode for regional trains has been restored.
- Free transportation of pupils/students and children under 16 has been started again.
- Restaurant wagons were gradually deployed in national transport
- Reintroduction of international transport with Austria in full.
- Reintroduction of one pair of IC trains - IC 44 and IC 45 (full service).

3. The COVID machine as a tool for evaluating anti-pandemic measures

Covid Automat is a system for monitoring the development of the epidemic and taking anti-pandemic measures depending on the intensity of the spread of SARS-CoV-2. Figure 4 shows the design of 7 degrees COVID machine.

COVID automat 7 degree			
Colour	**Risk**	**Description**	**Level of Risk**
Green	Monitoring	Unlimited	0
Yellow	1st level of	Recommended Home-Office	1
Orange	2nd level of	Recommended Home-Office	1
Ružová	1st level of waring	Recommended Home-Office	1
Red	2nd level of waring	Highly recommended Home-Office	2
Burgundy	3rd level of waring	Ordered Home-Office wherever possible	3
Black	4th level of waring	Ordered Home-Office wherever possible	3

Fig. 4. Design of 7 degrees COVID machine for measures of entry into employment (Source: authors, according to MZ SR, 2021)

The task of the "Covid Automat" monitoring and signalling system is to provide an early warning against the uncontrolled spread of the disease so that the (public) healthcare system can take the necessary preventive steps and prevent the uncontrolled spread of the disease in

advance - as well as contribute to its stabilization and gradual improvement (MZ SR, 2021).

The design of the Covid Machine should be simple, concise, understandable, and able to quickly convey the message to the entire population (MZ SR, 2021). Figure 5 shows the design of 5 degrees COVID machine.

COVID automat 5 degree			
Colour	**Risk**	**Description**	**Level of Risk**
Green	Monitoring	Unlimited	0
Orange	Vigilance	Unlimited	0
Red	1st level of threet	OTP mode	1
Burgundy	2nd level of threet	OTP mode	1
Black	3rd level of threet	OTP mode	1

OTP mode vaccinated-testing-overcoming

Fig. 5. Design of 7 degrees COVID machine for measures of entry into employment (Source: authors, according to MZ SR, 2021)

The Covid Automat was designed for the Slovak Republic in a combined way to assess and inform about the current epidemiological situation and inform about the level of risk at the level of individual districts.

The levels in the Covid Automat are defined by colours and scores. As the score increases, the degree of risk increases and stricter measures are applied.

The colours of the COVID machine represent the risk of infection. The higher the risk, the higher the probability of infection. On the contrary, the numbers assigned to individual risks show the degree of the given risk. This means how much impact a given risk has on a given measure.

The Covid Automat is activated when the World Health Organization (WHO) declares a pandemic. On the contrary, when the WHO declares the pandemic over or when the Office of Public Health declares the epidemic in Slovakia over, the Covid Automat will be switched off. Locally (at the district level) it can be turned off (without indicated colour) even earlier (MZ SR, 2021).

Evaluation system of anti-pandemic measures

The aim of this system is to ensure measures that are simple, understandable, predictable, targeted, feasible, safe and in accordance with the legislation. As the epidemic situation may be different within the individual districts of the Slovak Republic, the measures will reflect the differences in the needs of the individual measures at the district level. (MZ SR, 2021).

This evaluation system shows information about the current risk in relation to the implemented measure at weekly intervals during the validity period of the given type of COVID machine. Figure 6 shows the evaluation of the 7-degree COVID machine with respect to the introduced measure in the Žilina region.

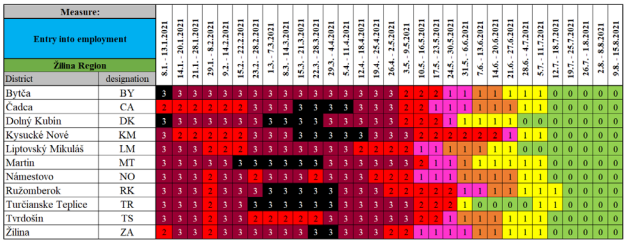

Fig. 6. Evaluation system of anti-pandemic measures according to the 7-degree COVID machine in the Žilina region (Source: authors)

The 7-degree Covid machine was in effect from January to August 2021. Subsequently, this machine was simplified to a 5-degree Covid machine. It was in effect from mid-August 2021 to mid-November 2021. Subsequently, nationwide measures were applied.

Figure 7 shows the system for evaluating anti-pandemic measures according to the 5-degree COVID machine in the Žilina region.

Measure: Entry into employment		16.8. - 22.8.2021	23.8. - 29.8.2021	30.8. - 5.9.2021	6.9. - 12.9.2021	13.9. - 19.9.2021	20.9. - 26.9.2021	27.9. - 3.10.2021	4.10. - 10.10.2021	11.10. - 17.10.2021	18.10. - 24.10.2021	25.10. - 31.10.2021	1.11. - 7.11.2021	8.11. - 15.11.2021	16.11. - 24.11.2021
Žilina Region															
District	designation														
Bytča	BY	0	0	0	0	1	1	1	1	1	1	1	1	1	4
Čadca	CA	0	0	0	0	0	0	1	1	1	1	1	1	1	4
Dolný Kubín	DK	0	0	0	0	0	0	1	1	1	1	1	1	1	3
Kysucké Nové Mesto	KM	0	0	0	0	0	0	1	1	1	1	1	1	1	4
Liptovský Mikuláš	LM	0	0	0	0	0	0	0	1	1	1	1	1	1	4
Martin	MT	0	0	0	0	0	1	1	1	1	1	1	1	1	4
Námestovo	NO	0	0	0	0	0	0	1	1	1	1	1	1	1	4
Ružomberok	RK	0	0	0	0	0	0	1	1	1	1	1	1	1	3
Turčianske Teplice	TR	0	0	0	0	0	0	0	0	0	1		1	1	4
Tvrdošín	TS	0	0	0	0	0	0	1	1	1	1	1	1	1	4
Žilina	ZA	0	0	0	0	0	1	1	1	1	1	1	1	1	3

Fig. 7. Evaluation system of anti-pandemic measures according to the 5-degree COVID machine in the Žilina region (Source: authors)

4. Implementation of anti-pandemic measures in railway passenger transport in the next period

One of the instruments that would succeed in mitigating the negative economic impacts on passenger (as well as freight) transport should be the introduction of measures for a sustainable rail transport market.

These measures should be implemented in each member state in a transparent, objective, and non-discriminatory manner. EU measures for a sustainable rail transport market should be as follows:

- Allow infrastructure managers to reduce infrastructure access fees.
- Allow infrastructure managers to release infrastructure access fees.
- Allow infrastructure managers to defer payment of infrastructure access fees.
- Selection of market surcharges for the use of infrastructure.

The infrastructure manager's proposed measures to slow the spread of the COVID-19 virus are listed in Table 2 and include measures intended for the infrastructure manager's employees and operational measures.

Table 2. Proposal of measures introduced by the infrastructure manager (Source: authors)

Measures of the Infrastructure Manager	
Employees	**Operation**
Provide employees who are in contact with passengers with protective and disinfectant products	Cleaning and disinfection of railway station premises (surfaces, handles, handrails, armrests, tables, and others)
Enable the employees of the infrastructure manager to work Home-office (if the nature of the work allows it)	Informing the public about ways to prevent the transmission of the virus during public transport (leaflets and information technology in stations)
Reduce the number of employees present during the shift (if the nature and conditions of work allow it)	Creating spaces for stopping trains or wagons for the needs of an unexpected stop
	Introduce the mediation of the sale of travel documents by an employee of the infrastructure manager (Contract)

The carrier's measures at the station and on the train are listed in Table 3. By introducing disinfection and increased hygiene measures in the vehicle spaces and including air conditioning, as well as other key measures, passengers will have the opportunity to travel by train comfortably, safely, and responsibly.

Table 3. Proposal of measures introduced by the carrier (Source: authors)

Measures of carriers		
In the station	**In the train**	
	Passengers	**Operation**
Introduce compulsory seat transport in Fast trains - Ex (except Passenger trains)	Introduce the obligation to wear a face mask/respirator in all the carrier's trains during the entire transportation period	Introduce a daily check of the functionality of the air conditioning
Introduce the sale / obligation to purchase travel documents in advance (e-shop, mobile applications, SMS ticket, etc.)	Reduce capacity in restaurant wagons - limit customer seating (every other table) to maintain the prescribed distance	Filter replacement once a month
Suspension of luggage reception in the storage room	Allow passengers to take food To Go or order food directly from their seat via the app	Disinfection at least once a day beyond normal cleaning
		Disinfection with polymer twice a week and effective for 6-7 days
Prohibition of sending and issuing found items on the train (after communication with the passenger who lost the item)	Allow passengers to buy snacks through mobile bars	Increase the protection of all employees of the carrier in operation
		Install disinfectants in all entrance areas of individual wagons in train

As part of the forecast for the further possible development of the pandemic, preventive measures are proposed. All measures listed below are defined for rail domestic passenger transport:

- Monitoring the situation and updating the legislation issued by the Slovak state authorities in the field of prevention of the disease COVID-19, analysis of their impact on society.
- Implementation of preventive measures towards passengers (intensive explanatory and warning campaign in the trains of individual carriers and in the premises of customer centres and when selling travel documents), expansion of services, etc.
- Monitoring the impact on employees of individual carriers. Priority focus on first contact employees who come into contact directly with the traveling public, or whose on-site performance of the job is essential for maintaining the continuity of the company's activities. Reviewing their provision in the field of health protection at work, defining minimum hygiene standards, ensuring, and controlling them.
- Monitoring the impact of restrictions or changes in the scope of the provision of passenger rail transport initiated by the customer of the services of the Ministry of Transport and Construction of the Slovak Republic, respectively cooperating foreign railway companies from the Czech Republic, Austria, Hungary, Poland, Ukraine.
- Monitoring of the effects of restrictions on the mobility of the population (overall restriction of movement, respectively the transition to individual car transport) and the related reduction in the number of passengers in passenger rail transport in the public interest and within the commercial activities of individual carriers, restrictions on commercial connections in connection with the effectiveness of spent funds.
- Monitoring the impact of measures in the field of hygiene of operations (increased cleaning, cleaning, and disinfection), introduction of strict hygiene measures in administrative and operating areas, introduction of new standards for hygienic maintenance of locomotives and wagons, updating of existing contracts for the performance of cleaning and cleaning, extension of technical equipment to disinfection.
- Preventive communication with the public due to the introduction of new measures, increasing trust in public rail transport, communication of problematic topics of compliance with measures, the competences of carriers in limiting passenger rail transport, revised timetables, and individual train connections.

Conclusion

The spread of the pandemic in the sense of restricting the movement of the population caused a serious disruption of rail transport, which in turn caused widespread disruption of train routes, which led to a temporarily lower capacity utilization. Even in this case, infrastructure managers should have the relevant option not to collect infrastructure usage fees in the specified reference period.

It is expected that a certain period after the end of the pandemic situation may be critical for ensuring long-term and sustainable development within rail transport. Investments and covering the losses caused during the pandemic situation by the state and European funds with the right focus can potentially decide whether the railway companies will be able to adapt and accept the amount of loss caused by the pandemic situation. Due to the personal protection of the health of each passenger, people's trust has decreased not only in railway passenger transport, but from a general point of view in the overall public transport. However, the assumption is that after the end of the pandemic situation and the reduction of the number of positive instances, passengers should again use the offer of rail passenger transport. The offer of connections will also be wider than during the pandemic situation, since trains operated at the commercial risk of private carriers have been called off and cancelled in many cases.

Measures should also be introduced that will not result in disruption of train connections. Such measures can be the above-mentioned hygienic, operational, organizational, reconstruction or digitization anti-pandemic measures.

Acknowledgement

This publication was created thanks to support under the Operational Program Integrated Infrastructure for the project: Identification and possibilities of implementation of new technological measures in transport to achieve safe mobility during a pandemic caused by COVID-19 (ITMS code: 313011AUX5), co-financed by the European Regional Development Fund.

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Transport technic and technology
Volume XVIII Issue 2 Year 2022
DOI: 10.2478/ttt-2022-0005

THE POTENTIAL OF NIGHT PASSENGER TRAINS IN EUROPE IN THE POST-PANDEMIC PERIOD

Abstract. Accommodation wagons and night trains have a relatively long tradition in Europe and have been a popular and developed segment of transport for decades. However, at the end of the last century, the trend began to change, and long-distance night traffic began to stagnate. The consequence was the significant restriction and cancellation of several direct international night train connections or direct accommodation wagons in several European countries, including Slovakia, also due to the fast and affordable air transport. In addition, the period of the corona crisis limited long-distance night transport even more significantly. However, bold plans are now emerging in certain countries to reintroduce more night train services. The article deals with a brief analysis of the development of night train connections in Europe, including the current state and vision for the future, while providing systematic conceptual proposals for the development of the mentioned transport segment in the future.
Keywords: night trains, passenger transport, railway transport, post-pandemic period, Covid-19 pandemic

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Introduction

The European disciplines launched in the last decade of the 1900s to introduce competition into railway transport system, guarantee access to the infrastructure without discrimination and facilitate the development of railway as an ecological means of collective transport, have led to transformations in structure of services and in international relations. In the following decades, these changes led to a progressive oblivion of the use of railways for international services, compared to other types of transport. However, in the past few years, there has been a gradual return to use trains for both day and night travels and cross-border (Martini & Pesci, 2022).

Long-distance rail passenger transport can be understood as the transport of people over longer distances, in a national or international context. Currently, it is very important to support the adoption of several measures for the conceptual and systematic development of long-distance rail passenger transport, since as of March 2020, due to the corona crisis, the demand for long-distance transport was significantly lower than the long-term trend until then.

The situation started to improve slightly during 2022, when several international train connections were restored (Dedík, et al., 2022) A specific concept of long-distance transport is the night transport of people. The basic idea of the mentioned concept is to ensure for passengers the so-called "hotel on wheels", where they would sleep during the night and at the same time be transported to the destination, where they would arrive in the morning. Therefore, the added value of night transport should be traveling in the so-called accommodation (bed and recliner) wagons (MDV SR, 2014).

However, several studies dealing with the mentioned issue showed the results that night train connections are unprofitable, uneconomical and have no future. In practice, however, the forecasts were not confirmed, as from the start of the Austrian NightJet project in 2016 to the end of 2019, the number of passengers on ÖBB night trains doubled (dromedar.zoznam.sk, 2019).

The years 2020 and 2021 were marked by the corona crisis and the number of passengers was significantly lower, since in the case of the tightening of anti-pandemic measures, it was international night train connections that were prioritized and cancelled and subsequently their operation was resumed only in the last stages of the relaxation of such measures (Bulková, et al., 2022).

Currently, the trend is improving, and a significant increase in shipping flows is expected for 2022. The increase in transport flows in NighJet trains was also preceded by successful marketing activities, which consist in motivating passengers to use rail transport instead of air transport (dromedar.zoznam.sk, 2019).

After several decades of decline, night train services have gained momentum in recent years. However, the willingness to use night trains as an alternative to airplane travel has so far received only limited research attention. The level of comfort is an important determinant for traveling by night train, and in particular the number of persons a compartment is shared with, hence the ‘privacy’ aspect is important. Heufke Kantelaar, et al., 2022 presenting the results of a two-stage stated preferences survey comprising of a comfort rating experiment and a mode choice experiment, an approach that is based on Hierarchical Information Integration (HII) theory. Night trains running on ultra-long-distance high-speed railways face certain difficulties. The paper by Alhossein & Peng, 2022 proposes a differentiated

operation mode for night-running trains on ultra-long-distance high-speed railways to ensure the completion of maintenance operations during each ‘‘skylight,’’ that is, the window of time available for maintenance between operating hours, on each section to ensure the completion of transportation tasks through a reasonable combination of key points under different modes of operation. The last train service offers the last daily chance for late-night passengers to utilize urban rail transit services to reach their target destination stations. Zhou, et al., 2019 formally introduces and models the destination-reachability based last train timetabling problem in URT networks, which involves both the last train timetabling and the passenger assignment.

1. Analysis of the development of night long-distance rail passenger transport

Night railway transport has a relatively long tradition. Passenger demand for night transport resulted mainly from the transportation need to move from point A to point B, where passengers needed to be in the early hours. Ways were gradually sought to make the night transport concept more attractive, so that it would be much more comfortable for passengers. Special construction wagons (so-called accommodation wagons) began to be produced. These are couchette and sleeping wagons. The couchette wagons have common compartments for men and women, the seats are not pre-arranged for sleeping. The hygienic equipment in the carriage is equipped with hygienic necessities. A passenger in a couchette wagon can occupy a 4-seater or 6-seater compartment. Sleeping wagons are more comfortable and pre-arranged for sleeping. They have separate compartments for men and separate compartments for women (groups can travel together though). A sink with running water is part of the equipment in every compartment. Passengers can currently travel in three classes (TRIPLE, DOUBLE, SINGLE) in sleeping wagons. The interior of the ZSSK and ÖBB sleeping wagon is shown in Figure 1 and Figure 2 (ZSSK, 2022a).

Fig. 1. Interior of a Slovak sleeping wagon (ZSSK, 2022a)

Fig. 2. Interior of the most modern Austrian sleeping wagon (ZSSK, 2022a)

Services in these wagons in the territory of the former Czechoslovakia began to be provided by the Prague-based company Jedálne a lôžkové vozne (JLV), which was founded in 1959. After the division of Czechoslovakia, the services were provided in the territory of Slovakia by the companies Wagon Slovakia Bratislava (until 2005) and Wagon Slovakia Košice (1996 - present) (Wagon Slovakia Košice, 2022)

Traveling by sleeping or couchette wagons has indisputable advantages. The passenger arrives at the destination station rested, because he can use the entire journey for a comfortable sleep. The arrival of night trains at the destination stations is usually in the morning, so he has the whole day ahead of him. At the same time, it saves funds for accommodation. Also, Železničná spoločnosť Slovensko (in short ZSSK) offers its customers the opportunity to comfortably travel longer distances during the night in sleeping and couchette wagons (ZSSK, 2017).

The popularity of night trains is growing especially in interstate transport, where it increased by more than 10.5% year-on-year. In the first eight months of 2017, more than 77,000 passengers used the services of ZSSK sleeping and couchette wagons in this segment. ZSSK operated 18 of its own sleeping wagons and 6 Czech Railways (ČD) sleeping wagons in interstate transport. Both companies also provide two couchette wagons each, in addition to which 6 rented couchette wagons are regularly deployed. In domestic transport, ZSSK uses 18 sleeping wagons and 4 couchette wagons (ZSSK, 2017). Table 1 shows the number of passengers transported in international night transport in 2016 and 2017. Current data is not available.

Table 1. Number of transported persons in international night transport (ZSSK, 2017)

Period (Year)	2016	2017
	Number of passengers	Number of passengers
January	6,292	6,694
February	5,918	6,330
March	7,000	6,621
April	6,055	8,449
May	8,509	9,132
June	9,256	10,539
July	13,316	14,540
August	14,008	15,433
Total	**70,354**	**77,738**

The price for the use of accommodation wagons is fixed for 1 night and does not depend on the number of kilometres travelled, or time spent in this wagon. Individual prices vary depending on the classes, but also on whether it is a domestic or international transport. For passengers who use free transport or have overhead benefits, the price in accommodation wagons is higher in the case of domestic transport. A comparison of current individual prices is shown in Table 2 (Wagon Slovakia Košice, 2022; ZSSK, 2022b).

Table 2. Comparison of prices in special construction wagons (ZSSK, 2022b)

Type of ticket	Domestic transport		International transport
	Standard price [€]	Price for a passenger using free transportation [€]	Price depending on route and number of tickets sold [€]
Ticket to couchette in a compartment with 6 seats	5	8	from 6
Ticket to couchette in a compartment with 4 seats	6	9	from 9
Ticket to sleeping compartment SINGLE with 1 seat	29	37	from 44
Ticket to sleeping compartment DOUBLE with 2 seats	16	23	from 20
Ticket to sleeping compartment TRIPLE with 3 seats	9	15	from 14

The concept of international and national night long-distance transport has undergone certain development and several changes over the past decades. In the past decades, several international night long-distance train connections were introduced within Slovakia (Czechoslovakia), which were able to serve a large part of the territory (several cities, regions, and countries), but their travel speed was relatively low. As an example, it is possible to cite three interstate long-distance connections:

- **R 227 Laborec** on the route Prague Smíchov (9:43 p.m.) – Horní Lideč (4:15 a.m.) – Medzilaborce (12:00 p.m.) – the service operated at the indicated time positions in timetable 1999/2000.
- **R 373 Balt-Orient** on the route Berlin Licht. (11.48 p.m.) – Prague Holešovice (5.58 a.m.) – Bratislava main station (11.45 a.m.) – Budapest Keleti (15.15 p.m.) – Curtici (9.06 p.m.) – Bucuresti Nord (5.59 a.m.) – the service operated at the indicated time positions in timetable 1994/1995.
- **EN 17/409** on the route Moscow Bel. (11.18 a.m.) – Minsk Pass. (8.35 p.m.) – Warsawa Wsch. (4.18 a.m.) – Bohumín (9.02 a.m.) – Břeclav (11.21 a.m.) – Innsbruck Hbf (9.44 p.m.) – Milano Rog. (2.57 a.m.) – Monaco-Monte Carlo (8.58 a.m.) – Nice Ville (9.35 a.m.) – the service operated at the indicated time positions on selected days in timetable 2014/2015.

