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POSSIBILITIES OF OBTAINING RAIL TRANSPORT DATA FOR THE PURPOSE OF UPDATING THE SOURCE DATA OF THE ERIC MOBILE APPLICATION

Abstract. The flow of information is important in any area of human life. That's why people try to develop applications to support the flow of information. But then it is also important to protect information, which means that not all employees have access to all information. In practice, this means above all a competitive advantage over other companies in the same sector. The purpose of the article is to define the positive and negative aspects of trade secrets from the customer's point of view in passenger and freight rail transport. The main goal is to connect the information systems of individual infrastructure managers and carriers into the ERIC MOBILE application in compliance with the conditions of modularity.
Keywords: freight carrier, passenger carrier, infrastructure manager, ERIC Mobile, trade secret

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Introduction

The roots of competition in rail transport must be traced to the beginnings of liberalization. It began in the 1980s in the United States with the goal of declining the performance of passenger and freight rail transport. In Europe, the beginning of the transformation is considered to be 1991, when the first railway package was adopted as Directive 4441/1991. Carriers in individual countries have started to progress gradually, the full opening of the market for passenger and freight rail transport took place in 2007.

The experience with the liberalization of the railway market in Romania is discussed in an article (Busu & Busu, 2015). On several case studies, it reveals the pros and cons of the whole process.

On systemic risk and its increase in the context of the liberalization of the rail market in Europe dealing with the article (Laperrouza, 2009). The article describes the increase in risk levels in the creation of a single European railway area. He considers that most risks in this area are limited to their management and ignore the institutional dimension.

The article aims to propose data collection to the ERIC MOBILE application in a modulation environment based on analyses of the impacts on carriers and carriers in freight transport, as well as passengers in passenger transport. First of all, the main criteria need to increase the competitiveness of railway companies while reducing the negative impact on customers (impossibility of prospective connections of all carriers in passenger transport, or declining transport performance with one hundred percent own structure of the state).

1. Language

The European rail market is characterized by the fact that it is not just about one country or one user. It is therefore certain that the users of the ERIC MOBILE application will not be from only one country. The very specificity of transport and washed technological operations requires the greatest possible proximity to users (carriers, transporters, infrastructure manager's operational staff) and therefore the installation of the application should be able to choose the language version (as well as the database base) of the application. The basic language mutations should be the languages of the countries where the services of ERIC MOBILE products are already used. In Figure 1, universal and other language mutations are proposed.

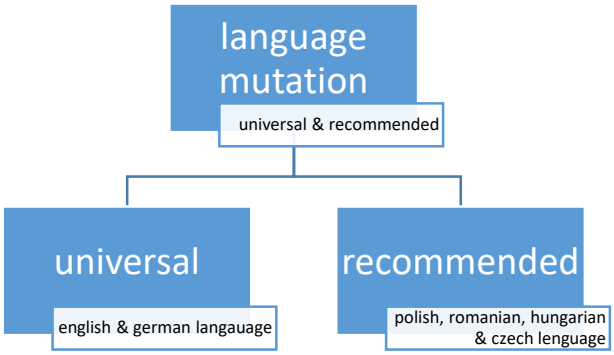

Fig. 1. Universal and recommended language versions

The users of the system will be representatives of transport, shipping and forwarding companies, which have their own data requirements for the application. Therefore, from the point of view of securing singularity, it is

important that the application includes the possibility of assigning selected databases for typologically determined customers. Application administrators have a comprehensive database access, due to the ability to modify permissions and customer requirements. It is essential that these are approved by the management of the application interfaces.

2. What an infrastructure manager should know

Manage infrastructure for executing state-owned infrastructure, boasting capacity for non-discriminatory employment and quality of employment under the auspices of the modernization and accounting department.

Železnice Slovenskej republiky (ŽSR) serve as railway infrastructure manager and as an administrator of railway lines in Slovak republic (Gašparík, et al., 2015). Its objective is to (Gašparík, et al., 2015):

- keep the railway line in working order;
- enable the use of railway infrastructure by other legal entities that demonstrate financial and professional competence, integrity, technical competence of rolling stock and ensure safe and smooth railway operation.

While in freight transport, carriers protect their know-how and participation in transport, in passenger transport they are ahead in special offers, discounts and other offers for passengers.

It is necessary for the infrastructure manager to see every passenger and freight transport on the network at any time. The number of trains on the network on a given day is monitored by the infrastructure manager according to relation 1.

$$Počet\ všetkých\ vlakov = PT + FT + LT + ST \quad (1)$$

where:
PT – passenger trains (express trains, fast trains a commuter trains)
FT – freight trains (freight express trains, continuous freight train, handling trains, and siding trains)
LT – locomotive trains
ST – service trains operated by infrastructure manager

A statistical overview for the last ten years is shown in Figure 2 in train-kilometres.

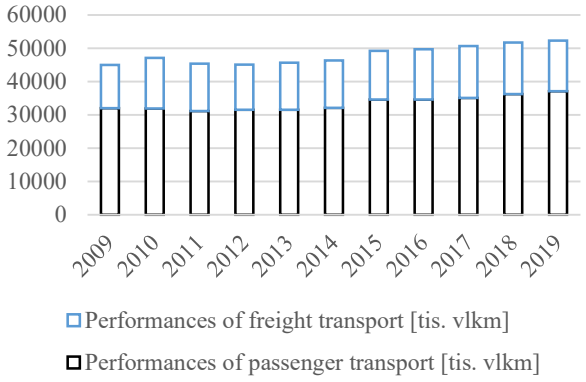

Fig. 2. Performance of passenger and freight transport on the ŽSR network in the years 2009 – 2019 in thousand train-kilometres (Železnice Slovenskej republiky, 2009 - 2019)

Revenues from the railway fee also derive from the monitoring of passenger and freight train performance. It is clear from Graph 2 that performance in either passenger or freight transport was relatively stable with smaller fluctuations, mostly caused by external factors. Figure 3 shows the revenues resulting from the railway toll in the years 2011 - 2019, as in 2011 there was a change in the principle and structure of railway tolls.

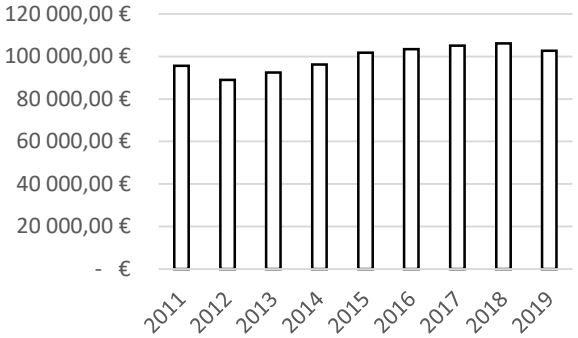

Fig. 3. Revenues from the fee for railway infrastructure in the years 2011 – 2019 in thousands € (Železnice Slovenskej republiky, 2009 - 2019)

In addition to economic indicators, the infrastructure manager, e.g., it also monitors extraordinary events (accidents, incidents, etc.), the transport of extraordinary consignments, or the condition of railway station buildings and other ones assigned to it.

3. What passenger & freight carriers should know

Carriers in passenger and freight transport provide information to the infrastructure manager on the basis of the Electronic Data Exchange Agreement (hereinafter EVI). Based on this contract, the information systems of the carriers and the infrastructure manager are interconnected. Each carrier has different types of access rights, according to different criteria (Čamaj & Gašparík, 2010).

Table 1 lists the selected monitored indicators of individual carriers

Table 1. Selected monitoring indicators for passenger and freight carriers

Passenger carriers	Freight carriers
passenger numbers	numbers of transported goods by commodities
economic indicators	
train path order	
important dates for the construction of the timetable	
exclusion	route diversions

For comparison, Figure 3 shows the number of licenses granted for passenger and freight transport and the number of real passenger and freight carriers to change the GVD in December 2020.

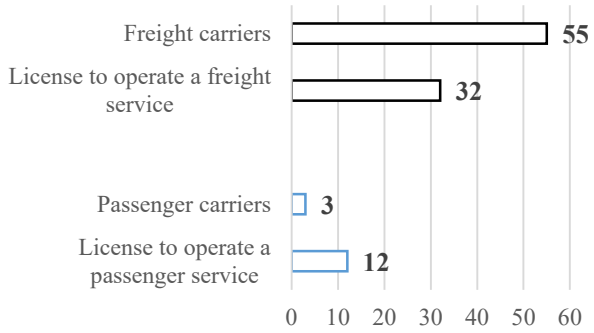

Fig. 3. Comparison of the number of licenses granted in passenger and freight transport with the number of active carriers (Dopravný Úrad Slovenskej republiky, 2019) (Železnice Slovenskej republiky, 2020)

Of interest is the higher number of freight carriers than licensees for this activity. This is because a license obtained in any country is valid in the territory of all EU Member States (Kendra, et al., 2020).

It turns out that, despite the open market for passenger rail transport, the Slovak Republic is not so topical for passenger carriers. Among other things, this is due to the minimum number of competed lines on which other carriers can provide services in passenger transport, to which the state as the customer will reimburse economically justified costs.

4. What passengers should know

For passengers, the liberalization of the rail passenger market has several advantages and disadvantages. These are described in Table 2.

Tab. 2. Benefits & disadvantages of a liberalized railway market

The benefits of a liberalized market	Disadvantages of a liberalized market
lower cost of transport	non-uniform tariff
higher transport comfort	the problem of buying one ticket for the whole route
more connections	problem with transfer and loss of connection
loyalty program	mutual derecognition of revenues

While in freight transport, carriers guard their know-how and participation in transport, in passenger transport they are ahead in special offers, discounts and other offers for passengers.