As part of night transport, it was also customary to introduce direct accommodation wagons on various international long-distance routes, which were gradually connected to several train connections on their route. Among the year-round direct sleeping wagons, it was possible to include:

- direct couchette wagon on the route Košice (4.20 p.m.) – Žilina (7.34 a.m.) – Česká Třebová (1.32 a.m.) – Szczecin Gl. (10:43 a.m.) and back – in the indicated time positions, he operated in timetable 2001/2002.
- direct couchette and sleeping wagons on the route Prague main station (6.50 p.m.) – Berlin Ostbf. (11.50 p.m.) – Koln Hbf (6.14 a.m.) – Amsterdam CS (10.27 a.m.) and back – in the indicated time positions they operated in timetable 2007/2008.
- direct sleeping wagon on the route Bratislava main station (7.50 p.m.) – Žilina (11.55 p.m.) – Katowice (5.13 a.m.) – Minsk pas. (8.39 p.m.) – Moscow Bel. (6.57 a.m.) and back - in the indicated time positions, it operated in timetable 2002/2003.

In the past decades, it was also very popular to introduce several seasonal direct accommodation wagons, which usually ran in the summer season. Among the most interesting ones, the following can be included:

- direct couchette wagon on the route Bratislava main station (5.40 p.m.) – Prague Holešovice (10.55 p.m.) – Berlin Licht. (4.12 a.m.) – Sassnitz (7.23 a.m.) – Malmö Central (12.58 p.m.) and back – operated in the indicated time positions in the spring and summer period in timetable 1998/1999.
- direct sleeping wagon on the route Kraków Gl. (10.30 p.m.) – Košice (5.10 a.m.) – Lőkösháza (12.00 p.m.) – Bucuresti Nord (1.30 a.m.) – Varna (10.07 a.m.) and back – in the indicated time positions it operated in the summer period in timetable 2005/2006.
- direct couchette wagon on the route Prague main station (6.08 a.m.) – Bratislava main station (11.58 a.m.) – Budapest Keleti (7.10 p.m.) – Bucuresti Nord (12.15 p.m.) – Sofia (11.00 p.m.) – Thessaloniki (7.10 a.m.) and back – in the indicated time positions, it operated in the summer period in timetable 2002/2003.

Gradually, however, individual direct night train connections and direct accommodation wagons began to be cancelled. The reason was the decreasing demand for long-distance night transport. Back in 2002, the companies Wagon Slovakia Bratislava and Wagon Slovakia Košice provided accommodation services in Slovak sleeping wagons and couchette wagons operated to several European destinations (Prague, Cheb, Dresden, Szczecin,

Warsaw, Moscow, Kyiv) and even during the summer tourist season also to Split, Varna, Burgas, Bar or Thessaloniki.

Since 2005, only the Wagon Slovakia Košice company has been providing accommodation services, and several direct international sleeping and couchette wagons have been cancelled. Currently, Slovak accommodation coaches operate only within Slovakia (Bratislava – Košice/ Prešov/Humenné and back) and the Czech Republic (Humenné / Prešov / Košice – Prague and back). The stagnant night long-distance international transport on the mentioned line was gradually expanded by the private carriers RegioJet and LeoExpress (from timetable 2014/2015), which, however, does not provide accommodation services in its wagons.

The current range of night traffic services provided by ZSSK is shown in Figure 3. The scheme also includes direct foreign accommodation wagons passing through Slovakia and the Czech Republic on the route Budapest – Bratislava – Prague / Berlin / Warszawa (ZSSK, 2022a).

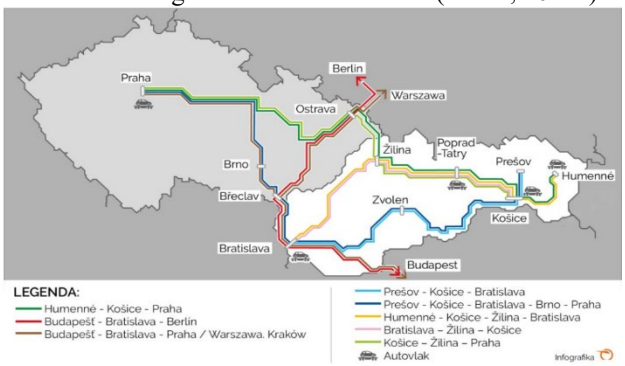

Fig. 3. Current range of night train connections (ZSSK, 2022a)

However, in the pan-European context, the trend was similar for other years. The gradual cancellation of several long-distance night trains and direct trains was also implemented in the developed countries of Western Europe. German state carrier Deutsche Bahn (in short DB) has sold all its low passenger sleeping and couchette wagons, declaring them unprofitable. However, in 2016, the unfavourable trend began to change for the better. The first carrier that tried to revitalize night long-distance transport was the Austrian state carrier ÖBB. New modern accommodation wagons were purchased, and they began to operate also on the lines previously served by the DB carrier.

The correct setting of prices and timetables on individual lines is also very important, while the basic philosophy is not that the night train should arrive at its destination quickly. In fact, the most important thing is that the departure and arrival is at a suitable time (evening or morning hours) (dromedar.zoznam.sk, 2019).

Following the successful development of the Austrian NighJet project, plans for the revitalization of night trains were gradually created in other European countries (Switzerland, Sweden, Denmark, France, Great Britain, etc.). The most interesting night train connections that operate in timetable 2021/2022 are shown in figure 4 (Dodsworth, 2022).

Fig. 4. The most interesting current night train connections (Dodsworth, 2022)

Other current night trains that have relatively long routes are, for example, the following connections:

- **EN 40462** on the route Budapest Keleti (8.40 p.m.) – Wien Hbf (11.27 p.m.) – Zurich Hbf (8.20 a.m.) and back.
- **NT 347 Dacia** on the route Wien Hbf (7.42 p.m.) – Budapest Keleti pu. (10.45 p.m.) – Bucuresti Nord (3.47 p.m.) and back.
- **NZ 94** on the route Stockholm C. (6.11 p.m.) – Narvik (12.48 p.m.) and back.
- **seasonal train of RegioJet** on the route Prague main station. (4.38 p.m.) – Bratislava main station (9.32 p.m.) – Zagreb Gl. col. (5.23 a.m.) – Split (1.43 p.m.) with direct trains to Rijeka (10.19 a.m.) and back.

Another specific example of night train connections is the German InterCity Expresses (ICE) of the DB company, which run on various routes on the German railway network and provide transport services between individual important German settlements even during the night transport saddle. However, the operation of the mentioned trains is carried out without accommodation wagons, often with longer travel times between individual railway stations, as well as longer stays in the stations. As an example, it is possible to mention:

- **ICE 1688** on the route München Hbf (11.00 p.m.) – Hamburg – Altona (7.10 a.m.) and back.
- **ICE 921** on the route Hamburg – Altona (10.30 p.m.) – Frankfurt (Main) Hbf (7.02 a.m.) and back.
- **ICE 948** on the route Berlin Hbf (11.52 p.m.) – Köln Hbf (6.57 a.m.) and back.

2. Scientific and professional principles of solving this problem

Forecasts for the development of night train connections in the coming years are currently relatively favourable. Further development of the NightJet project and the launch of other night trains connecting European capitals are expected within the year. From December

2022, direct night trains between Zurich and Rome should operate, in December 2023 connections are planned to be introduced on the route Berlin-Paris and Berlin-Brussels, and from December 2024 night trains should start running between Zurich and Barcelona. The current scope of traffic services of the NightJet project, including the new plans, is shown in Figure 5 (dromedar.zoznam.sk, 2019).

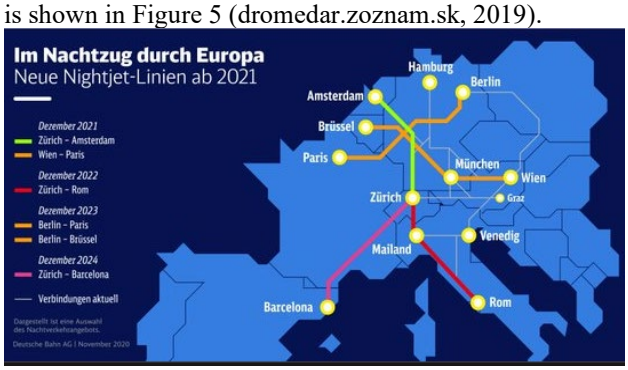

Fig. 5. The current and planned scope of the NightJet project's traffic service (dromedar.zoznam.sk, 2019)

In the case of the proposal of a new concept and vision of night trains in Europe, it is necessary to start from scientific and professional knowledge and principles. As a matter of priority, it is necessary to determine the factors that affect the potential of night train lines (connections). The mentioned factors are based on those factors that affect the potential of long-distance rail transport as such, which are shown in Figure 5. The factors that specifically affect the concept of night long-distance transport, and thus also the potential of long-distance night lines, are marked in red frame (Dedík, 2020).

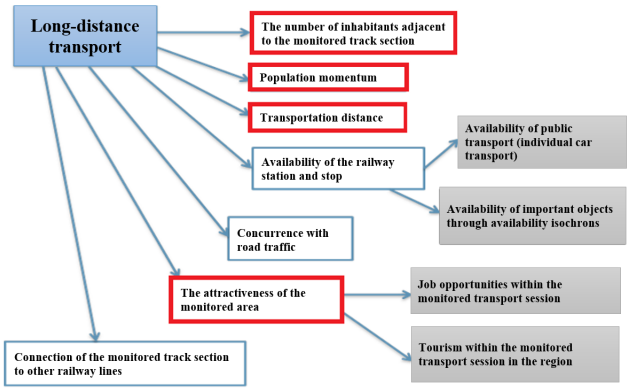

Fig. 6. Factors influencing the concept of long-distance night transport (Dedík, 2020)

These are mainly factors based on which it is possible to establish a forecast for the intensity and direction of transport currents. Therefore, it is most important to monitor and analyse:

- The number of inhabitants of individual settlements located on the railway line (transportation route) in question.
- Population dynamics in the regions in question and between individual settlements (not only rail transport), including current and long-term passenger frequencies.
- Transport distance between individual settlements (this is necessary due to respect for the basic principle of the so-called gravity model in transport).
- The attractiveness of the monitored area (including the potential for job opportunities, tourism, and others).

Following the mentioned factors, it is appropriate to consider whether it is possible to express their influence through certain mathematical formulations or relationships. It is essential to focus primarily on those factors that can be expressed exactly, since this is not possible for all factors.

Research focused on the mentioned issue is based on an existing relationship that is used in geography and through which it is possible to calculate the population density. The mentioned relationship could be modified and applied to railway operations, respectively railway passenger transport, within which it would be possible to calculate the population density of a certain transport session. The proposed modified relationship is as follows:

$$H = \frac{A}{D} \qquad (1)$$

whereas:

H – population density of the transport session [number of inhabitants per one kilometre]

A – the number of inhabitants of individual locations of the transport session [pcs]

D – length of the transport session [kilometre].

The mentioned calculation could be used to determine the potential of passengers, or modelling of transport flows between individual locations on certain transport sessions. Detailed outputs and methods of determining the mentioned potential will be the subject of further scientific and research activities of the authors of the contribution (Dedík, 2020)

3. Proposal of new potential routes of the night trains

Based on the assessment of the mentioned factors and the initial scientific and professional outputs of the mentioned research task, it is possible to propose potential new routes of night train connections. The mentioned proposals will be implemented in three areas (concepts). The proposals also include such transport sessions where there are currently no night connections, while in most cases there is a relatively high-quality transport service during the day with a higher number of transported passengers.

3.1 Standard night trains

The first area will be standard direct night trains or direct wagons, the operation of which will generally be carried out at night (exceptionally longer, max. 16 hours). Within the mentioned concept, there are three main groups of proposals.

The first group of proposals is a night connection between Bratislava and Žilina (with potential direct trains to Košice/Humenné or Banská Bystrica/Zvolen) with

cities in western Czech Republic. The added value of the first part of the proposal (route Bratislava – Cheb) would also be the overnight connection of Bratislava and western Slovak Republic with Prague, and the added value of the second part of the proposal (route Žilina – Františkovy Lázně) would also be the overnight connection of Ostrava with Karlovy Vary. The framework perspective design of both mentioned routes is shown in table 3.

Table 3. Proposal for a night connection of the Slovak Republic with Prague and the western Czech Republic

Ex	Train route	Ex
10.13 p.m.	**Bratislava main station**	6.47 a.m.
0.25 a.m.	Púchov	5.02 a.m.
5.45 a.m.	Prague main station	11.45 p.m.
7.15 a.m.	Plzeň main station	10.00 p.m.
8.36 a.m.	**Cheb**	8.36 p.m.

Ex	Train route	Ex
10.10 p.m.	**Žilina**	6.50 a.m.
11.55 p.m.	Ostrava main station	5.10 a.m.
4.35 a.m.	Prague main station	0.45 a.m.
5.58 a.m.	Ústí nad Labem main station	11.05 p.m.
9.00 a.m.	**Františkovy Lázně**	8.00 p.m.

The second group of proposals consists of a proposal to connect Slovak and Czech cities at night with advanced centres in Austria, Germany, and Switzerland. The added value of the first part of the proposal (Košice - Munich route) will also be express night traffic service between Košice and Bratislava, or connecting eastern Slovakia and Vienna, and at the same time it will be the first morning connection, or the last evening connection between Bratislava and Vienna, or Vienna and Munich. The added value of the second part of the proposal is the night connection of Prague with Munich, the Austrian tourist-attractive city of Bregenz and the Swiss Zurich. It is also the first, or the last express long-distance connection between Prague and Pilsen and between Munich and Zurich. The proposal is shown in Table 4.

Table 4. Proposal for a night connection of the Slovak Republic and the Czech Republic with western countries

NJ/EN	Train route	NJ/EN
11.00 p.m.	**Košice**	6.00 a.m.
2.10 a.m.	Žilina	2.55 a.m.
4.20 a.m.	Bratislava main station	0.50 a.m.
5.40 a.m.	Vienna Hbf	11.30 p.m.
9.35 a.m.	**Munich Hbf**	7.25 p.m.

NJ/EN	Train route	NJ/EN
11.30 p.m.	**Prague main station**	5.50 a.m.
1.00 a.m.	Plzeň main station	4.25 a.m.
5.50 a.m.	Munich Hbf	11.40 p.m.
7.56 a.m.	Bregenz	9.18 p.m.
9.22 a.m.	**Zurich Hbf**	7.50 p.m.

The third group of proposals is focused on night connections transiting through the Slovak and Czech Republics. In the first case, it concerns the reintroduction of a night connection between Budapest and Berlin via Bratislava and Prague with an extension to Hamburg. In the second case, it is also about the re-introduction of the night connection between Budapest, Košice and Krakow, while it is proposed to extend it through Warsaw to Gdynia. The added value of both proposals will also be the improvement of traffic service on several section transport routes. The proposals are presented in Table 5.

Table 5. Night connection of Budapest with Germany and Poland

NJ/EN	Train route	NJ/EN
7.40 p.m.	**Budapest Nyug. Pu.**	8.20 a.m.
10.06 p.m.	Bratislava main station	5.57 a.m.
11.40 p.m.	Brno main station	4.23 a.m.
2.30 a.m.	Prague main station	1.40 a.m.
6.50 a.m.	Berlin Hbf	9.15 p.m.
9.15 a.m.	**Hamburg Altona**	6.45 p.m.

NJ/EN	Train route	NJ/EN
8.10 p.m.	**Budapest Kel. Pu.**	9.00 a.m.
11.30 p.m.	Košice	5.45 a.m.
1.06 a.m.	Plaveč	4.10 a.m.
5.30 a.m.	Kraków Gl.	11.50 p.m.
8.40 a.m.	Warszawa Wsch.	8.35 p.m.
11.50 a.m.	**Gdynia Gl.**	5.20 p.m.

3.2 Proposal of introduction of Super-Express trains

The second design concept will be the introduction of super-express trains, the travel time from the starting station to the destination station will take approximately one day, or in the interval of 20-30 hours. The basic intention of the proposed concept is to connect several important centres and large cities across the entire European continent. The travel time between the departure and destination station of the mentioned train connections will not be competitive compared to air transport, but their added value will be the provision of high-quality and fast transport service to individual intermediate stations (usually important cities) where the flow of passengers is interrupted. Another added value is the very possibility of using a direct connection between these settlements by rail without transfers, including the possibility of using accommodation wagons. Individual super-expresses could offer significantly discounted fares on certain transport sessions, thereby significantly competing with air low-cost carriers. These services would operate on selected days of the week, potentially more frequently during the summer season. Potential routes for super-express could be as follows:

- Hamburg – Prague – Bratislava – Budapest – Bucuresti.
- Brussels – Luxembourg – Mannheim – Zurich – Milan – Rome.
- London – Paris – Munich – Vienna – (Bratislava) – Budapest.
- Stockholm (Oslo) – Copenhagen – Hamburg – Amsterdam – Brussels – Paris.

- Kyiv – Przemysl – Kraków – Wroclaw – Berlin.
- Moscow – Minsk – Warszawa – Ostrava – Vienna – Munich (Zurich).

3.3 Proposal of introduction of tourist trains

The third proposed concept will be the introduction of seasonal "tour" trains that will connect tourist attractive destinations. The basic intention is to provide passengers with several-day train tours, while each day will be spent in a different city and the transfer between them will be carried out at night and will be provided by special accommodation wagons (with the use of services beyond the scope of ordinary accommodation wagons). It is also necessary to find a suitable concept for how the mentioned connections will be able to be operated all year round, that is, without unnecessary downtime in the period outside the main summer season. A potential solution will be the introduction of the following three types of individual tour trains:

- **Type A** – sightseeing trains for the purpose of sightseeing tours to prestigious European cities – main operation in the period from 1 March until 15 June and from 1 September until 15 December.
- **Type B** – tour trains for the purpose of recreational trips to seaside and high mountain destinations – main operation in the period from 15 June until 15 September
- **Type C** – tour trains for the purpose of the winter tourist season – main operation in the period from 15 December until 28 February.

Specific potential tour train connections of type A and type B are listed in Table 6. Their operation could be implemented once a week.

Table 6. Design of new tourist trains of type A and type B

	Type A	**Type B**
1st night	Prague-Bratislava (Vienna)	Prague (Bratislava)-Rijeka/Opatija
2nd night	Bratislava (Vienna)-Venezia	Rijeka/Opatija-Rimini
3rd night	Venezia-Munich	Rimini-Lecce
4th night	Munich-Paris	Lecce-Livorno
5th night	Paris-Amsterdam	Livorno-Nice
6th night	Amsterdam-Prague	Nice-Prague (Bratislava)

Specific potential tour train connections of type A+B and type C are listed in Table 7. Their operation could be implemented once a week.

Table 7. Design of new tourist trains of type A and type B

	Type A+B	**Type C**
1st night	Prague (Bratislava)-Beograd	Prague (Bratislava)-Innsbruck
2nd night	Beograd-Sofia	Innsbruck-Interlaken
3rd night	Sofia-Burgas/Varna	Interlaken-Garmisch-Pertenkirchen
4th night	Varna/Burgas-Bucuresti	Garmisch-Pertenkirchen-Prague (Bratislava)
5th night	Bucuresti-Arad (Timisoara)	Prague (Bratislava)-Lienz
6th night	Arad (Timisoara)-Prague (Bratislava)	Lienz-Prague (Bratislava)

Conclusion

The paper deals with the analysis and development of night traffic in the Slovak Republic, as well as in neighbouring countries. The first chapter contains a brief overview of certain historical and current night train connections. In the second chapter, the vision of the development of the concept of night transport in the context of several European countries is proposed and briefly presented. Consequently, the potential routes of night trains represent only a certain framework proposal in which way night transport could be developed in the short- and medium-term time horizon. However, to increase the potential of the mentioned transport concept, it is necessary to increase the quality and level of services provided in the accommodation wagons and to take advantage of the advantages compared to air transport, namely the possibility to sleep on the train and arrive at the destination rested in the morning, but also the possibility of serving a larger area including seats on the given transport session. The speed of night trains is not decisive, but if their speed is increased, it is possible to cover a longer distance per night, and thus to move the walking distance by night trains further.

It could also be beneficial for the development of tourism in the Slovak Republic if the route of some of the current NightJet train connections was extended from Vienna to Bratislava. However, in connection with this proposal, it would be necessary to establish a company in Bratislava (as in the past Wagon Slovakia Bratislava), which would deal with the operation of wagons of special construction, as is also customary in the capitals of other countries (Vienna, Prague, Budapest, Zagreb, etc.).

The current trend in the development of night trains in the post-pandemic period is still relatively favourable with a positive outlook and plans. However, it will be important to propose and put into practice new progressive solutions that will need to be constantly innovated to make night train travel attractive and affordable for passengers, as it is also an ecological and sustainable mode of transport that must be supported and developed in the future as well.

Acknowledgement

This publication was created thanks to support under the Operational Program Integrated Infrastructure for the project: Identification and possibilities of implementation of new technological measures in transport to achieve safe mobility during a pandemic caused by COVID-19 (ITMS code: 313011AUX5), co-financed by the European Regional Development Fund.

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Transport technic and technology
Volume XVIII Issue 2 Year 2022
DOI: 10.2478/ttt-2022-0006

SIMULATION AS TOOL FOR LOGISTIC CHAIN OPTIMIZATION

Abstract. Simulation is one of the methods in which a real system is substituted with a computer model where experiments are practiced and then subsequently analyzed and evaluated. After the application of the results of simulation and verification of its effects the results are applied in the real system with the aim to optimize processes. It seems that simulation is appropriate tool which offers all useful information about how model system works in given conditions. Simulation in planning and optimizing allows better and faster understanding of processes and guarantees that operational devices will work at the top of their effectiveness. Simulation plays an important role in optimization of logistic chains organization. There is a need to analyze strictly, find narrow places, remove them and consequently to repeat simulation with the new data. It is also very profitable to parallelly simulate more possible alternatives when there is a change in input data and consequently to compare them. The model of logistic chain created by simulation will considerably influence right decisions in process solving related to distribution. Subsequent optimization of logistic chain management can be aimed at the organization where the sum of final costs for transport and warehousing is minimum in compliance with basic parameters of customers' service level.
In the paper classic systems of the management of logistic chains are compared, namely direct distribution and indirect distribution made by technology Cross-Dock canter. Final comparative analysis of both systems simulation points out not only to their advantages and disadvantages but also to the possibilities of their optimization and application in particular operational conditions.
Keywords: Logistic chain, simulation of process, distribution, transportation chain, Cross-Dock technology.

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Introduction

Simulation as a tool for process optimization is one of the basic practices used in companies to improve their existing situations. Optimization can be characterized as a process leading to the search for solutions that are better (more advantageous) than the current state. It is therefore a process of improving that seeks the optimum but may or may not achieve it. Although simulation is not one of the optimization methods, it is a very often used tool in the conditions of the Industry 4.0 concept with which it is possible to analyse processes and then optimize them by applying a suitable mathematical method (Illes et al., 2022).

Thus, simulation is one of the experimental methods in which ae real system is replaced by a computer model, on which experiments are performed which are then analysed and evaluated. After applying optimization and verifying its effects, the results are applied back to a real system and the whole process can be repeated. Therefore, simulation is a suitable tool providing all the necessary information about how a modelled system works in the given conditions. However, the results obtained by the application of simulation tools are conditioned by the correct (i.e., real) setting of input parameters. With purposefully set input values, the entire simulation process can then be deformed, and the resulting simulation product loses value (Plakhin et al., 2017).

An important role in the organization of logistics chains is also played by the ongoing concept of Industry 4.0, which is primarily production-oriented, but also necessarily affects the transport sector. By applying the Industry 4.0 concept, processes and applications of new technologies are gradually optimized.

Given that transport and warehousing are the most cost-creating logistics subsystems, it is necessary to analyse individual logistics distribution strategies and thus to establish acceptable criteria for the selection of a suitable distribution system. There are several linear or networked goods distribution systems, each of which has its advantages and disadvantages and is suitable for a certain capacity, frequency, periodicity, etc. Recently, the Cross-Docking system is often preferred at the expense of the linear shuttle service system, and the last-mile logistics, in which the Milk-Round technology plays an important role, is also often mentioned. One of the tools that is able to confirm or refute the advantage of the system of each of the distribution systems is the simulation of logistics chains or their distribution parts.

1. Simulation organization of transport chains

Simulation as a tool for process optimization is one of the basic practices used in companies to improve their existing situations. Optimization can be characterized as a process leading to the search for solutions that are better (more advantageous) than the current state. It is therefore a process of improving that seeks the optimum but may or may not achieve it. Although simulation is not one of the optimization methods, but it is concept with which it is possible to analyse processes and then optimize them by applying a suitable mathematical method (Hlatká et al., 2020).

Thus, simulation is one of the experimental methods in which ae real system is replaced by a computer model, on which experiments are performed which are then analysed and evaluated. After applying optimization and verifying its effects, the results are applied back to a real system and the whole process can be repeated. Therefore, simulation is a suitable tool providing all the necessary information about how a modelled system works in the given conditions.

However, the results obtained by the application of simulation tools are conditioned by the correct (i.e., real) setting of input parameters. With purposefully set input values, the entire simulation process can then be deformed, and the resulting simulation product loses value (Plakhin et al., 2017).

Simulation also plays an important role in the organization of transport or rather logistics chains. The results of simulation of the organization of logistics chains must be analysed thoroughly, bottlenecks identified, removed and then simulation must be repeated with new data. (Kampf et al., 2016) It is also advantageous to simulate several possible alternatives in parallel while changing input data, and then to compare them. A thorough and complete model of a logistics chain will significantly support correct decision-making in solving distribution-related processes. Subsequent optimization of logistics chains focuses on such an organization, where the sum of the resulting costs of transport and warehousing is minimal while maintaining the basic parameters of the level of customer service (Ližbetin et al., 2016).

The usual possibilities for simulating the organization of transport chains are:

1. Direct transport (a shuttle service system), i.e. transport from suppliers to customers without the use of distribution warehouses.
2. Indirect transport, i.e., transport where there is a change in the type of transport or transport system in distribution centres (warehouses).

Both the handling systems can still have several subsystems, each of which needs to be analysed and its suitability for a given transport type or a transport system assessed. In many cases, a transport chain forms part of a logistics chain, in which case it is necessary to consider other subsystems of the given logistics chain (Fedorko et al., 2021).

1.1. Direct transportation chain

Direct transport systems use a simple linear method of connecting suppliers and customers during distribution (see Fig. 1). From the organizational point of view, the shuttle transport service is one of the simplest ways of operating between two points without any intermediate stops. The simplicity and speed of transport and the absence of reloading and warehouses in the chain favour it to a large extent over other systems (Strnad et al., 2021). The performance level of the shuttle transport system is extremely high, and it can therefore operate at a relatively low cost recalculated to a unit transported. However, it is conditioned by the fulfillment of the set (relatively high) capacity. Each transport unit in the shuttle system has a constant capacity and therefore needs to obtain a specified volume of transport from the source to the customer. Therefore, the shuttle service system requires a relatively high transport demand which is as evenly distributed as possible throughout the year. Low flexibility in capacity is a disadvantage of the system (Bukvić et al., 2021).

Fig. 1. Shuttle distribution system (Source: author)

In addition to the shuttle transport service, which is a typical example of direct transport, various subsystems are also used, which try to eliminate the main disadvantage that lies in the relatively high and regular scope of transport. These are mainly conventional linear service (see Fig. 2), which also uses, in addition to the start and end points, customer points on a given route. The supplier's capacity is thus divided among several customers and the advantage of high performance at a low unit price is maintained (Maretić & Abramović, 2021).

Fig. 2. Conventional linear distribution system (Source: author)

Circular service is another subsystem, which is like a conventional linear service system, but the location of customers is not typically linear and customer requirements are asymmetric (see Fig. 3). The advantages of this system are like those of a linear system, but this variant accepts spatial distribution and changing capacity requirements of customers. The system is quite often used as final distribution in last-mile logistics (Abramović et al., 2021).

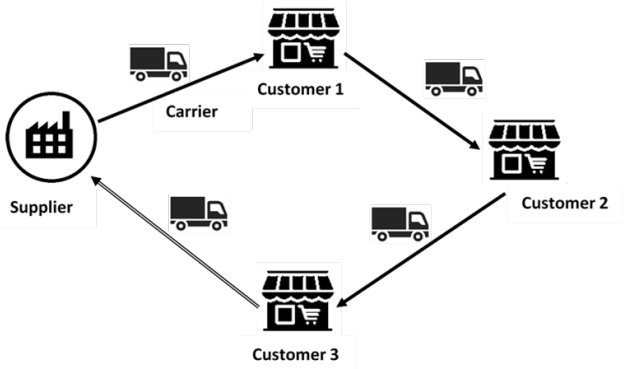


Fig. 3. Circular distribution system (Source: author)

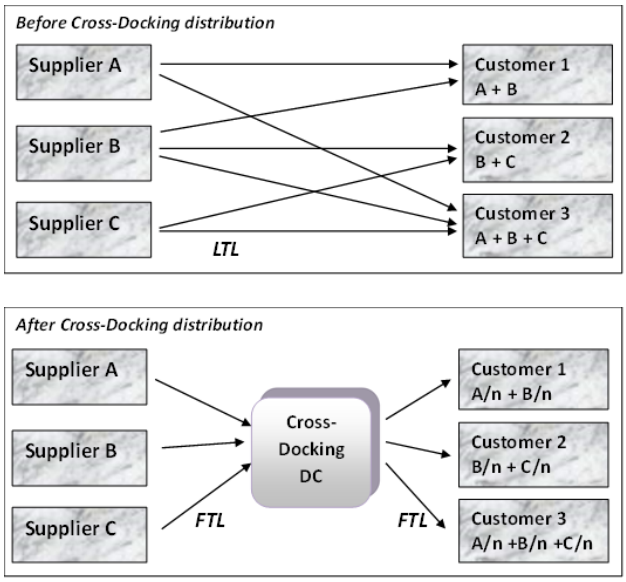
1.2. Indirect transport by Cross-Docking distribution center

In indirect transport, warehouses, or distribution centres (DC), which in part act as warehouses, are used in distribution. Due to the fact, that warehouses are integrated in a transport chain, it is necessary to consider the additional costs associated with keeping stocks in warehouses and the operation of warehouses. In addition, these costs should be offset by savings in transport costs, namely through using the capacity of means of transport or

through using transport systems with a higher capacity, which will reduce the unit price of transport (Pasagic Skrinjar et al., 2017).

In distribution logistics, when transporting goods with the same or similar purpose from several suppliers to multiple customers a warehousing system called Cross-Docking is used. With this system, the goods delivered to a distribution centre are not stored but they are transported continuously in the required quantity and composition to a specific business unit. Compared to conventional warehouses, this logistics system largely eliminates the costs associated with keeping stocks. In addition, transport costs can be reduced during distribution through a suitable combination of vehicle capacity and a reduction in the number of trips. The resulting total costs per a transport chain can thus be advantageous when using the Cross-Docking system (Jurkovic et al., 2021).

A comparison of the distribution before and after the introduction of the Cross-Docking system is shown in Fig. 4.



LTL - Less than truckload, FTL – Full truckload

Fig. 4. Distribution system before and after the Cross-Docking (Source: author)

However, Cross-Docking requires accurate synchronization of all incoming and outbound shipments. This requires high-quality information security and powerful reloading technology. Cross-docking is currently used quite often, especially in the distribution phase of supply chains. This is mainly due to the already mentioned fact that this technology allows simultaneous reduction of transport as well as warehousing costs, which represent the largest share of total logistics costs, and thus it contributes to the optimization of the supply chain (Ližbetin, & Stopková, 2021).

2. Comparison of systems for organizing logistics chain

A transportation chain is defined as an efficient sequence of sub-processes in transport, handling, packaging, and storage necessary to move goods from manufacturers to consumers. To organize transport chains in distribution processes, as already mentioned, possibly as direct transport or distribution, or as indirect transport or distribution (Hruška et al., 2021).

Direct distribution is performed by one type of transport, without reloading, usually by one means of transport. The participants in such a transport chain are: a manufacturing company that wishes to place its product on the market, a transport company that performs the transport, and a consumer to whom the product is intended. All distribution activities are usually organized by the manufacturing company at its own expense and risk. The manufacturer cooperates directly with a relatively small network of customers or with its own network of stores (Hamdi et al., 2021).

The following factors are the main prerequisites for the use of direct distribution:

- a small number of potential customers,
- high spatial concentration of the customers,
- relatively high and evenly distributed transport demand,
- relatively rapid loss of utility value of the product sold (e.g., food),
- high cooperation of suppliers and customers (Motaghedi-Larijani et al., 2018).

Direct distribution is used mainly in the transport of agricultural products, bulk materials, or special-purpose types of products. Given that the purpose of such a distribution system is the transport of a significant amount of goods without intermediate reloading, the fulfillment of a relatively large capacity of the means of transport is a necessary condition for its implementation (Pečený et al., 2020). The advantages of this type of distribution mainly include direct connection between the supplier and the customer, information, and control of the entire distribution process by the manufacturer, which in practice allows a very quick response to any changed requirements from the customer. The overall level of stocks in the distribution channel is low, which has the effect of reducing logistics costs. Another advantage is in fast and direct market information, immediate control over concluded transactions and the possibility of a flexible response to changes in demand (Široký et al., 2021).

Its disadvantages include the problematic filling of the relatively high capacity of the transport system and the associated high amount of product stocks in the supplier's warehouse. A high number of medium- or small-scale individual orders can have the effect of increasing transport costs. In direct distribution, it is necessary to focus on a smaller number of customers with requirements for even high-capacity transport, or a higher speed of delivery of larger quantities of goods. The supplier must also be prepared to provide additional services required by the customer, not only services at the place of delivery but also services related to the quality of transport.

Indirect distribution is in practice a more frequently used strategy for the distribution of goods. The participants in a chain are, in addition to a manufacturer, various carrier, consumer and warehouse keepers, or logistics

groups that take over part or all the distribution-related activities. In this system, the manufacturer is relieved of organizing a transport chain and this role, as well as the risk and costs, is taken over by one of the participants in the chain. This distribution chain organizer, typically a transport operator or a logistics company, also seeks to increase the level of customer service by offering additional services (Jimo et al., 2019).

The advantages of the system on the part of the manufacturer include lower level of stocks of finished products in stock, simpler administration, fewer individual orders and the associated lower transport costs. The disadvantages of the system include larger stocks of finished products in a distribution channel (in distribution warehouses) and reduced information for manufacturers about customer feedback, thus slowing down the ability to respond quickly to changes in the market situation (Fabry et al., 2022).

The indirect distribution strategy has many variations in servicing the market and it is therefore essentially suitable wherever direct transport of large quantities of goods from one supplier to one customer is not required. In indirect distribution, a combination of two or more modes of transport or a combination of means of transport within one mode of transport may also be used to reduce the total costs. The combination of means of transport or modes of transport into a transport system must guarantee reliable performance of transport in compliance with the specified quality parameters as are speed, specified transport time, accuracy of delivery for loading, etc. (Hruška et al., 2021).

Conclusions

Cross-Docking is a method based on indirect distribution through a warehouse, which, however, brings additional costs associated with loading operations and storage. This negative should be offset by lower transport costs. However, if, in direct distribution, road sets are used sufficiently and the loads from several suppliers cannot be cumulated, then the benefits of this system disappear. Naturally, the opposite is also true, i.e., if road sets are unused in capacity and it is possible to cumulate the loads from individual suppliers, which will reduce the number of trips, then there is also a reduction in transport costs. However, this reduction must be higher than the costs associated with the implementation of the Cross-Docking system.

However, when calculating the total costs for the implementation of the logistics chain for indirect transport, it is necessary to add the costs of warehousing and the costs related to handling, combination of shipments, unloading, loading, etc., to the transport costs.

Total costs for indirect transport must be lower than the cost for direct transport, see equation 1. (Xi et.al., 2020):

$$\sum_{k=1}^{n} N^{\mathrm{IDT}} = N^{T} + N^{W} + N^{H} \leq \sum_{k=1}^{n} N^{\mathrm{DT}} = N^{T} \quad (1)$$

N^{IDT} - total costs for indirect transport (€),
N^{DT} - total costs for direct transport (€),
N^{T} - transport costs (€),
N^{W} - warehousing costs (€),
N^{H} - handling (reloading) costs (€),
n - number of transportation chain (Xi et al., 2020).

The Cross-Docking method can be considered as a method that brings positive effects, but its success depends on its correct application. It is mainly about the arrangement and organization of a logistics chain as a self-contained, i.e., not only to solve the suitability of distribution itself but also its connection to subsequent processes.

Considering the results of the research, the following can be considered as the basic conditions for the introduction of the Cross-Docking system:

- Insufficient capacity utilization of road semi-trailer sets.
  The system almost always (if only this criterion is accepted) appears to be advantageous when using the capacity of road sets below 60 %. When using them between 60 and 80 %, the application of the system can be considered, but it is necessary to consider a summary of other criteria, such as regularity or frequency of transport trips, etc. It does not make sense to consider the application of the system when using road sets over 80 % (Humič et. al., 2019).
- Sufficient transport distance.
  As transport distance increases, so do the benefits of implementing the system. This is because the level of costs associated with implementing the system is essentially constant. But the transport costs decrease roughly linearly depending on the transport distance when there is accumulation of the loads from individual senders or accumulation of trips during distribution. The so-called critical distance cannot be determined precisely, it depends on many factors, such as in particular, warehousing prices and transport prices. However, it almost certainly does not make sense to consider implementing the system at distances below 100 km Jensen et. al., 2019).
- Convenient location of a Cross-Docking centre.
  A Cross-Docking centre can basically be located anywhere on the route between suppliers and customers. However, three basic concepts can be applied:
  1. The centre is close to suppliers (e.g., regional logistics centres).
  2. The centre is close to customers (e.g., the Gateway concept).
  3. The centre is at the centre of gravity between suppliers and customers (e.g., international logistics centres), (El Yaagoubi et all., 2022).

The choice of a suitable concept depends on the number and distribution of suppliers, the number and distribution of customers, the utilization of capacity in transport and distribution, the basic function of the centre with respect to the national or international level, etc. However, when using mathematical models in determining the location, the density of the infrastructure, the throughput of the transport network, etc. must also be

considered. Incorrectly set input data and limiting criteria may invalidate the results of the location model.

However, when considering the application of the system to the concept of organization of transport chains, several other criteria related to distribution logistics must be considered:

- Possibilities of information flow between suppliers and customers (EDI, email, ...).
- Participation and responsibility of suppliers (regular deliveries on time, specified quantity of goods, ...).
- Customer readiness (customers must be informed in time and ready to accept shipments).
- Equipment of the Cross-Docking centre with information and handling technology (pelletizing, depalletizing, variability of means of transport, ...).
- Number and location of potential suppliers.
- Number and location of potential customers (e.g., in how large attraction area customers are located), (Ashima et all., 2022).

The actual decision on the system and a method of organizing a transport chain is usually responsibility for a transport operator. This operator must always assess the technical and technological possibilities (alternatives) of the organization of a transport chain and then evaluate them in a relevant economic way. The operator must also evaluate whether to organize a transport chain as monomodal (either direct or indirect), or as multimodal, where most of the route is travelled, for instance, by rail.

The task of simulation and subsequent optimization of logistics chains is to indicate such an organization, where the sum of the resulting costs of transport and warehousing is minimal while maintaining the basic parameters of the level of customer service.

Acknowledgment

The paper was supported by the VEGA Agency, Grant No. 1/0379/20 " Socio-economics aspects of rail transport market services deregulation in the context of EU legal framework and sustainable mobility", at Faculty of Operations and Economics of Transport and Communication, University of Žilina, Slovakia.

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Transport technic and technology
Volume XVIII Issue 2 Year 2022
DOI: 10.2478/ttt-2022-0007

EMPLOYEE EVALUATION PROJECT USING FEEDBACK

Abstract. At present, in business practice, we meet the requirements of the employer for employees to work better, faster and better in order to satisfy the customer as much as possible. It often happens that this requirement on the part of the employer is evaluated subjectively and then subsequently the presentation of the results of the employees' work is not objective. Several methods can be used to improve the evaluation process, and in our case we used an evaluation system using a full-fledged feedback methodology.
Keywords: employer, evaluation of work performance, monitoring of competencies, personal interview, 360^0 feedback.

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Introduction

The employer strives to get the best possible work results of its employees and therefore tries to define the boundaries of success in individual competencies so that it can clearly distinguish between employees who achieve excellent results and those who need help to improve and streamline their work in the team (Kudláč,et al 2018). The determinants of the boundary can be various competencies that need to be considered in the work of employees. In the following article, we defined these limits of success in the context of determinants (Majerčák, et al., 2015, Majerčák et al., 2016).

1. Methodology used in practice

The aim of the 360 ° feedback project was to provide counseling and consulting activities in the field of employee development to obtain independent, constructive and objective feedback on the competencies of employees according to pre-assigned competencies. The output of the project is the final report, which summarizes the results of the 360 ° feedback project (Project, 2018). The content focus of the final report is a comprehensive view of the statistical results of all employees, divided according to individual competencies. The results of the project should be used as a stimulating tool for system management of employee development. Based on it, it is appropriate to plan individual / group development plans. The results can be used in the following personnel activities (eg: managerial planning, motivation and remuneration of employees, training and development of employees, succession planning and others) (Zmeškal, et al., 2020).

1.1. Project description and its parametric settings

The place of implementation of the project is defined in the office space of the company and a personal interview with the employees of the company. The specification of the company is in its services provided to the customer. The evaluation is a final report with a graphical evaluation (competencies and the number of employees reaching the limit of success in the competence), evaluation of the obtained data by personal interviews and a summary of development and training activities that are recommended for the company (Project,2018).