Most infrastructure managers provide passengers with a tool to track the position of trains with information on delays or alternative bus services in the event of a closure. Figure 4 shows a map of ŽSR, on which passengers have access to such information in real time.

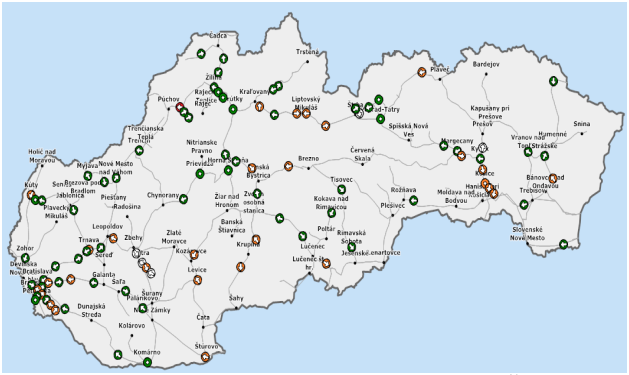

Fig. 4. Map with the position of passenger trains (Železnice Slovenskej republiky, 2020)

After clicking on the train by the user, the basic information about the train will be displayed as (Železnice Slovenskej republiky, 2020):

- category, number, train label,
- time and date of departure from the departure station with time and date of arrival at the destination station,
- the name of the last travelled point with the current delay in minutes,
- the name of the last waypoint crossed,
- time at the last crossed transport point,
- time according to the timetable at the last travelled point,
- carriers name.

The delay scale of the individual trains is color-coded as shown in Table 3.

Tab. 3. Colour scale of train delay times (Železnice Slovenskej republiky, 2020)

Colour	Delay
	0 – 5 min.
	6 – 30 min.
	30 and more min.
	replacement bus service

In this way, the passenger has an overview of the current departure / arrival time of his train. It is also worth mentioning the idea to expand this information to the Slovak radio airwaves, where it would be appropriate to create a so-called A "rail service" to inform potential passengers of current delays and current emergencies.

Conclusion

Liberalization of the transport market brings with it both positives and negatives. Trying to unify the flow of information with an overlap to a satisfied customer is beneficia l. With the unification of the information flow, trade secrets need to be maintained in order to make rail companies competitive.

The article discusses the possible capabilities of the ERIC Mobile application, which is to be connected between the infrastructure manager, carriers, and passengers. Combining the proposed measures into one application would create an acceptable possibility for all components of the rail market to function. Not only would communication be facilitated, and competitiveness increased, but above all customer care would be intensified to a greater extent.

Acknowledgment

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REGRESSION MODELS FOR DETERMINING DEPENDENCIES ON VARIOUS FACTORS ON THE RAILWAY LINE ZOHOR – ZÁHORSKÁ VES

Abstract. Public passenger transport is presented as an opportunity to achieve future goals for establishing sustainable transportation systems. These systems are demanded from every member country of the EU for securing an ecologically friendly, fast, and reliable way of traveling in regions. Railway passenger transport is proven as a reliable and capable way of connecting regions. In many EÚ countries, railway transport has a certain gap, that could be improved without significant investments. In this study, we are focusing on negative consequences emerging from the cancelling operation of passenger transport on the chosen railway track. Most of the cancelations are affected by external influences. Individual car transport presents significant reasons with a noticeable impact on the potential of railway passenger transport in every region. On the railway line addressed in this article, passenger transport was cancelled in December 2019. This step was implemented for the constantly declining number of passengers. The object of the research is statistical dependence, characterized by the fact that the dependent variable is affected not only by independent variables but also by other unspecified variables and random effects. They are often called model faults or errors. This fact must be captured in a mathematical expression in a regression model. Based on this decision, it is necessary to seek answers to this situation using regression models that show the relationships between the number of passengers carried and the factors influencing their development. The main hypothesis is that the canceled of passenger transport was caused by low use by passengers. For example, with an increase/decrease in population, the number of passengers should increase/decrease the article verifies the dependences of the use of railway transport on the population of individual municipalities and on the development of fuel prices. Various dependencies (linear, polynomial, etc.) are used to test hypotheses. Testing of these dependencies will be performed using Fisher–Snedecor distribution. In the final part, the article also deals with the possibilities of using this line, as freight railway transport is no longer operated on this line. The research was carried out by a case study.
Keywords: railway line, infrastructure manager, regression line, correlation analysis

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Introduction

The performance of passenger rail transport in Slovakia is increasing every year. For example, between 2017 and 2018, the number of passengers increased by 1,018,000 (ZSSK, 2020). However, this does not play to individual lines. In particular, the regional lines, which in recent years have experienced a recovery in the form of renewal of passenger transport (Zvolen – Šahy; Bánovce and Ondavou – Veľké Kapušany), in 2019 again fell into decline. This also applies to the Zohor – Záhorská Ves line. Despite the fact that it is included in the integrated transport system of the Bratislava region, the number of passengers on this line has decreased every year. For this reason, the Ministry of Transport, as the client of railway transport, in agreement with the Bratislava self-governing region decided to stop passenger transport on this line to change the schedule of train transport (in 2019 it fell on 15 December).

The objective of the article is to use statistical analysis tools to determine the causes and dependencies between passenger depletion and the external effects on passengers. At the same time, it proposes measures that could help revive the transport needs. The usual case of stopping passenger transport leads also to stopping of freight transport and railway infrastructure is slowly declining. The infrastructure manager does only basic maintenance of the line so that it can be operated by potential subjects.

The solution of this problem is influenced, for example by the economic situation in the state (Dolinayová, 2019), the requirements of the state budget, which have the performance of passenger rail transport on regional lines (Dolinayová, 2018) and the efficiency of passenger transport operation on regional lines (Dolinayová, 2017). The article will present the dependencies between the number of passengers, the number of inhabitants in the villages through which the line passes and the price of fuel.

1.1 Characteristics of the railway line from the technical point of view

The line is classified as a regional line with a total length of 14,511 km. The track is constructed for 60 km/h.

The track has a normal gauge of 1 435 mm and track is not electrified. The train normative length is 230m. The beginning of the track is in Plavecký Mikulaš railway station and end of the track is in Záhorská Ves railway station. Braking distance is 700 m (ZSR, 2020). The track includes two railway bridges and three railway crossings (Vlaky.net, 2019). Table 1 is describing the individual control points on the railway line.

Table 1. Operating control points and posts on the railway line

Railway stations	Loading place with halt	Halts
Zohor	Vysoká pri Morave	Lábske Jazero
Záhorská Ves		Vysoká pri Morave

Source: (ŽSR, 2009)

Vysoká pri Morave stop has been closed since December 2006 and trains do not stop there (ŽSR, 2006). The line security is secured with telephone communication 1st category of security. There is a mechanical station security device in the Vysoká pri Morave and Záhorská Ves transport stations. There are one transport and one handling track in the loading depot with the Vysoká pri Morave stop. There is a total of two transport tracks and one handling track in the Záhorská Ves railway station. None of the above transport is occupied by transport employees. Simplified railway traffic management is introduced on the entire line with the abolished reporting obligation [8].

1.2 Characteristics of the railway line form the transport point of view

The last timetable schedule of passenger transport 2018/2019 was operated by 8 pairs of trains on working days and three pairs of trains on weekends and holidays. In the summer of 2019, another pair of tourist train Záhorská Ves – Plavecké Podhradie was added (ŽSR, 2018). Figure 1 displays the railway timetable for the direction Zohor – Záhorská Ves.

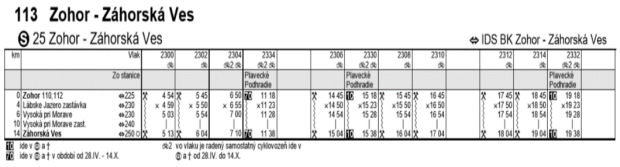

Fig. 1. Route timetable Zohor – Záhorská Ves [10]

It is clear from the timetable that the trains are operated mainly in the morning and afternoon rush hours in an hourly interval. In the notes in the header, each train has a bicycle symbol, which means that the carrier on the trains offered to transport the bicycle until the capacity is depleted.

Figure 2 displays the train schedule for the opposite direction, Záhorská Ves – Zohor.

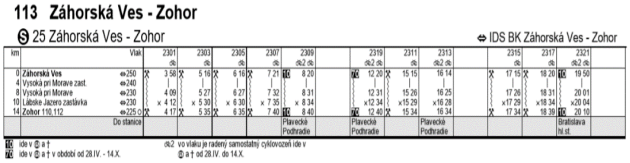

Fig. 2. Route timetable Záhorská Ves – Zohor (ŽSR, 2018)

2. Regression models

The aim of the use of regression models in the investigation is a deeper penetration into the essence of the observed phenomena (stopping passenger traffic on the line) and processes in a certain area. When solving, we get to the so-called causal links. A causal relationship between two phenomena is a state where the existence of one phenomenon is related to the existence of another phenomenon (Hindls, 2003). Table 2 lists the types of dependencies investigated.

Table 2. Division of aspects of research methods

Type of dependencies	Characteristic
fixed dependence	the occurrence of one phenomenon is necessarily responsible for the occurrence of another phenomenon
free dependence	the occurrence of one phenomenon affects the occurrence of another phenomenon only in the form of probability

Examination of dependency

When examining this dependence, a free dependence will be used, because in the studied phenomena it is not certain to what extent the indicators will be dependent.

One-sided dependencies are dealt with by regression analysis. This is a state where the explanatory (independent) variable in the role of causes and the explained (dependent) variable in the role of consequences stand against each other (Hindls, 2003). Table 3 lists the individual dependencies examined.