In the implementation of the project, we relied on monitoring competencies in the positions of specialists and in the positions of senior employees. A total of 3,258 complaints were collected, which were then statistically processed. The number of complaints per employee was determined by the company's management.

Subsequently, individual personal interviews were conducted with all employees involved in the project. We have defined the areas that we will examine as follows (Table1.)

1.2. Data collection

Data collection by the analytical portal was focused on identifying the level of individual competencies of each employee. The data collection system has been set up to provide input to employees from different levels in the organization. By default, the employee received suggestions from his colleagues who are at his level, from colleagues from other departments with which he works closely, from his superior and from subordinates if he holds a leading position (Project,2018, Zmeškal, et al., 2020).

2. Evaluation of the obtained data

The evaluation of the data is divided into three categories. The level of competencies of employees is summarized in category 3.1, suggestions from personal interviews are summarized in category 3.2 and a summary of educational and development activities is summarized in category 3.3 (Majerčák, et al., 2016, Project, 2018, Zmeškal, et al., 2020).

Table 1 Monitored competencies of employees (Source: autors)

MONITORED COMPETENCIES	
In specialist positions:	**In managerial positions:**
Conscientiousness and reliability	**Leading of people**
Focus on results and potential for the future	Self-management
Communication skills	**Delegation of power**
Interpersonal relationships	
Independence at work	
Motivation for the achieved results	
Initiative in solving tasks	
Team work	
Analytical, conceptual thinking	
Ability to work under pressure	

2.1. Evaluation of the obtained data by the analytical portal

Figure 1 shows the average achieved values of all employees in the individual monitored competencies, arranged from the best evaluated competence to the worst evaluated competence by the employees.

The limit of success in the competence indicates the point that divides the competencies into those that need to be worked on and those that are above the limit of success in the competence, which means that it is necessary to work on maintaining this state or gradual improvement. Competencies that are below the threshold of successful competence need to be strengthened and work to improve them (Majerčák, J, Majerčák, P,2018).

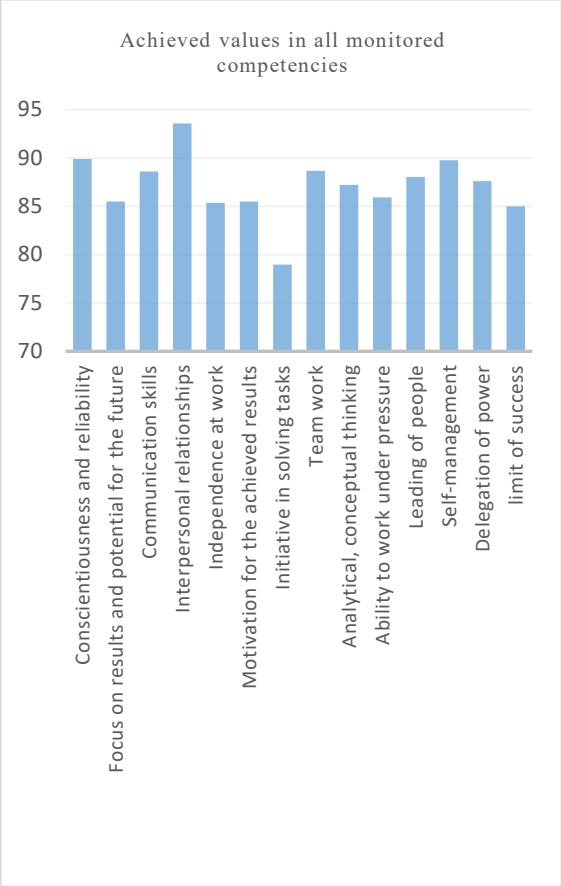

Fig. 1. Average of achieved values in all monitored competencies (Source: autors)

The determinants of the boundary of success are:

- effective management of employees,
- stabilized processes,
- controllable work performance,
- lower employee turnover,
- lower rate of long-term incapacity for work,
- lower rate of short-term incapacity for work, resp. use of paragraph,
- greater satisfaction of employees with the work environment and job classification,
- seeing employees' own work perspective,
- lower burnout rate,
- more stable corporate culture,
- more standard working relationships without conflicting and tense relationships,
- better work performance,
- better sharing of suggestions from employees.

The goal of every employer should be to achieve the level of most competencies above the limit of success in the competence. This means that in the case of evaluation of individual competencies above this limit, we achieve a high degree of success in the above-mentioned determinants (Majerčák, J, Majerčák, P, 2018).

For the area of conscientiousness and reliability, the fact that an employee with this competence fulfils his / her work duties properly, on time and thoroughly is assessed. He usually has a very good overview of the status of tasks in progress, deadlines and other important requirements related to the performance of his job position. Colleagues can rely on him, and the results of his work are presented in high quality. The success rate was 85 % (Majerčák, J Majerčák, P,2018, Zmeškal, et al., 2020).

Recommendations for management are defined as follows: thoroughly train new employees on internal procedures and require their implementation by the direct superior, periodic control and evaluation (evaluation interviews of the superior - subordinate) of tasks and responsibilities performed by superiors - focusing control and evaluation on main work activities , but also support work activities resulting from the job description of a particular job, in case of unreliable implementation of tasks and responsibilities it is necessary to implement the employee's guidance by the superior, the superior should not do the work to be done by the subordinate due to ("I will do it faster and better."), Clearly formulate expectations from the superior (deadlines, ...), set priorities and logical sequence for junior employees (should this problem be started, or should other problems be solved first?) (Project,2018).

Focusing on results and potential for the future is an employee with this competence has no problem taking responsibility for a more demanding job. He is interested in feedback on his work from colleagues, superiors, or. subordinates. An employee who achieves good value in this competence is aware of his strengths, from which he draws in his work. He is also aware of his weaknesses and is systematically working to eliminate them, e.g., in the form of on-the-job training and self-education. The average achieved value in the competence is 85.50 %. We recommend using different management styles for individual employees, provide open feedback on work results (evaluation interviews), point out weaknesses and propose measures that would eliminate weaknesses, in case of identifying employee talent, set a plan for their professional development in relation to the agenda, which it performs to follow the competency models in the organization (Majerčák, et al., 2017).

For the area of communication skills, an employee with this competence can convey information clearly, clearly and concisely. His verbal and nonverbal communication is consistent. He can adapt his communication speech to the situation and to the communication partner with regard to the goal of communication. He can actively listen and understand, process and constructively understand the information he receives. The average achieved value in the competence is 88.61 %. We recommend organizing trainings on customer communication, organizing trainings for active listening comprehension, organizing trainings on argumentation skills, organizing workshops focused on training non-verbal communication, providing continuous feedback from superiors to employees who do not have sufficient communication skills and proposing solutions to these shortcomings (e.g., after each phone call that was not good, the employee should receive feedback between 4 eyes (superior) (Majerčák, J, Majerčák, P, 2016, Majerčák et al., 2016).

Interpersonal relationships. An employee with this competence does not create conflict situations. In the event of a conflict situation in which he participates, he solves the given problem regarding the needs of all participants. He also tries to honestly understand the other party and look for a solution that is effective for all parties involved. A person who has this highly valued competence is friendly and has good not only formal but also informal relationships in the workplace. The average achieved value in the competence is 93.58 %. We recommend focusing on identifying potential conflicts and resolving them as soon as they arise, opening hidden conflicts by direct superiors through individual consultations aimed at discussing problematic issues, organizing training aimed at resolving conflicts, organizing joint informal meetings - teambuilding, supporting team meetings in the form of organizational contributions. , consider introducing new forms of relationship building once in a while, e.g. (breakfast with the chairman, joint lunch, ...) (Majerčák, J, Majerčák, P, 2016, Majerčák et al., 2016).

Independence. An employee with this competence works without detailed management and control. It achieves a high quality of work, especially thanks to high expertise. He can work on complex work tasks so that he obtains the necessary information independently without the involvement of colleagues who have nothing to do with the current work task. The average achieved value in the competence is 85.34 %. We recommend focusing on regular control by the supervisor, whether we should assign independent employees in teams to more demanding tasks after training, set specific tasks for specific employees, remove the "mom" effect in management, require employees to solve problems, not just state them, to support the provision of support and recognition by a superior (adding self-confidence - building a culture of trust), continue to increase the qualifications and competencies of employees (Majerčák, et al., 2015, Majerčák, et al., 2016).

Motivation. An employee with this competence has an active internal motivation to perform work tasks. He is actively educated in areas related to the performance of his profession, even at the expense of his private time. He is interested in the functioning of the entire organization, individual departments and examines the context to be able to effectively perform his work tasks. In some cases, he often works beyond his working hours. The average achieved value in the competence is 79.81 %. We recommend supporting the enthusiasm of most employees for work for the employer through joint activities that would unite the work team, identify motivators for

employees by a superior, each superior should know what motivates whom in his team, provide a wide range of training and encourage participation in training in areas related to the performance of work, focus on building a system of non-financial benefits that would serve as a motivating factor, achieve a state in which will be clearly defined what who should do in which job, what results are expected of him and how to This tied his reward, in the case of exceptional projects to expose a team of motivated people and reward them (Majerčák, et al., 2015, Majerčák, et al., 2016).

Initiative. An employee with this competence often comes up with suggestions for improving processes. This competence is closely related to motivation. In the event of extraordinary situations, an employee with this competence is willing to take responsibility for activities that are not directly related to the performance of his job position. The average achieved value in the competence is 78.97 %. We recommend actively encouraging employees to provide incentives to improve work activities, motivate the system of non-financial remuneration, employees must feel that management can consider proposals to optimize certain processes and implement them directly, established constructive incentives from employees to actively communicate with the team. praise for a specific employee who came up with a constructive initiative, when assigning a task by a superior, it is always necessary to say the meaning of the task, goals, and context (Majerčák, et al., 2015, Majerčák, et al., 2016).

Teamwork. An employee with this competence can work in a team as a full member. Can actively listen to other team members, share information effectively with them and actively collaborate on team tasks. He is also interested in the work of others and, if the situation requires it, he is willing to help to achieve the team's goal. The average achieved value in the competence is 88.65 %. We recommend organizing training focused on effective teamwork, organizing training focused on the development of creative thinking, organizing informal team meetings, setting clear team goals, specific definition of team roles (who is responsible) competency matrix, regular evaluation of opportunities for better team functioning (in consultation) to carry out a regular survey of customer satisfaction, then jointly evaluate the team and eliminate the identified weaknesses in accordance with a procedure agreed upon by the entire management of the company at the workshop (Majerčák, et al., 2015, Majerčák, et al., 2014).

Analytical, conceptual thinking. An employee with this competence can independently, systematically prepare for demanding work tasks. He thinks analytically about individual processes, which allows him to work very efficiently and systematically. A person with this competence can identify the causes of many work problems and prepare a plan to eliminate them. The average achieved value in the competence is 87.20 %. We recommend in the process of employee selection to focus on candidates with strong analytical and conceptual thinking, organize training for the development of analytical and conceptual thinking, assign work tasks that stimulate analytical and conceptual thinking, do not take over the tasks of subordinates who do not master analytical and conceptual thinking. thinking, if the employee is working on a task that requires analytical and conceptual thinking, then continuously guide employees or go in the right direction, if not, direct them, but do not do it for them (Majerčák, et al., 2015, Majerčák, et all. 2014).

Ability to work under pressure. An employee with this competence provides a constant work performance, regardless of the degree of stress. In tense situations, he can think effectively and look for solutions to potential problems. Even in situations that are stressful, he communicates politely and does not allow himself to notice discomfort and stress. It acts as a rational support for the other members of the team even in a difficult situation. This is also because it has the ability to focus on details even in a situation that is demanding on time and quality of performance. The average achieved value in the competence is 85.91 %. We recommend organizing training focused on time-management, organizing training focused on stress-management, in tense situations managers should be more consistent in managing people who have a given competence rated lower, in tense situations delegate simpler, partial tasks to these people not complex projects, in case there is a situation where the employee does not manage to work under pressure, then give him feedback that it is not right and his superior should divide his tasks according to priorities to eliminate stress due to - I have many priorities and I do not know as soon as possible an employee who has not been able to work under pressure for a long time should only be assigned tasks that have a predetermined procedure according to which the employee can perform his work. (Project,2018, Zmeškal, et al., 2020).

People management with senior employees. An employee with this competence is a recognized leader. He has a strong formal but also informal authority. He actively listens to his subordinates, seeks solutions to their problems, encourages creative thinking and proactivity. It maintains a productive atmosphere between subordinates without competitive matches and work conflicts. The average achieved value in the competence is 88.05 %. We recommend organizing group training specialized for managers focused on people management - leadership, organizing individual development programs focused on individual management activities of subordinates, organizing training focused on modern management trends, encourage self-education in people management, introduce a universal management system meeting, regular provision of feedback, ...), attend at least once a year management conferences for management staff (Majerčák, et al., 2014, Zmeškal, et al., 2020).

Self-management of senior employees. An employee with this competence can control himself in all

work situations. Can adapt the management style to a given situation and a specific person. He has his work activities and the activities of his team organized, he has an overview of what his subordinates are working on, what condition the projects are in and to whom it is necessary to help. The average achieved value in the competence is 89.76 %. We recommend organizing training focused on self-management for groups of managers, organizing meetings with a coach / mentor focused on managing themselves and subordinates, organizing training focused on time management, organizing training focused on managing difficult situations (Majerčák, et al., 2017, Majerčák, et al., 2015).

Delegation to senior staff. An employee with this competence can clearly define the job task for his subordinate so that the subordinate knows exactly how to proceed independently in fulfilling it. He does not tend to over-control his subordinates in performing assigned tasks. Can assign the right role to the right person according to the skill level of individual subordinates. The average achieved value in the competence is 87.61 %. We recommend organizing training focused on effective managerial delegation, organizing training focused on managerial skills, organizing training focused on managerial feedback (Majerčák, et al., 2015).

2.2. Evaluation of the obtained data by personal interviews

Based on interviews with employees, we can identify the following as positive aspects in terms of management and perception of the company: increasing the expertise of employees and thus the company, pleasant working environment, non - financial benefits, working hours, technical equipment, gradual investment in material and technical support.

Based on the above opportunities for improvement and personal interviews, we summarized a list of recommendations, the application of which in practice will help improve the situation:

precisely define job responsibilities in individual jobs, simplify the process of selecting service providers - is relatively complicated, think about simplifying mailing - the process is relatively lengthy, improve communication between departments, consider securing a car to eliminate logistics problems, consider securing a printer for a customer centre (minimum in periods when a lot of materials are printed), the print quality is not adequate and capacity is insufficient, consider training in the field of MS Office (Excel, Word ...), introduce a system of rotation of new employees in the institution - when hiring a new employee, we recommend using a fast rotation, when a new employee would get acquainted with the activities of other departments for better understanding as a whole, in case of any change it is necessary to argue for all people why the change is happening to avoid rejecting the change just because until now it was done and was That's good ... senior staff they do not have time to manage because they are dealing with a routine agenda - it is necessary for managers not to solve the work activities to be performed by their subordinate, but to guide subordinates to deliver results in the expected quality, employees feel that from some data they record are not outputs and therefore find it unnecessary to label it - it is necessary to clearly explain in each activity why it is done so that employees can see the meaning of why they are working to consider simplifying the process during business trips, set up one system for recording events in the calendar for all employees with labeling In order for everyone to know that the person is not at work from - to, to provide gel pads for mice and PC keyboards for greater comfort when working with PCs and to prevent health problems, consider gradually increasing wages (Majerčák, et al., 2017, Project,2018, Zmeškal, et al., 2020).

2.3. Summary of educational and development activities

Within the individual competencies, the final report proposes types of training that help employees to improve in individual competencies. At present, employees have a positive perception of the possibility of training in the company. Regarding the implemented project, we recommend keeping selected trainings and, depending on the possibilities of the institution, also considering new trainings. Continuation of selected trainings and development programs (Majerčák, et al. 2016):

- leave employees the opportunity to register for conferences,
- seminars and workshops related to the performance of their profession (eg work with social networks, IT area, legal topics, legislation),
- continue to consider the specific needs of employees in the field of individual education - change legislation,
- new trends in specific areas in case of changes in the law, we recommend automatically organizing trainings for employees who work with the law.

Introduction of new trainings depending on the possibilities of the company

From the point of view of maintaining high professionalism, motivation and development of people, we recommend setting up the education system so that each of the employees completes at least one development training (1 day) during the year, organizes training for managers focused on: managing their time and subordinates' time; to handle difficult communication situations; for effective managerial delegation; to provide effective feedback; to work properly with praise and criticism; focused on management trends; coaching; mentoring. In the field of IT, in case of any changes (eg update of the operating system, e-mail client, ...), we recommend that you immediately organize internal training for the change for all affected employees; training focused on WORD and EXCEL - most employees have a

great interest and need to participate in training focused on working with these programs, training aimed at developing active listening comprehension; for training non-verbal communication; to manage and resolve conflict situations; to develop analytical and conceptual thinking; on time-management; on stress management training focused on effective communication in the system of follow-up levels, e.g. Effective communication I. (basics of effective communication), Effective communication II. (Advanced techniques of effective communication), thus ensuring that the content of the course will be directly proportional to the participant's abilities, trainings focused on the development of argumentation skills in the system of subsequent levels Argumentation I. (basics of argumentation), Argumentation II. (Advanced techniques of effective communication), thus ensuring that the content of the course is directly proportional to the abilities of the participant. (Majerčák, et al.,2016, (Project,2018, Zmeškal, et al., 2020).

Conclusion

Current employees see a positive trend in the company. They appreciate the changes that have been made recently. This starting point allows the employer to work with current employees in the future.

We consider the best competencies according to the implemented 360 ° feedback project: interpersonal relationships (93.58%), conscientiousness and reliability (89.90%), self-management (89.76%), teamwork (88.65%), communication skills (88.61%), people management (88.05%), delegation (87.61%), analytical and conceptual thinking (87.20%).

On the verge of success in the 85% competence are the competencies: ability to work under pressure (85.91%), focus on results and potential for the future (85.50%) and independence (85.34%).

Below the threshold of success are competencies: motivation (79.81%) and initiative (78.97%).

All these competencies can be developed for existing employees with the potential for positive evaluation in the future, compared to the current situation. The solution is to understand the rules of competence - the precise definition of the responsibilities of individual job positions, active communication, individual and group training of employees, building and uniting the team, resolving the germs of conflict, and building a positive atmosphere in the team. (Project,2018, Zmeškal, et al., 2020).

We consider the most important role of management to be to clarify the competencies of individual departments. Once the responsibilities have been clarified, it is essential to inform all employees by their immediate superiors of their rights and responsibilities in the performance of their work, to avoid any confusion as to who is responsible for what. By strengthening open communication within the organizational structure, management towards employees will provide space to improve processes and work performance itself.

Acknowledgment

This publication has been produced thanks to the support of KEGA project No.057ŽU-4/2021: Innovative approaches in the system of teaching logistics with a focus on the creation of logistics networks in pandemic conditions.

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Transport technic and technology
Volume XVIII Issue 2 Year 2022
DOI: 10.2478/ttt-2022-0008

USE OF SOFTWARE SOLUTIONS FOR SIMULATIONS OF TRAFFIC PROCESSES DEPENDING ON THE TYPE OF TRAFFIC MODELS

Abstract. This article is aimed at introducing the issue of simulating traffic processes and the possibility of creating traffic models using software solutions. The introduction describes the basic problems that are present for the responsible authority in the decision-making process on the implementation of transport infrastructure projects and the verification of the validity of their implementation. The importance of computer technology in the process of evaluating projects and the socioeconomic effects they bring is also mentioned. The benefits of retrospective evaluation of already implemented projects and comparison with predictions made in the preparation process in relation to the verification of forecasts and the structure and scope of input data are also indicated. In the next part, the starting points for the creation of traffic models, input data and expected outputs are summarized due to the nature of the performed simulation. The final part provides an overview of the possibilities of using software solutions for the creation of traffic models and the suitability of their application according to the specifics of the simulation and output requirements.
Keywords: simulation, transport model, transport processes, simulation software

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Introduction

Modelling the transport network with the help of computer technology is a relatively new professional discipline, known in our country only since the 1980s. Computer simulation is a method that is used for analysis, evaluation and optimization of systems that exist or could exist. The basic process includes building a computer simulation model, abstraction, experimentation, interpretation and use of the results. (Čamaj et al., 2021). Computer technology allows, in addition to traffic simulation itself, to deal with other accompanying phenomena, e.g. by simulating the burden of externalities on the affected population. At present, these simulations are increasingly requested by the decision-making authority (state, managers of infrastructure, municipalities, etc.) of transport construction projects. A significant advantage is the possibility of verifying several variants of infrastructural constructions and subsequently selecting the optimal variant in the context of the technical solution, financial demands and socioeconomic benefits, taking into account the Value for Money principle. Without the need to verify the effects of the building by its real implementation and subsequent comparison with other assessed solutions. At the same time, it is possible to assess the benefits of already implemented projects, such as the assessment of the impact on the distribution of traffic flows, capacity suitability for the projected future density of traffic, the effects on the environment or increased safety, in comparison with projected values.