2.1 Values on the vertical axis

The vertical axis will include data on population and fuel prices for the period from 2007 to 2016.

Table 4 shows the population of the Zohor, Vysoká pri Morave, and Záhorská Ves. Knowingly that Lábske Jazero is the only nature reservation and the nearest village is Láb, 4,3 km away from the railway station, we will not take its population into the count (Statistics, 2020).

Table 3. Number of inhabitants in individual municipalities

Place	Year	Population
Zohor	2007	3 297
	2008	3 330
	2009	3 335
	2010	3 330
	2011	3 207
	2012	3 224

	2013	3 264
	2014	3 264
	2015	3 302
	2016	3 313
Vysoká pri Morave	2007	1 679
	2008	1 726
	2009	1 767
	2010	1 825
	2011	1 795
	2012	1 816
	2013	2 196
	2014	2 211
	2015	2 247
	2016	2 287
Záhorská Ves	2007	1 679
	2008	1 726
	2009	1 767
	2010	1 825
	2011	1 795
	2012	1 816
	2013	1 815
	2014	1 825
	2015	1 841
	2016	1 868

It is clear from the table that the number of inhabitants in individual municipalities gradually increased. This was also due to the fact that the inhabitants of the capital moved to the countryside, due to more affordable real estate prices. In Vysoká na Morave and Záhorská Ves, you can see a year-on-year decrease in the population in the period 2010 and 2011. Fuel prices per litre of petrol 95 in the observed period are shown in the graph in figure 3. The prices are represented in €.

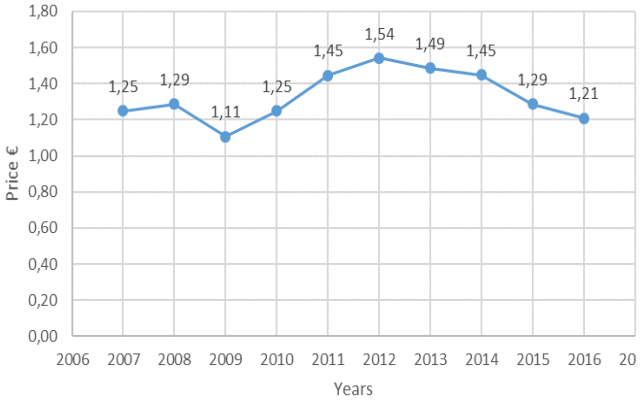

Fig. 3. Development of fuel prices (Autoplan.sk, 2020)

The lowest fuel price was observed in 2019 when the prices were at 1,11€ for a litre.
On the contrary, in 2012 the price peaked at 1,54€ per litre.

2.2 Values on the horizontal axis

The horizontal axis shows the number of passengers carried on a given route. As these data are internal and are not published by the carrier, it is necessary to determine the approximate number of passengers for the reference period using a transport model.

The transport model talks about the burden on public passenger transport (bus and rail) by passengers in 24 hours. It is being prepared for the current period and is also used to implement the traffic forecast (there is currently a scenario until 2050). According to the transport model, the load on rail transport represents intensity of 0-5,000 passengers in 24 hours (MDV, 2014). For the purposes of this article, we will count on an average occupancy of 83 passengers, which is also the capacity of seats in the engine unit. According to Equation 1, we determined the number of passengers per year.

Number of passengers per year = number of passengers in 24 hours * 365 (1).

After setting the values, we get an average of 30,295 passengers a year. In the next step, using the data in the carrier's annual report, we will determine the percentage share of power on the line to the total share of power on the network (ZSSK, 2018).

Percentage of passengers carried = number of passengersper year/number of passengers carried (2).

The individual shares of shipments for the observed period are shown graphically in percentages in Figure 4.

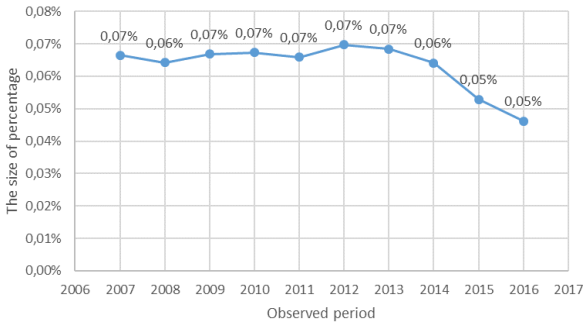

Fig. 4. Share of transport performance in percentage on the railway line Zohor – Záhorská Ves

During the entire period under review, the share of output remained in the range from 0.05% (in 2015 and 2016) to 0.07%. Performance on this line has been relatively stable, but despite the introduction of free transport for selected population groups, performance has declined slightly in recent years.

In the final step, the number of passengers in the observed period is calculated using Equation 3.

Number of passengers on the line = number of all passengers * percentage of passenger carried (3)

Figure 5 shows the approximate average number of passengers for the period 2007-2016.

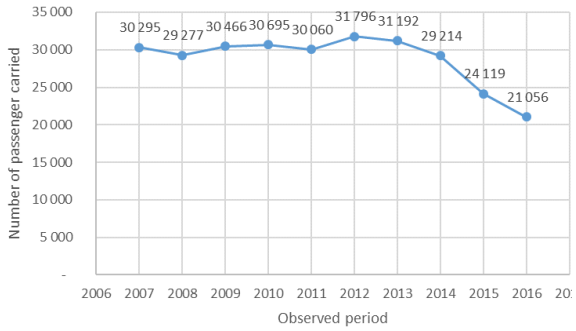

Fig. 5. The number of passengers carried for the period

The number of passengers begins to decline after the year 2014. Before the year 2014, the number of passengers was relatively stable.

2.3 F-test

To determine the dependence between the observed phenomena, the so-called F-test. An F-test is any static test in which the test statistic has a distribution of F assuming the null hypothesis is valid. It is most used when comparing statistical models that have been estimated from a data set to identify the model that most closely matches the population from which the data were collected. Exact F-tests arise mainly when the models were estimated using the least-squares method.

If the tabular value of the F-test is less than the calculated value, it can be stated that the investigated quantities are dependent. However, if the tabular value of the F-test is greater than the calculated value, it can be stated that the investigated quantities are not dependent. We use Equitation 5 to calculate the F-test value.

$$F = (R^2 / k) / (1 - R^2) / n - k + 1 \qquad (4)$$

where:
k – coefficient (for a linear dependence it takes the value 1 and for a polynomial dependence it takes the value 2)
n – number of years in the reference period
R^2 – reliability equation (coefficient of determination)

3. Testing statistical hypotheses

To begin with, it is necessary to establish hypotheses, that we will either accept or reject after testing. These are listed in Table 5.

Table 4. Determination of statistical hypotheses

H_0	The number of passengers depends on the population
H_1	The number of passengers is independent of the population
H_0	The number of passengers depends on the development of fuel prices
H_1	The number of passengers is independent of the development of fuel prices

3.1 Examination of the relationship between the number of passengers carried and the number of inhabitants

In examining this relationship, we will use a linear dependence, since the reliability equation R^2 was the highest for this function. When plotting a simple regression model, we will use the data in Table 4 and Figure 5. A graphical representation is shown in Figure 6.

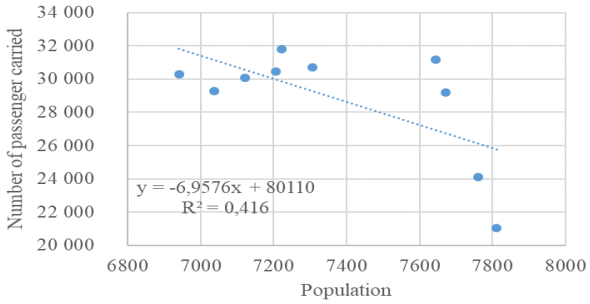

Fig. 6. The linear relationship between the number of passengers carried and the number of inhabitants

To verify the dependence, it is necessary to form a table. The table should display the individual variables in which dependency or independence will be verified. This verification is in table 6.

Table 5. Dependency verification

R^2	0,42
k	1
n	10
n – (k + 1)	8
F	5,70
F_{TAB}	5,32

We can see from the table that the calculated value of the F-test, according to Equation 5, is larger than the table value. Based on this fact, it can be concluded that it is possible to accept hypothesis H_0 and reject Hypothesis H_1. After 2016, the number of passengers continued to fall. This is even though the weekend seasonal operation of motor trains on the route Záhorská Ves - Plavecké Podhradie and back has been introduced. Passengers prefer to use bus transport, which is characterized by a larger number of connections and more stops in individual villages, which also plays a significant role. In addition, a large part of the population uses individual transport (passenger car) for transfers.

3.2 Examination of the relationship between the number of passengers carried and fuel prices

In examining this correlation, we use a polynomial dependence, since the reliability equation R^2 was the highest at this dependence. In plotting this dependence, we will use the data in Figures 3 and 5. A graphical representation of the results is shown in Figure 7.

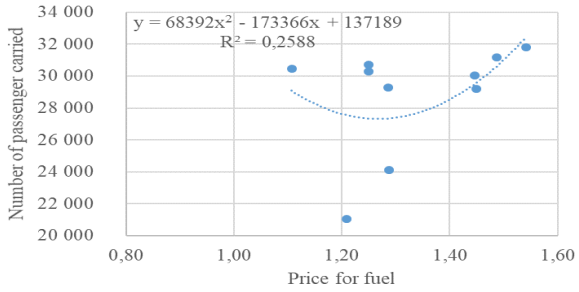

Fig. 7. Polynomial relationship between the number of passengers carried and the price for fuel

To verify the dependence, it is necessary to form a table. The table should display the individual variables in which dependency or independence will be verified. This verification is in table 7.