The disadvantage of simulations with the help of computer technology is the assumption of the availability of input data in an adequate range and accuracy, and at the same time, a forecast of future development is always necessary in the scope of the reference period during which the project is evaluated (in the case of transport infrastructure projects, usually 30 years). The mathematical model may be useful to take some utility criteria as “constraints,” but this should be considered a heuristic that helps reduce the set of relevant variants and simplifies the utility function’s specifications. (Bukvić et al., 2021). The creation of a model is always to a certain extent influenced by the intention of its creator and the level of knowledge of the problem at the time of processing. An inappropriate approach can be, for example, placing redundant emphasis on the geometric accuracy of the transport network model, while simultaneously neglecting the identification of the necessary data, their structure and scope. A common mistake is also the creation of the model and the presentation of its outputs, which, from the point of view of the purpose of the model, is not necessary or even wrong.

1. The importance and structure of traffic models

The first models of the transport network, without the use of computing technology, were based on similarities with the theory of fluid flow. As with fluid flowing through a cylindrical body, fluid that flows in at one end must also flow out at the other end. As with the flow of liquid through a pipe with sharp edges (turbulent flow), problems arise on a road with a small turning radius. These models are classified as macroscopic models, they do not understand vehicles as individual moving objects, but take into account flows of vehicles, and intersections are understood as traffic nodes, but they are not modelled more precisely in terms of their specific layout, capacity and infrastructural (traffic) specifics and limitations.

Computer technology allows to simulate traffic on small sections in a much more detailed view, on the so-called microscopic or nanoscopic level, where individual vehicles are already understood as separate objects with defined traffic behaviour and network nodes are modelled in more detail (numbers of road traffic lanes, topology and extent of tracks in the railway station, etc.). Input

information for these models is data of the speed and direction of individual vehicles, acceleration and deceleration of vehicles, infrastructure capacity, degree of line saturation, maximum speed of vehicles, and other traffic and technical characteristics.

With macroscopic models created through computer technology, however, we get more reliable data in mass results, such as densities, directions or speeds of traffic flows.

Traffic modelling and simulation are used to represent the current traffic load of individual roads as well as the design of new traffic connections and redistribution of the investigated traffic flow on the modified network.

With the help of traffic models and simulations, it is possible to determine the traffic. Load during the implementation of various variants of traffic network modifications.

This leads to cost savings and the selection of the most suitable solution. (Křivda et al., 2011)

According to the scope of the investigated transport network, transport models can be divided into:

- macroscopic models,
- mesoscopic models,
- microscopic models,
- nanocsopic models.

2. Basic quantities of traffic flow

The basis of traffic models is a two-dimensional expression of the relationship between the speed and density of the traffic flow, where the speed of the traffic flow is indirectly dependent on its density. (Dym, 2004)

So, above all, on the relationship:

$$q=v.k \quad (1)$$

Where q is the intensity of the traffic flow, given in vehicles per hour in one lane, v is the speed of the vehicles in kilometers per hour, and k is the density of the traffic flow, given in vehicles per hour in one lane.

3. Division of models according to the scale of the modelled network

It is not possible to define one universal traffic model, for the reasons that each model is suitable for modelling other, specific situations. Each model differs in the range of modelled details and the resulting computational complexity. Larger models (macro and mesoscopic) generalize the behaviour of vehicles and neglect the details of their movement, while smaller models (micro and nanoscopic) take into account the behaviour of each individual driver, with the parameters of his vehicle and also consider human factors (e.g. reaction time).

The hierarchical structure of the models with respect to the scope of the assessed area is shown in the following figure.

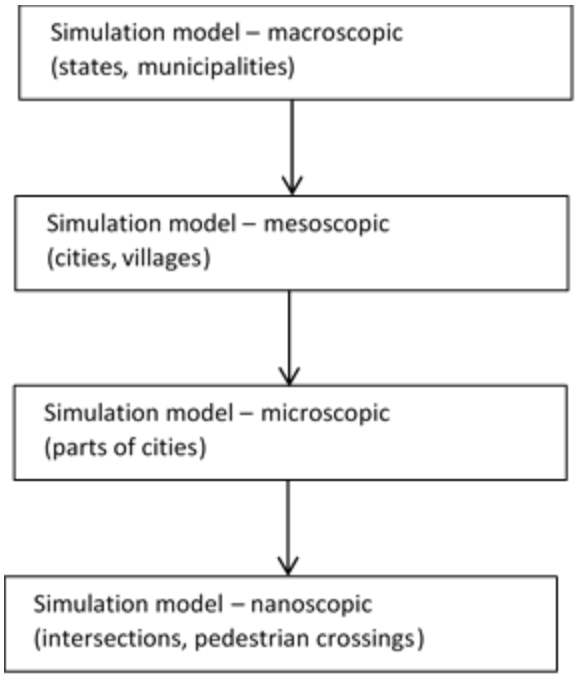

Fig. 1. Hierarchy of models according to the extent of the modelled territory

4. Macrosimulation models

Macrosimulation models are intended for modelling extensive transport networks and are used for the purpose of forecasting traffic flows in the future for strategic decision-making. During the construction of this model, it is necessary to collect a large amount of input data, such as the use of individual areas in the vicinity of the transport network, which are the source of transport supply or demand (for example, whether it is an area used for residential purposes, or a shopping zone or an industrial zone).

Macroscopic models use only the basic properties of the traffic flow, such as speed, intensity and density, and neglect parameters such as the individual parameters of each vehicle, the individual behaviour of the driver.

The output parameters of these models are the distribution of the traffic load on individual links, the identification of traffic congestion and their effect on the average speed on the examined line (part of the road between two nodes). This is used to identify critical points in the transport network, analyse the existing transport network and find proposals for its modification.

The models used include:

- Greenshield's linear model,
- Greenberg's logarithmic model,
- Underwood's exponential model,
- Modified Greenberg model,
- Payne's model,
- Kerner's and Konhauser's model,
- Multi-regime models.

5. Microscopic models

Microscopic models take into account the behaviour of each individual driver, taking into account the parameters of the infrastructure on which the vehicle moves and the parameters of the means of transport.

The input data of these models are characterized by a precise geometric description of the shape of the environment (shape of the road, its division into individual lanes, traffic restrictions, etc.).

The models used include:

- Car-following model,
- Pipe's model,
- General Motors car following model,
- GHR (Gazis – Herman – Rothery) model,
- Linear model,
- Wiedemann's model,
- Nagel-Schreckenberg model,

6 Simulation tools

There are a number of available simulation tools for traffic modelling. In this article, we will focus on the most frequently used solutions. Among the most used tools is the solution developed by TSS - Transport Simulation Systems, which is called AIMSUN.

Another frequently used software solution is VISUM and VISSIM, each of these programs is focused on a different subfield, VISUM is a macroscopic and mesoscopic modelling tool, while VISSIM is focused on the simulation of vehicle and pedestrian traffic on a microscopic scale.

The following table summarizes the characteristics and suitability of using individual software.

Table 1. Selected features of possible software solutions

Function/software	VISUM	VISSIM	AIMSUN
Model size	macro, meso	micro, nano	macro, meso, micro
Network size	unlimited	unlimited	unlimited
Size of traffic demand	yes	yes	yes
Hybrid model	no	no	yes
Traffic modelling	yes	no	yes
Multimodal analysis	yes	yes	yes
Traffic simulations	no	yes	yes
Modelling / simulation of pedestrians	yes	yes	yes
Modelling / simulation of public transport	yes	yes	yes
Managing traffic with lights	yes	yes	yes
Defining geometry of intersections	yes	yes	yes
Multiplatform software	no	no	yes

Conclusion

Modelling and simulation of transport systems give us a large range of application possibilities and approaches to solving the respective transport process depending on the need to minimize the external negative impact. Modelling brings a new added value to the solution of traffic processes in the form of a relatively simple rearrangement of given traffic situations with the possibility of variability of approach and final solution of the given situation and specific traffic process.

The use of models and simulation methods leads to the realization of the results of the proposed solutions and thus to the faster application of new procedures in the implementation of transport processes.

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Transport technic and technology
Volume XVIII Issue 2 Year 2022
DOI: 10.2478/ttt-2022-0009

STRATEGY DEVELOPMENT IN THE SERVICE OF RAILWAY UNDERTAKINGS

Abstract. Railway undertakings face many challenges and obstacles to competition in the transport market. Strategic management methods in relation to quality assurance of services provided by carriers, used not only in transport sectors but also in industrial sectors, are a way to continuously improve the quality of services and thus the competitiveness of railway undertakings. Nowadays, customers are becoming more and more demanding, also in view of the wider range of services offered by other modes of transport. For this reason, quality requirements are increasing. Most business strategy evaluation systems are only partial, limiting themselves to the assessment of certain factors where many shortcomings remain hidden. In the same way, a strategic plan for the economic growth and development of a transport organisation does not always ensure the achievement of the set objectives.
Keywords: strategy, railway undertakings, competition, transport organisation.

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Introduction

In the current period, it is important to examine the tools of strategic management, and their application in domestic and foreign transport organizations and to develop recommendations to improve their use in the management system of transport enterprises in order to ensure successful implementation of the economic corporate strategy. Accordingly, there must be new ways of finding more progressive approaches to the evaluation of service quality and strategy enterprises. The long-term maintenance of quality is difficult and costly, however, when appropriate strategic methods, it is realistic. However, it is the only way a railway undertaking can conditions of the transport market to gain the trust of customers and possibly reach new one potential customers who have not yet used rail transport. In the context of providing transport services, the undertaking must make a major effort to customers not only feel that their requirements have been met for a predetermined amount, but also that they have received higher quality than they expected. Fundamental issues in a service-oriented transport business in freight transport are related to which commodities the company is focused on transporting, in what volume the carrier is able to transport in a given time, and by what means of transport means available to the carrier. A crucial strategic tool is not only the setting of the pricing policy and the tariff applied by the carrier to carry out the transport, but also additional services for the customer. Creating strategy in the organisation and at the same time maintaining it determines a large range of strategic management tools and methods that ensure that effective results are achieved.

1. Impacts of the COVID-19 pandemic on railway transport in Slovakia

The definition of strategic management is currently not entirely clear. In current literature, the prevailing view is that strategic management is a set of instructions, decisions and activities that are necessary for an organization to achieve a strategically competitive advantage and competitive position in the market (Hitt et al, 2011).

The issue of strategy development in the transport company is a key factor for the sector services for the reason that it is a crucial procedure for creating differentiation and gaining competitive advantage of the company's position in the transport market. Therefore, every enterprise has developed its own strategy, which ultimately has the same intention, but its development and strategic decision-making are different and it is an internal document of the transport organisation. The difference in strategy development lies mainly in the use of strategic and management methods, which are used both at home and abroad. However, these methods have not been developed directly for the transport and transport services sector, but the use of the methods is applicable to a variety of sectors, be they industry, transport or other types of services. The available scientific studies and publications describe strategy development mainly using the methods strategies that have international application and use in other countries outside EU (Sikora, 2018).

A market-oriented approach in which customers, or in this case carriers, are seen as consumers of services, must therefore be fully to meet their needs with core and ancillary services, focusing on establishing achievable targets and monitoring the effectiveness of the services provided. It is also necessary to take into account to take into account a focus on the efficient use of resources in order to achieve maximum quality of service delivery with sufficient cost control with the operational activity of the transport undertaking, using incentive systems Intra-enterprise environment (Gu, Bei, 2019).

2. Strategy development and strategic management

At the heart of strategic management is strategy. According to Porter (Porter, 2010), strategy is a broad-based concept that determines what the competitive

capability of an enterprise is, what its objectives will be and what strategic policies will be needed to achieve these goals. However, strategy is not

The written article exclusively the creation of competitive advantage, but it is also the creative destruction of advantages competition. The authors Andersson and Dubois (2014) list three dimensions of strategy, which are relevant in the formulation of strategic priorities. Some contemporary authors (Fadhil, Ismail, Alnoor, 2021) describe the emergence of strategy styles that are defined by the nature of the business environment. The following have been selected as appropriate for the transport services industry

Strategies for the transport sector:

- Classic strategy that can be applied in companies operating in predictable and low-changing environment. Managers in these strategies focus predominantly on the sustainability of the competitive advantage gained. Strategic practices are guided through detailed analyses of the factors constituting competitive excellence of the enterprise, to the planning and subsequent implementation of the strategy,
- The strategy being formulated is designed for an environment that is unpredictable but has the enterprise has the possibility to influence. A typical application of this strategy is the emergence and growth new industries where competitive links have not yet been established. In transport services, an example might be the transport or the emergence of a new commodity transport or a new transport technology,
- An adaptive strategy that is suitably flexible and open to experimentation. This type of strategy is applicable in an environment whose evolution is difficult to predict. In transport services, this type of strategy is often used, as in this area conditions are constantly changing and transport operators are forced to continuously improve and innovate. The company is not in a position to influence the evolution of the environment,
- Process strategy is a tool to achieve the operational objectives of an organisation. Managers at the operational level of management implement strategies leading to an increase in process performance, reduce costs, increase availability and ensure quality of services provided.

In the current conditions of economic globalisation, high dynamics of external environment, strategy becomes one of the key factors of competitiveness of the enterprise on the market. The range of strategic decisions in the economic sphere of the transport organization is considerably extensive. The basic issues in a transport enterprise focused on freight services transport are what commodity transport the company is focused on, in what volume is the carrier capable of transporting the goods within a fixed and specific time and by what means of transport, available to the carrier (Rogerson, 2013). However, a strategic plan for economic growth and transportation development does not always generally ensures the achievement of the set objectives. In this context, it is important to examine the current strategic management tools, their application in domestic and foreign transport organizations and to develop recommendations for improving their use in the management system transport enterprises in order to ensure the successful implementation of the economic corporate strategy. However, for the decision and selection of the right and appropriate strategic plan, it is it is important to accept the various factors that influence the speed of implementation of the strategic plan. These are factors such as the level of organizational factor, specific factors for decision making, the speed of decision making and the economic performance of the business. In the strategic decision making process, it is important to consider the principles of multiple possible strategic alternatives at the current time, also need to assemble an expert team for decision making, resolving conflicts in the decision-making process and avoiding its risk, and last but not least Increase the effectiveness of decision integration (Hendrix, 2016). A graphical description is expressed in the following figure.

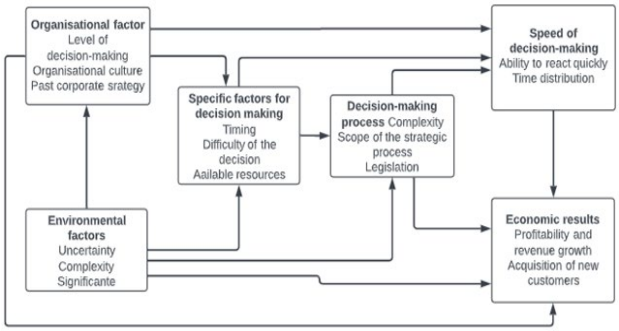

Fig. 1. Factors influencing the decision-making process (Source: Spring, 2015)

The method of developing a strategic plan involves sequential steps, including decision-making processes that are further formulated into a strategy, which further incorporates strategic map, investment studies. These influencing factors further lead to the definitive elaboration of alternatives to the strategic plan. The long-term strategic objectives need to be decomposed into short-term objectives, which are given a functional strategy and are the basis for operational management. The strategic plan thus developed is ready for implementation. At present however, there are several models of recommended process for formulation, implementation and evaluation strategy (Slocum, 2014).

The model is composed of four parts of strategy development:

- **Formulation of the strategic intent**, where, based on known external and internal factors of the business environment, the initial strategic development scenarios are generated environmental scenarios, on the basis of which relevant strategy alternatives can be established and define and guide the strategic intent. Within this phase of the strategic of the strategic management process, it is necessary for managers to acquire knowledge and methodological procedures to be able to navigate flexibly in a challenging and constantly changing environment. It would be necessary to develop new innovative methods

and procedures for exploring the internal and external environment,

- **The development of a strategic plan**, whereby the basic organisational and communication links, developing investment studies and projects and establishing functional strategies supporting the development and implementation of the strategic plan. In this part it is necessary to in addition to the strategy, address the initial steps that should precede the actual development. These steps address the issues of visioning, defining the mission and the overall strategic objectives and questions about the internal hierarchy of the strategy of the enterprise,
- **Strategy implementation**, where objectives for operational management are developed, allocate the available resources (original and newly acquired) to them, implement the processes leading to fulfilling the set objectives and core values of the strategic plan. The phase is also is concerned with the redesign and refinement of the integration of the corporate planning system. In addition, however, other tools, programs sand procedures,
- **Strategy evaluation** is concerned with measuring and assessing the performance of the strategy as in time sequences relevant to operational management, as well as throughout the planning over the entire planning horizon. The methodology and tool that is most applicable in this section is controlling. As part of the last phase of the process, a new concept of control needs to be thought through in management, which should form one of the most important components of strategic management. Strategic control should, through feedback to the previous phases to give the strategic management process a continuous ongoing process (Lorenzo, 2018).

The model shown in the following figure describes the individual the above phases.

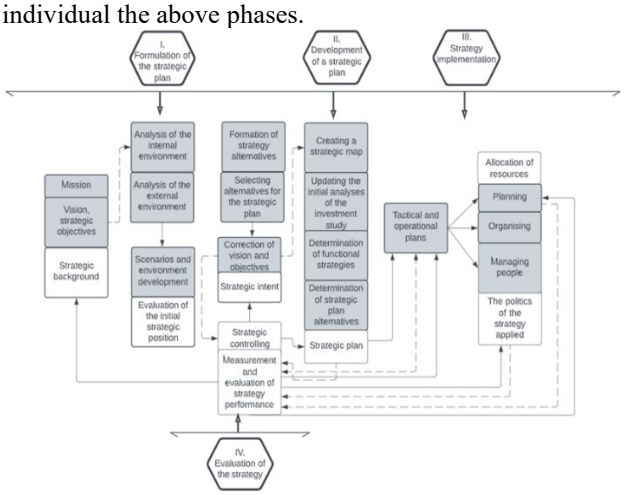

Fig. 2. Strategic management diagram (Source: Curseu, 2010)

However, it is important to point out the importance of the starting point, i.e. the mission, the vision and strategic objectives, long-term goals and the strategy to achieve them. Strategic management should take into account all the factors of strategy implementation, ensuring a constant balance and alignment of the components of the model, as changes in one variable through a system of linkages affect the state of the others. In the context of the application of the model however, it is necessary for the enterprise to focus primarily on the needs and requirements of customers within the provision of transport services. The important variables are in particular Reliability, timely and flexible response capability, carrier security and reliability and, last but not least, empathy and individual approach to each client (Soputan, 2020).

Strategy implementation is a process that forms a logical set of interrelated of activities enabling the implementation of the formulated strategy of the enterprise. Strategy implementation is primarily concerns the tactical and operational levels of management. A well-implemented strategy requires the setting of short-term operational objectives for sub-activities, enabling the allocation of available resources and then to establish a policy for the application of the strategy. In the course of strategy implementation, the strategic plan is developed into a business plan (Pricop, 2012).

The driving element of the strategy implementation is its innovation potential, whose basic characteristics can already be applied in the vision itself. These objectives can be divided into several groups of internal and external business environment. These are financial and internal objectives with the aim of optimising operational processes and reducing costs. Then there are indicators with the aim of higher service value for the customer and understanding of needs customer and learning and growth of the business to improve management processes and increase productivity. The following section lists examples of strategic objectives that may work best in an organisation. However, transport businesses largely have the same missions, especially in terms of transport performance. However, each organisation has different stated objectives and a different approach of unique strategic sets to achieve these objectives (Sandra, 2019).

A closer characterization of the strategic objectives of an enterprise is found in the following figure.

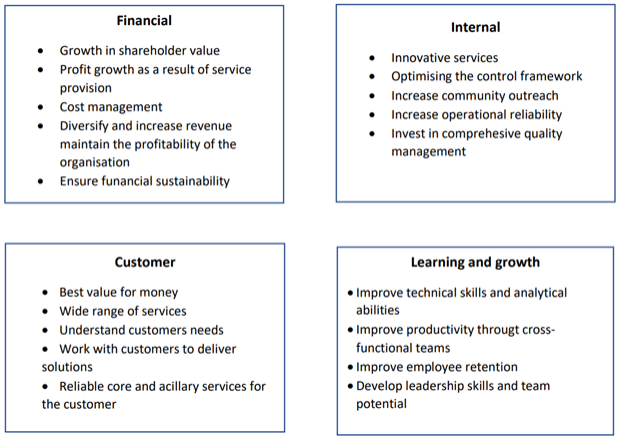

Fig. 3. The basic strategic objectives of a transport service organisation (Source: Hansen, 2015)

These organisational indicators also serve to enable the organisation to use them to be able to develop sufficient and, in particular, knowledge-based strategic goal-setting that leads to overall improvement and increase organisational performance.

3. Strategic decision-making and methods applicable in strategic management of railway undertakings

Strategy formulation and strategic decision-making is a challenge given the current supply of (Hanasini, 2016) would decision-making process should mainly include the identification of external and internal environment, analysis of resources, bottlenecks and selection of appropriate strategic method and alternative. The author of a professional publication (Ioannis, 2017) evaluates strategic decision making as a theory of a three-stage process. According to the author, the important stages are the identification and recognition of the decision, the development stage, which deals with the search for suitable proposals, and lastly the selection phase, which reviews, evaluates and approves the proposals.

Fig. 4 Company strategy implementation process (Source: authors)

Prior to any implementation of the strategy, an evaluation of the strategy must be carried out. The current strategy evaluation foresees its application throughout the strategic management. The specific strategic practices that an enterprise decides to apply cannot be immutable because the environment in which the enterprise's strategy takes place is constantly changing (Basu, 2015).

The following indicators are needed to respond to this:

- Continuous monitoring of the internal and external environment, which has a significant impact on the strategy adopted,
- Evaluating the results achieved and comparing them with the assumptions made by the organisation's strategic plan,
- Propose necessary corrections in the adopted strategic procedures.

The strategy evaluation phase ultimately contributes to the growth of competence of the enterprise and the experience gained can be positively applied in its development. The procedures of strategy evaluation are focused on two basic directions:

- Correction of ongoing processes, using early indicators,
- Evaluating the fulfilment of the strategy and the strategic objectives as a whole after completion
  implementation of processes, using lagged indicators (Kurtz, 2019).

Supporting the strategy implementation process requires the comprehensive development of models and methods for measuring results that are developed by individual departments and staff of the enterprise in relation to the fulfilment of strategic objectives. Although the theory of strategic of strategic management was only developed at the end of the 20th century, there are now a number of methodological tools that enable enterprises to shape their development strategy on the basis of an analysis of the external and internal environment. Of the many available methods and strategic of strategic alternatives, it is necessary to select the right method for a particular process or product to achieve set objectives (Borjalilu, 2018).

From the research conducted on international best practices in strategic management shows that transport companies that implement strategic management usually focus on economic growth and make extensive use of known strategic management tools management. The practical application of strategic management in most national transport however, does not meet the requirements of effective management. There is no tool for the application of economic strategy to the operational level of system management. This may be because, the organisations apply the different strategic tools separately. For example, business processes of large national transport companies generally do not correspond to the chosen business model for strategic development and do not adapt to reflect changes in the external environment (Barhmi, 2016). The transport market model is constantly changing and transport organisations need to adapt. These changes are transforming transport companies into multimodal transport and logistics companies. Current pricing and its methods reduce the possibility of investment resources for the economic growth of the company. This is reflected in lower financial equity resources to finance the investment programme related to the creation and development of the corporate structure and the modernisation and renewal of the vehicle fleet. Insufficient developed strategic instruments for the implementation of the economic strategy of the transport undertaking are are considered to be the most limiting factor causing the low rate of achievement of strategic objectives and calling into question the possibility of using significant resources and the relevant methods at the stage of its development. To ensure the effective implementation of the economic strategy of the transport company, adapted to the current tasks of the development of the national transport of the national transport system, it is necessary to use a mechanism including integrated relevant instruments strategic management, which are integrated into the overall system of the company. A transport company strategy adapted to the current market situation is understood as the creation of a mechanism for the implementation of the economic strategy of the transport company strategy, which includes all key strategic management tools, tailored to to the specificities of the sector so that it is integrated into the overall management system, thereby ensuring an effective balance between the development of operational, investment and financial activities of the transport organization (Liao, 2016).

Critical factor success

The most common mistake businesses make when creating a strategy is defining very quickly objectives or projects. By defining a set of critical success factors, an organisation can refine the factors that will accelerate change and improvement. Critical success factor tool is also defined by J. Rockart. He defined critical success factors as "several key areas that must be fully operational for an enterprise to thrive. If the results in these areas are inadequate, the organization's efforts over a given period will be less than the enterprise originally planned. The above strategic methods have universal application in all business organisations, including application to freight transport. However, there are many strategic tools that can be used to assist in the development of a corporate strategy. Some of the methods described above, if their use is adequate, can be paired and mixed to ensure full coverage of the objectives, for example in the analysis phase. Other strategic methods that are most commonly used are the following.

PEST analysis

A PEST analysis is a graphical or verbally composed construct that depicts a political, economic, socio-cultural, technological, legal and environmental analysis. It is a strategic tool that is used to take an overall view of an organization. It focuses on changes of the business environment that may ultimately have a positive or negative impact. Positive impacts include the introduction of a new service to a customer that that is directly related to the business and which may also reach new customers. In rail transport, for example, this may be the introduction of the transport of a new commodity. Among negative impacts include changes in safety and legal regulations, which most often lead to increase costs and thus reduce profits. This increase in costs should consequently be reflected in an increase in transport prices, which may lead to customers switching to competitors or to another mode of transport (Courtney, 2013).

A PEST analysis usually consists of three steps:

- Using a mnemonic to identify changes in the overall picture of the enterprise
- Identifying opportunities or threats arising from the changes.
- Implements elements to mitigate threats or exploit opportunities into the strategy Identifying and mitigating opportunities and opportunities for the enterprise.

The analysis further looks at various external indicators that have a fundamental impact in a significant way on a given organisation's operations.

Porter's 5 forces

In contrast to PEST analysis, which focuses on the image of the firm, Porter's suggests that analysis focuses more on the microenvironment. In doing so, it expresses the 5 forces that take into account the proximate companies that can influence an organization's ability to provide services to its own customers and thus make a profit. These 5 forces are:

- **Buyer**: customer satisfaction is also expressed by the customer being provided with a service of a higher quality than he or she originally expected. Given that in the transport sector the range of offerings is very wide and it is very important to look at the quality factor the quality of the service provided.
- **Suppliers**: Suppliers, on the other hand, offer a lower quality of service compared to their customers. quantities at higher prices.
- **Substitute**: The supply of transport services by transport operators is very very easily substituted by another mode of transport or by a competing transport company.
- **Potential new competitors**: In this case, new carriers can often cause tensions between carriers. In particular, they can threaten the organisation by offering the customer a lower price for the same, better quality service, or other additional services.
- **Competition on the horizon**: It is important for the organisation to constantly take into account competition. Intense competition thus reduces the returns to other organizations.

Porter's five forces model is currently one of the basic and most important tools for analyzing an organization's competitive environment and its strategic management. This analysis is useful for evaluating strategic opportunities, threats and competition. In addition, this analysis examines the areas that determine the behaviour of competitors by indicators of the risk of entry of potential competitors, current competitors and the threat of substitutes. In the following figure is a model that can be applied to each transport organisation using the above indicators.

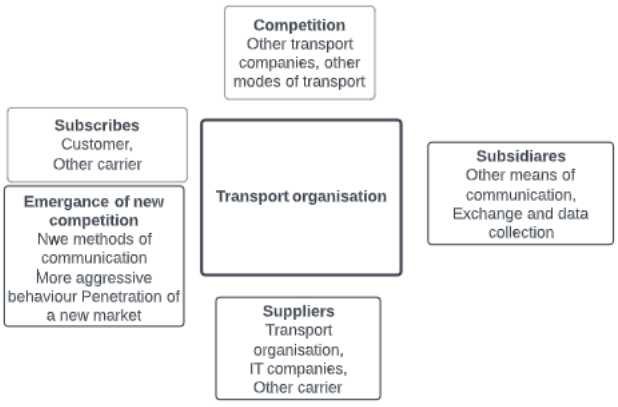

Fig. 5 Porter's Five Forces Model (Source: authors)

Balanced Scorecard

Railway companies, which are mainly oriented towards freight transport, are have chosen the BSC system as a tool for monitoring the fulfilment of the company's strategic objectives (Balanced Score Card). For all levels of objectives, factors have been identified that serve to monitor developments in individual areas of the companies' operations. These are factors such as finance, customers or resources. These are measurable factors

whose value the company would like to to achieve in the shortest possible time and whose positive impact will be evident in the future. All possible areas that are subject to appropriate improvements and that would be the railway undertaking should focus on should be incorporated into a methodology which indicates a comprehensive picture of how the company is able to meet its strategic objectives. Strategic methods in the field of strategic corporate management shall be applied as part of the methods the research process, which help to find, optimise, manage and evaluate research tools and information resources (Timmins, 2020).

The methodology functions as a tool for enterprise performance management and also serves as a framework for the implementation and management of enterprise strategy. Together, it links vision with strategic objectives and various measures to achieve them. Furthermore, the methodology primarily focuses not only on results, but on financial and non-financial objectives in the context of the strategic objectives. Therefore there is a need to first identify which objectives can be measured and only then to determine the specific ways in which these objectives. The method also makes it possible, by means of strategic maps, to indicate transparently the functional strategy of the processes so as to maintain overall consistency with the corporate strategy. Once the strategy planning phase has been carried out and the appropriate strategic methods have been selected, the it is important that the organisation defines the correct and specifically achievable strategic objectives. Given that key performance indicators (KPIs) are applicable to strategic objectives, these objectives and indicators must be measurable. This is in order to to be able to compare the planned status with the current status or the current status with the past status. Therefore, KPIs also depict organizational goals in measurable values. These values must be quantifiable and must also lead to the fulfilment of the strategic objectives. To each strategic objectives are then assigned parameters for measuring the performance of the KPIs. These are shall be applied to define the required values and to regularly evaluate the fulfilment of strategic objectives of the transport undertaking. The achievement of the target to the required level and in the specified deadline (Qehaja, 2017).

SWOT analysis

SWOT analysis is a strategic method for selecting a strategic decision. This analysis breaks down the strengths, weaknesses, opportunities and threats. The purpose of this analysis is to summarize the overall position of an organization into a single chart. The analysis also has the same use for rail freight transport services. The SWOT analysis is very useful strategic tool that can be used as part of an organisational analysis. One of the inputs to the analysis is the competitor profile, which is a brief but also essential overview information in a specified format about a competitor. Information such as mission or vision of the company are publicly available for the purpose of the analysis. Table 3 below shows an alternative SWOT analysis applicable to freight transport services. It goes a survey of competitors, opportunities for improvement of the company's internal operations and relevant opportunities for the organisation in the market (Ulaga, 2011).

S – Strenghts	W – Weaknesses
• What advantages does the transport organisation have compared to its competitors? • Which strategic decision will yield the greatest return on investment? • Which strategic decision can be implemented in the shortest time? • Does the organization perform its processes at an adequate level?	• Which areas can be improved? • Is it possible to take inspiration from competing transport companies? • What do customers complain about most often? • Does the organisation have internal/external processes that are clearly lacking in quality?
O – Oportunities	T – Threats
• What are the new opportunities in the market that the company should take notice of? • What are the current market trends? • What are the predicted long-term trends in the market? • Are there various social, industrial, transportation changes that the enterprise can potentially take advantage of?	• What are the obvious opportunities that we can see in the market? • How are competitors carrying out the processes? • Are there regulatory changes that the organization must respect? • Can the organization keep up with technological changes?

Fig. 6 SWOT analysis applicable to freight transport services (Source: authors)

4. Strategic measures for strategy development in transport services

The strategic planning process in a transport organisation primarily involves research of market conditions, customer needs and requirements, identification of strengths and weaknesses

strengths and weaknesses of its own capabilities. In order to implement a successful strategy, it is particularly important to select achievable strategic objectives, especially with a customer orientation. For achieving many of the objectives in a transport organisation it is not necessary to spend large financial resources and can be managed and planned on an operational strategic level. One of these objectives and measures is to increase the level of service provided for the customer. An indicator of the quality of service offered by transport organisations to their customers is a crucial indicator that can influence satisfaction and retention customer satisfaction and can also generate new customer interest. If a railway transport undertaking organisation increases the level of service offering at an optimal price and reasonable cost costs, the carrier can then motivate and attract new customers and increase profit generation and increase transport market share. This strategic objective is the carriers are constantly forced to implement due to the high competition in the transport market. This strategic objective is at company level and also applicable to both road and for both road and rail carriers. In the case of customer retention and new customer acquisition, the transport organisation has the opportunity, in addition to increasing profit generation, to achieve increased share of transport performance in the transport market. The annual increase in international traffic is currently the largest The efficient and optimal determination of operational processes in relation to international transport can result in efficient use of the carrier's or customer's wagons, which can consequently reduce transport costs and optimise transport times. Consequently, these measures further efficient use of the railway infrastructure can also be achieved by shortening and optimising the overall transport time and thus reduce the carrier's operating costs. Lastly, it is about the efficient use of the means of transport, which can increase the

efficiency of the transport organisation's operational activity. At present, a major problem is in rail freight transport is the non-utilisation of wagons on the return journey, particularly in the case of rows of specific wagons for a specific commodity. In the case of the implementation of the strategic objective there is an opportunity to increase the efficiency and effectiveness of both rail transport and transport organisation. The strategic objective could be realised through a higher share of market and transport performance of rail transport and thus achieve higher efficiency. However that matters most to the carrier's customer is lower transport costs. This is due to, in the case of empty wagon runs, the carrier can charge the customer higher fees, that are not related to the transport in question. In this context, from the carrier's perspective, there may be a higher profit generation and a more efficient use of operating costs.

The following table below shows the main strategic objectives that should be to be implemented by every transport organisation, regardless of the mode of transport operated, together with the positive impacts of the strategic objectives for the transport organisation. In the following section of the thesis, the strategic methods by which these strategic objectives can be achieved.

Strategic objective of the transport organisation	Impact of the strategic objective for the transport organisation
Increasing the level of service of rail freight operators	• Customer satisfaction and retention • Greater share of transport performance of the transport organisation • Optimisation of operational processes • Higher revenue growth • Reaching new customers
Assessing options for reducing time in international transport	• Efficient use of means of transport • Reduction of transport costs • Transport time optimisation • Greater share of transport performance of the transport organisation
Efficient use of the means of transport and increase in the efficiency of the carrier's operational activity	• Efficient use of means of transport • Lower transport costs • Beneficial effect for the environment • Greater share of transport performance of the transport organisation • Higher revenue growth • Reaching new customers

Fig. 7 Basic strategic goals of transport organisation (Source: authors)

Conclusion

The article aimed to develop a methodology for applying strategic planning and management in a transport organisation. On the based onretical analysis of the creation of of strategic plans, universal methodologies and algorithms for universal creation and implementation of a strategic plan. Based on the findings, models of strategy development were subsequently developed and evaluation of the quality of services provided.

Acknowledgment

This paper is supported by The Ministry of Education, Science, Research and Sport of the Slovak Republic, KEGA 014ŽU-4/2020 Six Sigma, and progressive education of quality management in the study program railway transport under the requirements of transport undertakings.

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Transport technic and technology
Volume XVIII Issue 2 Year 2022
DOI: 10.2478/ttt-2022-0010

COMPARISON OF TRANSPORT SERVICES PLAN ON THE LINE KOŠICE – PREŠOV – PLAVEČ – (MUSZYNA)

Abstract. The operation of railway passenger transport is characterized by high economic costs and also high requirements for personnel and vehicle means. Existing rail transport operators aim to provide transport services as modern, efficient and cost-effective as possible, while meeting all safety and quality standards. In the case of public service obligations, they must also respect the requirements of the contracts. Currently, a significant transformation of the railway passenger transport operation throughout Slovakia is being prepared in order to increase its efficiency, sustainability and quality. This primarily concerns public service obligations. The line Košice - Prešov - Lipany - Plaveč - (Muszyna) (line No 188) will also be affected. Transport services on this line will be significantly modified and intensified, inter alia, because of the introduction of an integrated transport system in the relevant region. The Route 188 service plans were prepared in two different Transport Service Plans (TSPs). The first one was prepared by the Prešov and Košice Regions. In parallel with the first TSP, a second TSP was prepared by the Ministry of Transport and Construction of the Slovak Republic (MT&C SR) for the entire Slovak railway network, which also includes line No 188. There are several differences in the proposlas included in TSPs for the line in question. The main objective of this paper is to compare the traffic service proposals in the individual TSPs developed for Line No. 188 based on a comparison with the status quo and a comparison of selected operational indicators, as well as to determine the basic advantages and disadvantages.
Keywords: transport service plan, railway passenger transport, public service obligation

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Introduction

The operation of the railway passenger transport on the line Košice - Prešov - Lipany - Plaveč and Muszyna started in the second half of the 19th century. Since then, a large number of changes have been implemented on this line, both in terms of the transport availability (TA) and of the railway infrastructure The line has gradually become one of the most important lines from whole network in Slovakia also because it connects the 2 largest towns in the eastern Slovakia region, to/from which it enables the collection and distribution of passengers to/from the surrounding area, and also transport between them. PSK studies have shown that the current state of TA on the line is not sufficient and adequate to satisfy future objectives of regional policy. (Ministerstvo dopravy, 2022; PDO PSK, 2021; Pribula. 2022).

As a result of the implementation of the integrated transport system (ITS) and efforts to increase the efficiency of the railway transport in the Slovak Republic (SR), transport service plans have been created. The previously published TSP, which also addressed the issue of line 188, was prepared by the Prešov and Košice Regions (P/KR), which monitored the improvement of public transport in Eastern Slovakia with a plan to introduce an ITS. The second, later published TSP was prepared by MT&C SR, which addressed the issue of optimising the overall public services obligation in railway transport, preparation for planned transport public tenders and efficient spending of public resources on performance in the railway passenger transport (Eisler, 2014; Poliaková, Gogola, 2020; Nedeliaková, et. al., 2007Pribula, 2020; IDS-Východ.sk, 2020).

The main goal of this article is first of all to characterise the line section Košice - Prešov - Plaveč - (Muszyna) and then to characterise and compare the presented transport availability proposals, respectively TSPs for line No. 188 on the basis of a comparison with the state of art, by using selected operational indicators and identifying their main advantages and disadvantages.

1. Characterization of the relevant region and railway line

The line section Košice - Prešov - Lipany - Plaveč - Muszyna is located in the eastern part of Slovakia, specifically it covers the districts of Košice, Prešov, Sabinov and Stará Ľubovňa. The line designation according to the Table of Line Ratios (ToLR) is 107A with the official start at the Kysak hub station due to the fact that the Košice - Kysak section of line No 188 is shared with line No 180 (according to ToLR 105A). It is a 1st category international line of major importance for both

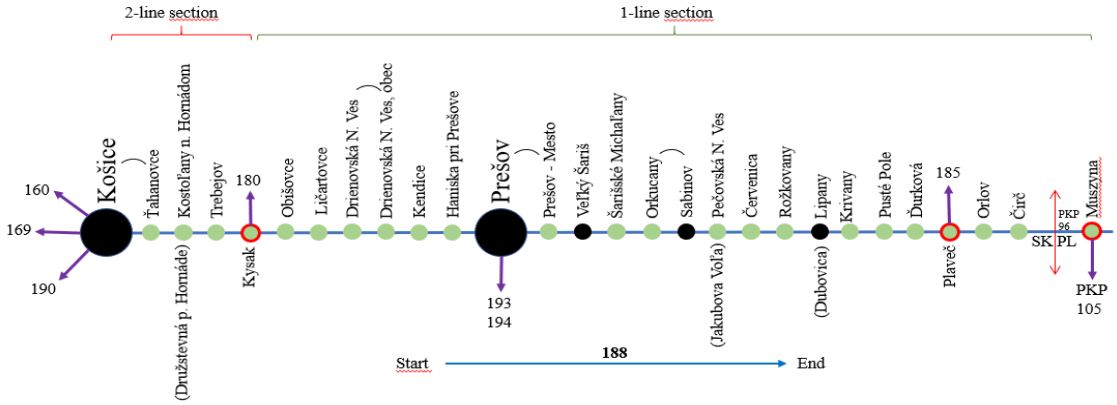

Fig. 1. Railway line No 188 (Source: Authors)

passenger and freight transport, it is part of the international corridors AGC, RFC 11 and AGTC. The line is electrified throughout its entire section with direct current at a voltage of 3000 volts and line is predominantly single-track. The Figure 1 shows the alignment of the line No 188, with the individual serviced settlements, the branch lines, the routing of the line, etc. (PDO PSK, 2021; PDO PSK, 2022; Pribula, 2022).

The line connects 26 settlements to each other, of which two are regional cities (big black dots). In addition to these regional cities, there are also other, so-called "smaller towns" on the line, in particular Sabinov, Veľký Šariš and Lipany (small black dots). Some of these settlements are not directly municipalities that have their own tariff point on the line, but there is a stop or station of another municipality in their accessible vicinity, e.g. Družstevná pri Hornáde -> Kostoľany pri Hornáde (the name of this settlement is in brackets). Orkucany is the part of Sabinov, or Ťahanovce is the part of Košice. The purple arrows represent the outgoing lines, by the way the line starts in Košice / Kysak and ends in Muszyna, town in Poland, or at the border crossing Čirč - Muszyna (Černá 2018; PDO PSK, 2021; Pribula, 2022).

The following combined graph (Fig. 2) shows the population in area of the mentioned railway line and the average daily number of the transported passengers on it, within the period 2013-2021.