Table 6. Dependency verification

R^2	0,26
k	2
n	10
n – (k + 1)	7
F	1,23
F_{TAB}	4,74

It is clear from the table that the number of passengers does not depend on the prices of fuel. The tabular value of the F-test is higher than the value of the calculated F-test. In this case, we accept the hypothesis H_1 and reject hypothesis H_0.

Conclusion

Regional rail passenger transport has been experiencing a slowdown recently. To revive it, it is necessary to examine the various factors and dependencies that characterize it. The article presented two factors, the dependence of which on the number of passengers carried was examined. The number of inhabitants of individual municipalities depended on the number of transported passengers. In practice, this means that if the population increases, the number of rail passengers should increase. However, negligible factors, such as the degree of motorization or competing bus transport.

The second dependence examines the number of transported passengers and the price of fuel. However, these factors are independent of each other.

Passenger transport was toped on the line in December 2019. The factors examined above were also signed under this step will be such as e. g. extensive marketing research or interest in the renewal of passenger transport, harmonization of railway transport and road transport, or expansion of the seasonal operation.

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CLEAN AIR FOR INDIAN CITIES – CAUSES AND ALLEVIATION STRATEGIES

Abstract: Air pollution in cities across the world is rising at an alarming rate. This rise in pollution has an adverse effect on people's health leading to breathing difficulties, skin diseases and even cancer. The pollution in cities is mainly due to fossil fuel fired vehicles plying on the roads. Different polluting gases and particulate matter are discussed in the manuscript. Indian cities are no exception to this problem. With the general increase in population in the country, migration into cities has increased many folds. As a result, vehicular traffic on the roads has increased polluting the city atmosphere. This pollution has turned cities into heat islands. Two major cities of India, namely, Bengaluru and Delhi are considered in the manuscript for discussion. There are no simple ways of controlling this vehicular pollution and regulating the pollution. Strong policies have to be made and implemented. The way forward is pondered upon in the manuscript.
Keywords: Pollution, Health, Vehicular Emission, Electric Vehicles

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Introduction

Atmospheric pollution from transportation sector has been on the rise in the last few decades. Globally, in 2016, about 7.87 Gt of CO_2 amounting to 24% of global CO_2 emissions were from fuel combustion (IEA 2018). In the business as usual (BAU) scenario the passenger transport is predicted to increase three-fold between 2015 and 2050 (ITF 2019) and the emission from transport sector is expected to reach around 12 GtCO2eq/yr by 2050 (IPCC 2014). The increase in per capita transport demand in developing countries will be responsible for this increase in emissions.

1. Pollution

By convention air pollution is any substance humans emit into the atmosphere that has a damaging effect on the environment. These pollutants are both visible and invisible; and contribute to global warming. Since transportation sector makes a sizeable contribution to the air pollution, this article highlights the impacts of increased transportation in large cities in India and some suggestions to control this pollution are made here.

The impacts of transportation activity can be categorized into 3 classes, namely: direct, indirect and cumulative (Ports 2008). Direct impacts are the immediate effects of transport activities on the surroundings. Here the cause and effect relationships are usually well understood. For example, effect of noise and emission of carbon monoxide are known. The indirect impacts of transport activities on the environment are the secondary effects. It is not clear if these effects have higher consequence on environment and human health than direct impacts as the correlations are not well understood and are more difficult to establish. Most common example being the particulate matter that are emitted from the tailpipe of a vehicle because of the incomplete combustion in the engine, are associated with respiratory and cardiovascular problems. Then the third category is the cumulative impacts. This category encompasses the additive, multiplicative or synergistic consequences of transport activities that are the combinations of the direct and the indirect impacts on an ecosystem. Climate change is a cumulative impact of several natural and anthropogenic factors.

2. Environmental Impact of buses

Buses can be flexibly organized to transport citizens in big cities. Bus routes can be flexible enough to meet the needs of changing population and expansions in a city. They can provide connectivity to every corner of the city with appropriate interchanges. Since bus services are for mass transport of population, they are affordable, cost-effective and space efficient. Buses are efficient as far as fuel used per passenger-kilometer is concerned (IEA 2002). Furthermore, switching to buses would also mean an high saving in oil and reduction in pollution in addition to saving money. The road space occupied by a bus is about twice the space taken by a car but ferries many more passengers, could be about 10 times more.

There are economic and political angles associated with increasing the fleet of buses in big cities for transporting people. With increasing number of cars and other motorized smaller vehicles, demand for oil will grow steadily. With increasing transport demand in developing countries usage of buses makes more economic sense since a good bus system will

substantially reduce oil usage in large cities. This will also put less pressure on the foreign exchange reserves of these countries by reducing the world oil demand.

Diesel, petrol and CNG are the most commonly used fuels for buses and all of them are produced from mineral oil that is commonly pumped out of an oil well, but the actual refining methods are different. Diesel is easier to refine than petrol and also contains higher levels of pollutants.