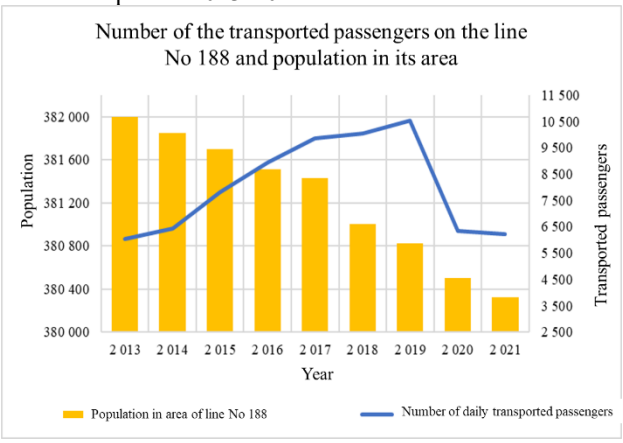

Fig. 2. Transported passengers on the line 188 and population in its area (Source: Authors)

The total population of settlements in area of the line No 188 was approximately 380,000 inhabitants in 2021, but this number is decreasing year by year (see Fig. 2 - yellow bars), nevertheless the number of passengers carried by regional trains on the line in question has been increasing until 2019 (see Fig. 2 - blue line). Since this year there has been a noticeable decrease in the number of transported passengers, mainly due to the outbreak of the COVID-19 pandemic, but at present the demand for transportation on this line seems to be returning to normal, but this is an expert estimate based on observation in real conditions. The implementation of ITS should also contribute to a significant increase of demand for transport in the future, while rail transport in this region should form a backbone network with a high-capacity character (Ministerstvo dopravy, 2022; Pribula, 2022).

2. Characteristics of the state of art and proposals for transport availability

In order to define and characterise the proposed changes and differences, it is also necessary to characterise the actual form of TA. After the description of the state of art, it will be possible to identify all the proposed changes in general and then in specific details for each existing PDOs. The following figure (Fig. 3) characterizes the sections of line No 188 to be served in three forms, respectively variants.

The first figure (A) represents the current state of TA, the second figure (B) the proposal or a variant in the TSP compiled by P/KSK and the third figure (C) the proposal or variant in the TSP compiled by MT&C SR. These figures will form the basis for the following subchapters

2.1. Current state of TA on the line NO 188

Currently, the railway line No 188 is mostly operated by regional public transport, namely trains of the category "Commuter train" (Os) and the category of rapid train "Regional Express train" (REX). The operation of these trains is illustrated in figure 3A.

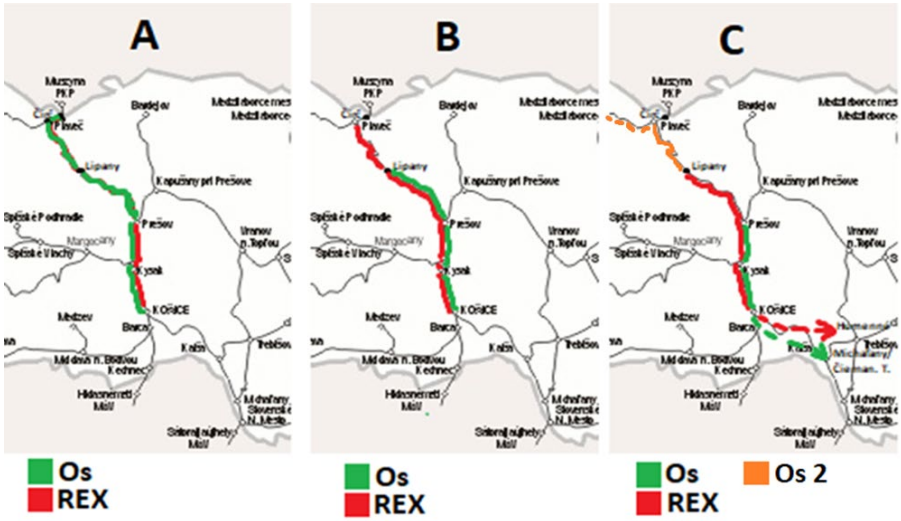

Fig. 3. variants of TA on the line No 188, (Source: Authors)

Trains of category Os (green) are operated daily on the section Košice/(Kysak) - (Prešov)/Lipany, while on selected days, usually Fridays and Sundays, these trains continue up to the Čirč stop. During peak hours, the axle trains are complemented by several REX trains (red), which serve the Košice - Prešov section and stop in the Kysak station. These connections increase the offer of transport services and will also allow faster passenger transportation between regional cities (PDO PSK 2022; Ministerstvo dopravy, 2022).

The operational performance of these trains is approximately 803 000 train-km/year with approximately 19 connections per day. The service is provided by various vehicles, for example: electric multiple units (EMU) 671+971, EMJ 460, EMJ660, EMJ 661, or trainsets 1XX+4/5B, etc. In addition to the above-mentioned trains, there are other train connections on the line, such as the booster fast train "Šarišan", seasonal, recreational and tourist trains, the daily fast train 9XX "Poľana" and the commercial international train "LeoExpress" (Pribulu, 2022).

2.2. The general changes of TA on the line 188

The most significant change affecting both TA proposals is its significant empowerment. An integrated timetable will be introduced on the line with zonal service via REX and Os trains. REX trains will operate on a regular basis and will be the high-capacity connection on the line No 188. This means that the Os train connections will no longer be supplemented by REX trains connections, but vice versa. Also, REX lines will operate on most of the line length, not only on the Košice - Prešov section, and they will be connected or connecting to fast trains R6XX, express trains IC and other trains in the Kysak hub station (Pribula, 2022).

In both cases, it is also planned to unify or change the train means or the type of used vehicles. It can be expected that the lines will be given their own designations after the implementation of ITS, for example R30 - REX or S30 - Os. It is also expected to reduce the number of parallel journeys or to optimise and coordinate the connections with the suburban bus services (PDO PSK, 2022).

2.3. Proposal of TA created by P/KR and MT&C SR

Specific plans in the proposal prepared by P/KR:

- Line Os operates the section Košice - Prešov - (Lipany), line REX operates the section Košice - Plaveč (Fig. 3 B);
- Selected connections of line Os will start or end in Kysak and selected REX connections will operate only the section Košice - Prešov;
- Line Os - 20 connections per working day and 15 connections per weekend; Line REX - 24 connections per working day and 16 connections per weekend;
- Extension of the operation of the section Lipany - Plaveč (Thursday + Saturday), cancellation of the operation of the section Plaveč - Čirč and stops Pusté Pole and Ďurková;
- Service by EMU 671+971 and their need will be 8 vehicles (PDO PSK, 2021; PDO PSK, 2022).

Specific plans in the proposal prepared by MT&C SR:

- Line Os operates on the section Košice - Prešov, line REX operates on the section Košice - Lipany (Fig. 3 C);
- Selected connections of the REX line serve only on the section Košice - Prešov;
- Os line - 15 pairs of connections per working day and 10 pairs per weekend, REX line - 19 pairs of connections per working day and 18 pairs per weekend;
- Operation of the section Lipany - Plaveč by means of a separate diesel train connection "Os 2", which will operate Lipany - Plaveč - (Stará Ľubovňa) and cancellation of the operation of the section Plaveč - Čirč;

Table 1. Transport indicators of 3 variants of the operation on the line No 188 (Source.: Authors)

A - State of art	Type of train	Interval of train [min]	Average operational performance per day [train-km/day]	Average operational performance per year [train-km/year]	Average vehicle capacity [seat-places]	Transport performance [seat-km]
	REX	-/60	264	64 152	324	20 785 248
	Os	60/120	2 022	737 929	324	239 088 996
	Total	-	**2197**	**802 081**	**324**	**259 874 244**

B - P/KR TSP	Type of train	Interval of train [min]	Average operational performance per day [train-km/day]	Average operational performance per year [train-km/year]	Average vehicle capacity [seat-places]	Transport performance [seat-km]	Comparison of yearly OP with state of art
	REX	60/120	3 310	1 208 251	307	370 933 057	+94,69 %
	Os	60/120	990	361 328	307	110 927 696	- 104, 23 %
	Total	**-**	**4 300**	**1 569 579**	**307**	**481 860 753**	**+ 48,90 %**

C - MT&C SR TSP	Type of train	Interval of train [min]	Average operational performance per day [train-km/day]	Average operational performance per year [train-km/year]	Average vehicle capacity [seat-places]	Transport performance [seat-km]	Comparison of yearly OP with state of art
	REX	60/120	2 032	741 580	289	214 316 620	+ 91,35 %
	Os	60/120	859	313 500	247	77 434 500	- 135,38 %
	Os 2	-	58	4 872	82	399 504	+ 100 %
	Total	**-**	**2891/2949**	**1 059 952**	**276**	**292 150 624**	**+ 48,90 %**

Table 2. Advantages and disadvantages of proposals TA, B & C variant (Source: Author)

Proposal of TA created by P/KR (B)	
Advantages	**Disadvantages**
Strong increase in TA compared to current situation (by nearly 50%), above-average transport availability	Increasing risk of unfeasibility, high need for train requirements
Reduction of travel time on most transport lines (Lipany - Košice)	Congestion of the railway section
Short transfer time in Kysak station adapted from/to R6XX and others connections (9 - 11 mins)	Spacing between Os and REX lines (Uneven loading of train lines)
Significant extension of the TA on the congested section (Prešov - Lipany)	Average vehicle capacity is lower than at current situation
Operation of the Lipany - Plaveč section also on Saturdays and Sundays	Cancellation of operation of the Plaveč - Čirč section and train stops Pusté Pole and Ďurková
Proposal of TA created by MT&C SR (C)	
Advantages	**Disadvantages**
Proportional increase in TA compared to the current situation, reducing the risk of unfeasibility	Electrification of the Bánovce nad Ondavou - Humenné section has not begun
Connecting several lines due to make efficient use of train requirements	The average vehicle capacity is lower than at the current situation and in the proposal of the P/KSK
Reduction of travel time on most transport lines (Lipany - Košice)	Long transfer time in Kysak station from/to R6XX and other connections (18-22 mins)
Reduction in the number of transfers (south of Košice)	Spacing between Os and REX lines (Uneven loading of train lines)
To not congesting the railway section	Operation Lipany - Plaveč section by a separate line, without operation of the Plaveč - Čirč section

- Selected connections of line Os will continue to Michalany or Čierna nad Tisou and selected connections of line REX will continue to Humenné, after the electrification of the section Bánovce nad Ondavou - Humenné;
- Operation of Os line connections by EMU 661 and operation of REX connections by EMU 661 and 1XX + 4/6 B, i.e. locomotive + 2nd class carriages. The required number of vehicles is not specified (Ministerstvo dopravy, 2022).

3. The evaluation of TSPS

The previous chapter identified the main differences or changes which are proposed within the addressed TSPs and which differ from each other or from the state of the art. Some changes can be evaluated numerically through operational indicators such as average vehicle capacity, operational performance (OP) in train-km or transport performance (TP) in seat-km.

Other changes can be evaluated verbally by comparing them in terms of advantages and disadvantages (Dolinayová, et. al., 2015; Pribula, 2022).

3.1. The evaluation of operational indicators

The following table (Tab. 1) shows the values of selected operational indicators (operational, transport performance and average capacity) of all three forms of TA on the line No 188. The first table "A" represents actual TA, the second table "B" represents values based on the P/KR TSP, and the third table "C" represents values based on the MT&C SR TSP. The values of the individual

indicators are divided among the planned lines in the tables, and the total values for the line No 188 are also shown in both of the tables. In both designs (Tab. 1 B and C), there is a noticeable increase in total daily performance. It is also possible to notice the reorganisation of the current transport services so that the majority of the performance will be provided by REX trains. The TA variant of the proposed P/KR is almost 50% higher in operational capacity than the current condition and 32% higher than the MT&C SR proposal. Transport performance is also the highest in variant B. The planned TA in the MT&C SR proposal is approximately 25% higher than the current condition. The highest average vehicle capacity is as calculated in the current condition and the lowest in variant C, therefore the offered TP is only 12% higher despite the 25% higher OP compared to variant A.

3.2. The characterisation of the advantages and disadvantages

In order to get a good idea of the planned changes in the TSPs compiled by the two different stakeholders, it is also useful to identify their most significant advantages and disadvantages. The particular advantages (green column) and disadvantages (red column) of the TA proposals on the line No 188 can be seen in the table 2 (2 B - TSP P/KR and 2 C - TSP MT&C SR).

The table 2 outlines some of the advantages and disadvantages of the TA proposals created by the P/KSK and the MT&C SR. It will only be possible to confirm if the claims presented in the table are also valid after the implementation of one of the TSPs plans on the line No 188. The most significant advantage of both variants is the increase in TA and faster travel times on selected routes. The most significant disadvantage is the cancellation of the service of some tariff points and the spacing between Os and REX connections of approximately 15/45 minutes in the section Košice - Prešov. This means that insufficient utilisation of connections can be expected, i.e. Os trains will be used mainly by passengers from the municipalities on the section, but these are fewer than passengers travelling between Prešov, Kysak and Košice. Another significant disadvantage in the P/KR TSP is line capacity congestion, due to the TA increase being too extensive, which increases the risk of unsustainability or infeasibility. A prominent disadvantage of the MT&C SR TSP is the long transfer time at Kysak station and this will reduce the quality of transfers (Černá, 2018; Drdla, 2014).

Conclusion

On one of the most congested lines in Eastern Slovakia, a transformation of the way of solving the transport service through rail transport will take place in the near future on the basis of one of the resolved TSPs. Their goals are to increase the quality, speed, efficiency of rail passenger transport and to simplify the implementation of ITS on this line. Both scenarios warrant an increase in availability on the line No 188 in similar, but in certain parts, different ways. For example, Option B presents strong increases but the lines would not be connected to other lines, Option C presents a more moderate increase but with more connected lines (Pribula, 2022).

However, it is important to assess these proposals in terms of their effectiveness and sustainability, or financial feasibility. Most likely, the TA design on the line 188, which is proposed by the MT&C SR, will be respected from several perspectives. The first aspect is a proportional increase in DO, i.e. 25% compared to 50% in option B, which could be difficult to sustain on a predominantly single-track line (Ministrestvo dopravy, 2022; PDO PSK, 2022; Pribula, 2022). The second aspect is the author of the proposal, in that proposal B is created by the MT&C SR, which is the ordering authority of the performances. The third aspect is cost. In railway passenger transport the main carrier of (high) costs is usually the OP in train-km or axle-km, or TP in seat-km, thus higher OP or TP usually means higher operating costs, of course also higher demands on the train means and staff (Dolinayová, 2015; Eisler, 2004). A higher offer of connections (variant created by P/KR) may increase the demand for transport, but from a certain number of connections the number of passengers transported (from them the revenues) will no longer increase linearly, but the value will stabilize and the transport will be inefficient, i.e. the transport market will be saturated (Nedeliaková, et. al., 2007; Vojtek, et. al., 2019). Therefore, it can be concluded that an proportionate increase in TA will be most efficient and operationally more sustainable than the customer-oriented offer of the TSP option created by P/KR.

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Transport technic and technology
Volume XVIII Issue 2 Year 2022
DOI: 10.2478/ttt-2022-0011

AIR QUALITY, METHODS AND EVALUATIONS IN SLOVAKIA AND ABROAD

Abstract. We currently rank road transport as one of the largest producers of harmful substances. In relation to the environment, we can say that it is a source of emissions, vibrations, and, last but not least, noise. Transport (especially road) puts pressure on land and contributes greatly to global environmental problems. Especially in road transport, a large number of accidents occur, which are reflected in material and especially human losses, as well as in congestion, which manifests itself in the loss of time. Global production of pollutant emissions is associated with the development of transport, an increase in transport performance, and fuel consumption. The Ministry of Transport considers it one of the largest in terms of the number of emissions produced. Today, a lot of attention is paid to ecology and especially to air quality. This article talks about the extent to which transport can adjust air quality and how difficult it is to prevent the number of emissions produced. Several actions and different methods are needed to answer these questions. The basis is the creation of a unified system of product production evaluation in the entire monitored area.
Keywords: air quality, exhaust emissions, pollution, air quality index, road transport,

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Introduction

Mobility plays a key role in the EU economy. However, the EU transport sector still relies heavily on fossil fuels and is responsible for a quarter of Europe's greenhouse gas emissions - a growing proportion. The transport sector is one of the biggest air polluters, despite significant progress since 1990.

The European Union continues to make efforts to change this. However, the gradual reduction of pollutants released into the air remains a priority. Establishing a uniform methodology on the basis of which it is possible to determine the value of the emissions produced is also an important step forward. Air quality and its measurement are also part of the whole cycle and are an integral part of the whole issue. Unfortunately, we must conclude that the current efforts to reduce the sector's environmental and climate impacts are not sufficient to meet the long-term goals of EU climate and environmental policy. (Transport increasing oil consumption and greenhouse gas emissions. 2021)

Developments in the production of greenhouse gas emissions from transport are influenced by unfavorable road transport (especially individual car transport), mainly by an increase in its transport performance and fuel consumption. In the observed period 2000–2014 (Figure 1), CO_2 emissions developed unfavorably, despite their fluctuating nature. CH_4 and N_2O emissions decreased throughout the period considered. CO_2 emissions increased by 16.2% during this period, despite year-on-year increases and decreases. N_2O emissions decreased by 15.7% in the period under review, despite a more significant increase in 2004. CH_4 emissions developed the most positively, with a decrease of 42.1% in 2014 compared to 2000. (Road transport. 2018)

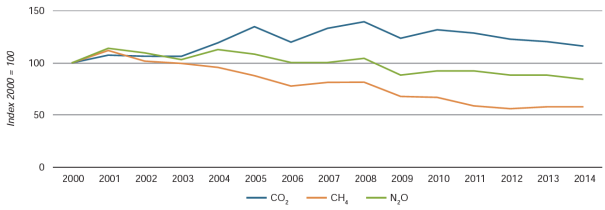

Fig. 1. Development of greenhouse gas emissions from transport (Source: Road transport. 2018)

In Figure 2, we follow a graphical representation of the development of emissions produced in the period from 2008 to 2014. This graph describes the emissions of basic pollutants from transport in the Slovak Republic. For comparison with Figure 2, which describes the evolution of greenhouse gases, this graph focuses on emissions production in general. As we have stated above that each of these substances has a negative impact on the health of the population. We have seen a decline over the years. Individual emissions such as CO decreased by 37.8%, NMVOC by 35.5%, SO_2 by 78.21%, TZL by 20% and NO_x emissions by 15.3%. In the total emissions of balanced pollutants in 2014, a significant 6.9% share of transport in CO emissions, a 34.1% share of NO_x and a 2.7% share of NMVOC. Solid pollutants (PM) accounted for 3.7% of total emissions in 2014 and SO_2 emissions for 0.08%. The share of non-exhaust particulate emissions (PM_{10} and $PM_{2.5}$), which make up a large part of total particulate emissions from vehicles, was 3.7% $PM_{2.5}$ and 3.9% PM_{10}. (Road transport. 2018)

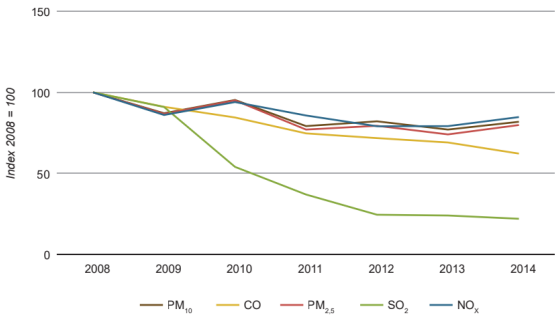

Fig. 2. Development of emissions of basic pollutants from transport in the territory of the Slovak Republic (Source: Road transport. 2018)

1. Air quality assessment in the Slovak Republic

In the territory of the Slovak Republic, the Slovak Hydrometeorological Institute (hereinafter referred to as SHMÚ) deals with air quality monitoring as well as assessment of pollutant emissions production. Together with the cooperation of other agencies (Slovak Environment Agency) and the Ministry of the Environment of the Slovak Republic, it publishes this information for the public and also for various organizations. Currently, there are several ways in which information is disseminated and sent to end-users. This is the fact that this chapter will describe. It is also important to state how the information processing itself takes place, respectively values that are found during the measurement.

1.1. Quality assessment based on monitoring equipment

SHMÚ is the main organization that deals with air quality measurements. It provides up-to-date information on air quality, which is obtained from measuring devices (hereinafter monitoring stations). These monitoring stations are located throughout the Slovak Republic and air quality data are recorded at regular intervals (1 hour). The result of such measurements is up-to-date information on the air quality at the relevant location. Research in the United States has been based on a similar principle, which has indeed confirmed the increase in monitored values and thus the deterioration of air quality due to road transport. (Road transport. 2018)

There are currently 53 monitoring stations located throughout the Slovak Republic, of which 45 stations are managed by SHMÚ and 8 stations are managed by other operators. However, information from them is also published and accessible to the public. SHMÚ records statistics on measured values on its website. When determining air quality, the measured data are classified into individual intervals, on the basis of which their final quality is determined. In simplicity, it is a matter of converting a number into a verbal expression, as the information is provided to the general public. Figure 3 shows the categorization of measured components (according to SHÚ) based on intervals. However, it should be noted that any organization that processes the measurement results can change these intervals (set their own intervals). This means that a certain concentration of substances in the air may not always represent the same final air quality. After including the measured value in the appropriate interval, we receive information about the air quality. The color design provides visual information for the reader to be notified at first glance if air quality deteriorates. (Up-to-date weather quality information. 2021)

	Kvalita ovzdušia	PM_{10} 1h µg/m³	$PM_{2,5}$ 1h µg/m³	O_3 1h µg/m³	SO_2 1h µg/m³	CO 1h µg/m³	NO_2 1h µg/m³
	veľmi dobrá	0 - 20	0 - 14	0 - 33	0 - 25	0 - 1000	0 - 20
	dobrá	>20 - 40	>14 - 25	>33 - 65	>25- 50	>1000 - 2000	>20 - 40
	zhoršená	>40 - 100	>25 - 70	>65 - 180	>50 - 350	>2000 - 10000	>40 - 200
	zlá	>100 - 180	>70 - 140	>180 - 240	>350 - 500	>10000 - 30000	>200 - 400
	veľmi zlá	>180	>140	>240	>500	>30000	>400
	znečisťujúca látka sa na tejto stanici nemeria						
PDL	pod detekčný limit						
*	hodnoty pre túto znečisťujúcu látku nie sú momentálne dostupné						
**	reinštalácia zariadenia						

Fig. 3. Determination of air quality (Source: Up-to-date weather quality information. 2021)

1.2. Monitoring equipment and air quality

We define air quality as the rate of air pollution by pollutants in a given area and at a given time.

The basic element of air quality determination is the monitoring station. It is a place to analyze the amount of pollutants in the air. For this case of air quality assessment, the amount of pollutants is determined at automated stations, that is, by continuous measurement of the pollutant on a measuring device. (SHMU research activity. 2020)

We divide stations according to two criteria - location and type. These two parameters than characterize the station. Depending on the location of the station, we divide into:

- **urban** - location of the station in the urban environment,
- **suburban** - location of the station on the outskirts of cities,
- **rural** - location of the station in a rural environment.
    - By station type:
- **background** - the station represents air pollution that is not directly affected by the source of pollution,
- **industrial** - the station represents air pollution by industrial activity. It is located in close proximity to the source (representativeness of the measured pollution concentrations is about 250 x 250 m from the station.),
- **traffic** - the station represents air pollution from traffic. It is located in close proximity to the source (representativeness of the measured pollution concentrations from the station is about 100 m.) (SHMU research activity. 2020)

The background station can be urban, suburban, or rural. The transport and industrial station can be urban or suburban.

Fig. 4. SHMÚ monitoring station, Prievidza - type of city background station (Source: SHMU research activity. 2020)

2. The resulting air quality and information system

As mentioned above, the SHMÚ deals with air quality and its monitoring in the territory of the Slovak Republic. He and the Ministry of the Environment of the Slovak Republic, in cooperation with the Slovak Environment Agency, presented a new web application dnesdycham.sk with the aim of raising public awareness in the field of air quality in Slovakia. (Enviromagazine. 2020)

In order to bring information about the current air quality to the public in a user-friendly form, the web application in question was developed within the LIFE IP project - Improving air quality. At the same time, it aims to raise public awareness of the atmosphere and to promote behavioral changes that may have an immediate impact on improving air quality - especially for substances that are problematic in meeting the limit values. (Enviromagazine. 2020)

According to a study by Global Burden of Disease (GBD), an independent research institute at the University of Washington (The Institute for Health Metrics and Evaluation), 9 million people worldwide died prematurely in 2015 as a result of environmental pollution. However, it is anticipated that this number may be significantly higher given that many impacts do not currently have sufficient knowledge to evaluate them. (New web application What am I breathing today?. 2020)

Air quality is generally determined by the content of pollutants in the ambient air. Air quality assessment is carried out in accordance with Act no. 137/2010 Coll. about the air. The basic starting point for air quality assessment in the Slovak Republic is the results of measurements of air pollutant concentrations, which are carried out by the Slovak Hydrometeorological Institute (SHMÚ) at the stations of the National Air Quality Monitoring Network (NMSKO). (New web application What am I breathing today?. 2020)

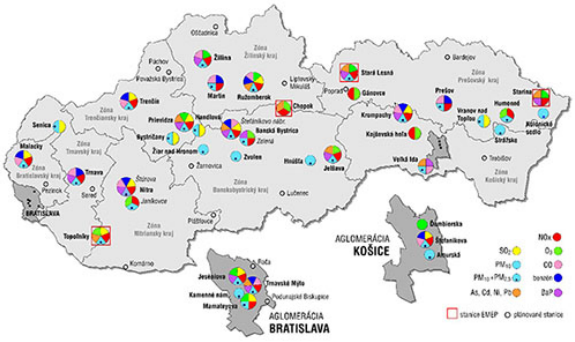

Fig. 5. Map of NMSKO and planned AMS stations (Source: New web application What am I breathing today? 2020)

Figure 5 shows the location of air quality monitoring stations. On the map, we can monitor their location and also the places with the planned construction of such monitoring stations (empty balls shown on the map). It is also possible to monitor which of the marked stations also belong to the EMEP stations. These are stations of European importance. This means that they are part of a European monitoring network. (New web application What am I breathing today?. 2020)

Data from the National Air Quality Monitoring Network, operated by SHMÚ, are transferred to the application by direct flow. They are represented in the application using the principles of the air quality index evaluated according to the methodology of the European Environment Agency. The purpose of such an assessment is to inform the general public in a comprehensive and comprehensible manner about the state of air quality through a simple color and word scale. (New web application What am I breathing today?. 2020)

According to the measured data, it is possible to clearly define the condition and air quality at the appropriate place with the help of the appropriate methodology. According to the color scale, we can clearly select the interval in which the monitoring station or. the monitored area is currently located. This is also one of the reasons for facilitating the monitoring of this data by the general public. Residents are not forced to monitor the numerical values of the measured indicators, but on the basis of color differences, they can assign an air quality measure to a given area.

The dominant visual, as well as navigation element of the application's home page, is the map. It contains colored dots that locate the network of monitoring stations in the Slovak Republic. The color of the dot indicates the air quality level. Below the map is a legend for each level of air quality, along with recommendations on what to do (not) in the case of the current level of air pollution. Recommendations are represented by icons with a brief verbal description. (New web application What am I breathing today?. 2020)

The map is zoomable, the boundaries of zones and agglomerations are marked on it and allows you to click directly on the subpage concerning individual zones and

agglomerations - which in principle corresponds to the breakdown by region. It is possible to click on the subpage of the zone directly via the color point - the monitoring station. After the first click on the station, the emoticon is displayed in the color of the current air quality level. After another click on the emoticon box, the user will be taken directly to the subpage of the specific zone/agglomeration. (New web application What am I breathing today?. 2020)

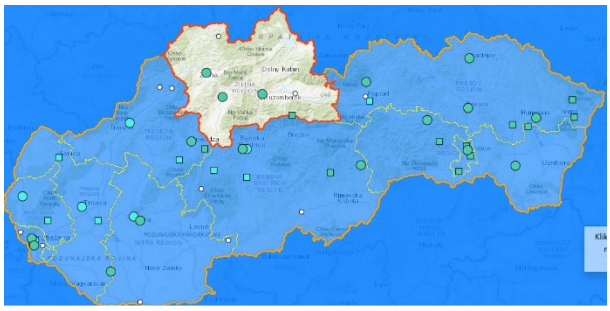

Fig. 6. Map of the Slovak Republic with marking of stations (Source: New web application What am I breathing today? 2020)

Figure 6 shows a map of the Slovak Republic together with the designation of all stations that monitor air quality accurately, as on the mentioned page. The locality of the Žilina region was chosen for an illustrative demonstration. From the picture we can see that there are 4 stations on its territory: Žilina – Obežná, Martin – Jesenského, Ružomberok – Riadok and the last station is located in Chopok and is also part of EMEP. We can notice that the construction of the station in Oščadnica is also planned within the Žilina region. (New web application What am I breathing today?. 2020)

After a closer click, it will appear under the window with the actual evaluation of air quality for my selected area. For the demonstration, I chose the city of Žilina or the monitoring station, which is located in Žilina on Obežná Street. Once selected, the measured values for the last 48 hours will be displayed. However, it is possible to select another range of monitored values. The emoticon at the name of the city shows us the condition and air quality at first glance, without having to study further information. (New web application What am I breathing today?. 2020)

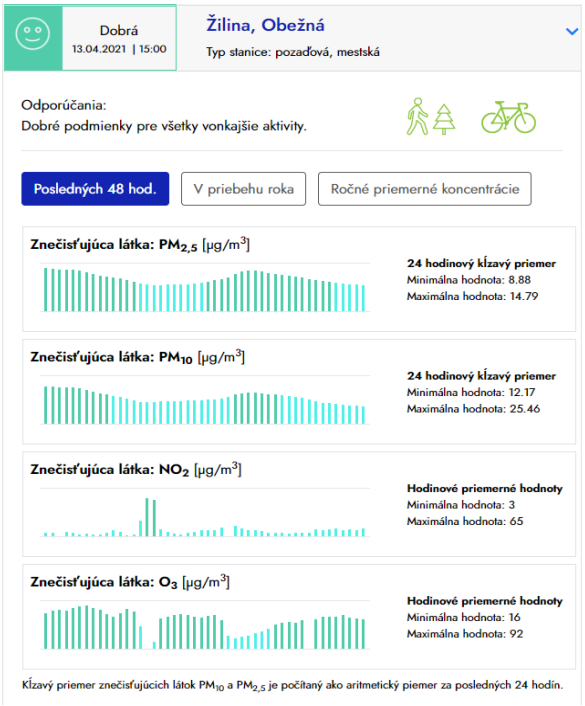

Fig. 7. Method for evaluation of measured data (Source: New web application What am I breathing today? 2020)

It is important that each reader is familiar with how to evaluate and determine the resulting air quality. Based on the measured values, the resulting air quality is determined as follows:

- the worst recorded level of air pollution of any pollutant. Example: Recorded air pollution rate: $PM_{2.5}$ it means very bad, PM_{10} it means bad, NO_2 it means very good, and O_3 this level of quality is good too. However the final assessment of air pollution rate: very bad. (New web application What am I breathing today? 2020)

3. Information system in the field of air quality assessment

Exceeding the concentrations of PM_{10} dust particles and fine $PM_{2.5}$ dust particles, benzo (and) pyrene, nitrogen dioxide NO_2 and ground-level ozone have a negative effect on air quality. The main sources of air pollution are local heating plants with the combustion of solid fuels in households, transport, industry, and energy. (LIFE IP - Improving air quality. 2020)

In connection with exceeding the limit/target values for health protection, Slovakia has been facing infringement proceedings since 2009. The European Commission decided on 18 February 2021 to refer the case of Slovakia to the EU Court of Justice in relation to poor air quality due to high levels of particulate matter (PM_{10}). The LIFE IP project - Improving air quality is one of the measures taken to improve air quality in Slovakia and is a direct response to the European Commission's call. (LIFE IP - Improving air quality. 2020)

The LIFE IP-Air Quality Improvement project (full text: Improving the implementation of air quality improvement programs in Slovakia by strengthening the capacities and competencies of regional and local authorities and supporting air quality measures) focuses on the implementation of specific air quality improvement measures and also supports educational, communication and monitoring activities of the involved partners in the field of air quality and protection and effective management by creating a national network of air quality managers. (LIFE IP - Improving air quality. 2020)

3.1. Air quality assessment abroad

The European Environment Agency (EEA) publishes information on air quality in European countries on its website. This information is expressed in the form of European Air Quality Indices. In general, air quality assessment is based on measuring the concentration of pollutants in the air. Due to the presentation of information to the general public, air quality is assessed by an index. The air quality index then converts pollutant concentrations (expressed in µg/m3) into a multi-level scale. At present, it can be a verbal assessment of air quality (good, satisfactory, bad, etc.) or numerical (1-10, 0-500, etc.). However, there is currently no uniform calculation methodology. Air quality indices are presented in other ways, depending on the country where they were surveyed, for example: (Air quality index. 2018)

- European Air Quality Index (The European Environment Agency, EEA),
- Daily Air Quality Index (UK - Committee on Medical Effects of Air Pollutants, COMEAP),
- Real-time air quality index (global air pollution according to The United States Environmental Protection Agency, EPA),
- Air Quality Health Index (Canada)
- Air Pollution Index (Malaysia),
- Pollutant Standards Index (Singapore). (Air quality index. 2018)

Information on the state and quality of the air is becoming more and more popular. People are gradually beginning to realize that the quality of the surrounding air directly affects their health. Large agglomerations in particular have the biggest problem, where air quality is very low and people are forced to use protective equipment. One of the largest producers of these pollutants is transport. It is this that contributes to the significant amount of emissions that are produced in to the air and degrade its quality. As a result, emphasis is placed on regular air quality inspections as well as the lowest possible emissions from transport. (Air quality index. 2018)

As we stated above, the method of determining emissions is not yet uniform. Within the CORINAIR program of the European Environment Agency (EEA) and its components (ETC-ACC) -EuropeanTopic Center on Air and ClimateChange, individual program modules have been developed to support the processing of annual emissions into the air. Thanks to these modules, transparent and especially standardized data processing is possible. The data processed in this way are comparable year-on-year, but also internationally. (Air quality index. 2018)

The EEA cooperates with all reference centers of all participating countries in assessing emissions production. The EEA also includes ETC / AE (EuropeanTopic Center on Air Emissions), focused on the production of air emissions, which have been operating since 1994. Cooperation with this agency is a priority for all EU Member States, as well as other European countries. These are mainly the countries that are candidates for EU membership. (CORINAIR – The New Family of Software Tools. 2020)

The basic pollutants include TZL (solid pollutants), SO_2, CO, NO_x, NMVOC (volatile organic compounds), and ammonia (NH_3). Emissions from mobile sources have been determined annually since 1990. The CORINAIR methodology is used to determine the amount of production of individual monitored pollutants, especially in EU countries, whose special software product COPERT is intended exclusively for the inventory of annual emissions from road transport operations. In 2008, the 4th generation of the COPERT program was used to process emissions from road transport and all emission values from 2008 have been recalculated according to this program. The input data for determining emissions is a number of different active factors it means, numbers of vehicles in each category (defined in the COPERT program), average annual calorimetric curves of each vehicle category. All emissions are calculated on the basis of fuel and also by vehicle type. Other data at the input are also information on the content of pollutants in individual fuels (petrol, diesel, LPG, CNG), as well as fuel consumption, including the share of bio-components in petrol and diesel. (Air pollutant emissions. 2021)

Based on the determination of the production of emissions of these gases, the air quality assessment itself can take place. The determination of air quality takes place abroad, similarly to the territory of the Slovak Republic. An important fact is that the values measured by the national monitoring stations are passed on to the organizations that have the task of monitoring this situation. The EU Ambient Air Quality Directives (AAQDs) obliges the EU Member States to divide their territories into zones and agglomerations for the purposes of air quality assessment and management. (Air pollutant emissions. 2021)

Air quality assessment and management should be carried out in all zones and agglomerations where each zone and agglomeration should be classified in relation to the concentration limits for sulfur dioxide (SO_2), nitrogen dioxide (NO_2) or nitrogen oxides (NO_X), particulate matter (PM_{10}, $PM_{2.5}$), lead, benzene or carbon monoxide as specified in AAQD. (Air pollutant emissions. 2021)

The AAQDs also requires the Member States to take appropriate measures to ensure compliance with the limit and target values within the set deadline, respectively. maintaining compliance after reaching the limit and target values. Therefore, air quality plans are required in polluted zones and agglomerations where air quality standards are exceeded or where such a risk of exceedance is highly likely. (Air pollutant emissions. 2021)

The aim of these plans is to reduce air pollutant concentrations below the legislative limits and target values set in the directives as soon as possible. Member States must notify details of the plans European Commission through the European Environment Agency (EEA). This is information reported by the Member States in accordance with the rules of Commission Implementing Decision 2011/850/EU. (Air pollutant emissions. 2021)

Where concentrations of pollutants in ambient air exceed the relevant target values or limit values, the AAQ guidelines require the Member States to draw up air quality plans or air quality plans. take appropriate measures (depending on the pollutant) so that the relevant target values or limit values are reached in the relevant zones and agglomerations as soon as possible. (Air pollutant emissions. 2021)

In many Member States, responsibility for drawing up and implementing air quality plans has been delegated to national authorities. Air quality plans usually include a series of measures based on air quality assessments and forecasts of future trends and a detailed analysis of high levels of concentrations, including responsible sources. Understanding the reasons for high levels of air pollution is crucial for urban air quality management decisions. (Air quality management. 2021)

4. Options for reducing air pollution

Due to the effective assessment of air quality, the territory of Slovakia is divided into zones and agglomerations. In individual zones, the concentrations of pollutants are not the same in all parts of the zone. There are usually areas with significant sources of emissions and deteriorating air quality, but also relatively clean areas without resources. (Air quality index. 2018)

The area is declared an air quality management area (ORKO) if the measured concentrations of a pollutant in the air at a given monitoring station exceed the limit or target value in the monitored year. ORKO is a subset of individual zones, each zone can contain several. ORKO is proposed by SHMÚ annually. The pollutant is removed from the ORKO list only after the pollutant concentrations at the station do not exceed the limit value for three consecutive years. (Air quality index. 2018)

The district office in the regional seat will prepare an Air Quality Improvement Program or an Integrated Air Quality Improvement Program for the relevant area of air quality management if the limit values or target values are exceeded for more pollutants. Air quality improvement programs identify measures to improve air quality in the areas of air quality management in order to achieve good air quality at a given time. Measures taken to achieve air quality objectives must take into account an integrated approach to air, water, and soil protection, must not infringe specific health and safety regulations, and must not have significant negative effects on the environment of neighboring countries. (Air quality index. 2018)

4.1. EEA reduction options

Air pollution and environmental noise issues are addressed by existing European Union legislation on transport, air quality and noise in order to improve human health and the environment. Pollutant emissions from different types of vehicles are regulated by European emission standards (Euro norms). For example, the current Euro 6 standard, which applies to new vehicles from 2014, prescribes particulate emission limits from petrol and diesel engines at 5 milligrams per kilometer (mg/km), a five-fold reduction from 2005 levels. NOx emission limits of 80 mg/km for diesel and 60 mg/km for petrol, which is again a significant reduction since 2005. (Transport and public health. 2016)

Euro norms include specifications for vehicle testing, but there are significant differences between official vehicle emissions (i.e. those recorded in the test conditions) and real-life emissions. Measures are being taken to remedy this situation, including the development of new test specifications and the introduction of portable emission measurement systems (PEMS), which can be fitted to cars when measured directly on the road. (Transport and public health. 2016)

The European Union has taken various measures to reduce noise damage, including technical standards to limit noise emissions at source (e. g. EU tire labeling, which helps consumers identify "quieter" tires). These standards are complemented by the Environmental Noise Assessment and Management Directive. The aim of the directive is to improve the quality of the data collected in order to better adjust the link between the population and transport. The Directive requires the development of action plans for large transport resources and large urban areas, which aim to reduce the impact of noise on the affected population (and, if necessary, reduce noise as such) as well as to protect quiet areas, i. j. those that are not noisy. The third five-year cycle of action plans is currently underway, lasting until 2018. (Transport and public health. 2016)

In parallel with the EU's efforts, there are several local and regional initiatives that seek innovative solutions to air pollution and traffic noise. Between 2006 and 2013, two initiatives were taken to support the development of infrastructure for cyclists: Step by Step in Ljubljana and Big Bang in Seville. Both have successfully contributed to reducing congestion, improving air quality, and reducing greenhouse gas

emissions. In Seville, where the number of cars coming to the city center per day fell from 25,000 to 10,000 during the project, they measured a 29% reduction in NO_2 and a 19.5% reduction in particulate matter. In Ljubljana, the share of cyclists in the total volume of traffic increased by 20% during the project. These are remarkable results. There are no official data on health improvement or noise reduction, but unofficial data suggest that there has been a significant reduction in noise levels in both cities. (Transport and public health. 2016)

Conclusion

We are currently dealing with air quality more and more often. Air quality is of great importance for the proper functioning of biodiversity and especially for human health. Air quality as one of the strictly monitored indicators changes every year. Its value depends on a large number of indicators and also on the type of pollution. Based on the results, a number of measures are being developed to improve or maintain the set quality standard (index). These tasks are in charge of various institutions at the national level (in Slovakia SHMÚ, SAŽP …), which provide this information to other organizations. These organizations (EEA) have the task of acting as transnationals and paying attention to the observance of set standards and limits in individual countries, territories.

The aim of the research was to characterize the air quality monitoring information system. In the introduction, the current situation in the Slovak Republic was characterized, as well as general information regarding air pollution. It was also necessary to characterize the individual pollutants and describe their negative effects on the human body.

The next part characterizes the assessment of air quality in the Slovak Republic and abroad. The procedure by which the quality itself is monitored and subsequently evaluated is described. The newly created application, which serves as a tool for determining the current air quality in the selected region, is also described in detail. Subsequently, the possibilities of disseminating information about the quality and the way of their further interpretation among the public are characterized. This is important in terms of further reducing emissions from various sectors. As we classify households as major polluters, it is there that it is necessary to direct this information and the opportunities through which man as an individual can improve air quality.

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