Petrol is a mix of alkanes and cycloalkanes with a chain length of between 5-8 carbon atoms. The alkanes from pentane (C_5H_{12}) to octane (C_8H_{18}) are refined into petrol. The boiling temperature is between 40°C and 200°C. Diesel is made of alkanes containing 12 or more carbon atoms with a boiling temperature between 250°C and 350°C.

The basic chemical reaction taking place inside combustion chamber in the Internal Combustion Engine (ICE) of a vehicle is,

Petrol/Diesel + Air Carbon Dioxide + Carbon Monoxide + Hydrocarbons + Nitrogen Oxides + Sulphur Dioxide+ water + soot

The main pollutants coming out of a petroleum fuel fired vehicles are all toxic. For example:

Inhaled Carbon monoxide (CO) can block oxygen from vital organs like the brain, heart, and other vital organs. Carbon dioxide (CO_2) is a greenhouse gas that can trap heat in the atmosphere and cause global warming. Nitrogen oxides (NOx) are formed during combustion of fuels where temperature is above ~1300 C by oxidation of some of the nitrogen in air. These gases cause irritations in the lungs and weaken the body's immunity against respiratory infections. From global transportation, it is estimated that the direct emissions of N_2O to be 0.142 ± 0.065 Tg N_2O-N yr^{-1} in 2010 (van der Zwaan et al. 2013). Sulfur dioxide (SO_2) is another pollutant generated by motor vehicles by burning sulfur-containing fuels, especially diesel. SO_2 is known to be responsible for acid rains and it is the largest health risk to young children and asthmatics. Particulate matter (PM) are particles of soot and metals which are responsible for the murky color to the smog. These fine particles are less than one-tenth the diameter of a human hair. These pose a serious threat to human health, as they can penetrate deep into lungs. PM of size < 0.1 micron pass through the lungs into the blood stream and can settle in other organs. Diesel exhaust is a major contributor to PM pollution.

Hydrocarbons (HC) are fragments of fuel molecules which are partially burned. These molecules, in presence of sunlight, react with nitrogen oxides to form ozone at ground level, which is a primary ingredient in smog. In upper atmosphere ozone is beneficial but at ground level this gas is responsible for irritations of the respiratory system and reduces the lung capacity.

Hazardous air pollutants (toxics) which include Benzene, acetaldehyde, and 1,3-butadiene — are known to be carcinogenic. These chemical compounds are linked to cancer, birth defects and other serious illnesses.

The amount of CO_2 emitted by burning petrol is 2.31 kg/litre whereas it is 2.68 kg/litre from a diesel engine. The energy content per litre in diesel is higher than petrol and diesel vehicles are more efficient to run than petrol engines because they are more efficient. Diesel does not contain any lead. However, when compared to petrol vehicles with catalytic converters, diesel vehicles have higher emissions of NOx and particulate matter.

Compressed natural gas is another fuel that is used to run buses. Natural gas consists of about 90% methane, with small amounts of higher alkanes. Methane is lighter than air, combusts almost completely giving out carbon dioxide and water as byproducts. There are issues like methane leak and emission of unburnt methane into the atmosphere.

A diesel bus engine emits 14, 5.5, 3.2, and 1.8 times higher HC, SO_2, PM and NOx emissions, respectively, when compared with the CNG bus. With longer the carbon chain, the probability of finding other elements like sulphur and nitrogen attached to it are higher. However, a CNG bus engine emits 20 times higher CO than diesel/petrol buses (Yasar et al. 2013). Also, because of longer carbon chains, diesel contains more energy per unit volume compared to CNG. Higher energy and better combustion efficiency would mean that diesel delivers greater power and ensures better mileage. If energy content, in other words, energy density is compared diesel scores the highest with 1.1 times that of petrol while CNG is <40% of petrol (EIA 2013).

Though methane contributes little to the formation of low-level ozone it plays a major role in global warming. Though the life of methane in the atmosphere is only 12 years, it has a greater effect on climate. Based on the study of Shoemaker et al. short-term radiative forcing has an effect on the rate at which climate change occurs (Shoemaker et al. 2013). This study suggests that methane emissions, converted to carbon dioxide equivalents, have global warming potential (GWP) numbers of 28 for a 100 year time horizon but an alarming 84 for a 20 year time horizon (Myhre et al. 2013). As per the GREET model (Greenhouse gases,

Regulated Emissions and Energy use in Transportation) developed by Argonne National Lab, under a 100-year GWP time horizon, natural gas emits 4 to 5 percent lower levels of GHG emissions than diesel throughout the fuel life cycle. But under a 20-year time horizon, 19 to 24 percent higher levels of GHG emissions than diesel. On a distance-specific metric (grams of CO_2 eq per mile) that takes into account the differences in fuel efficiency, with an assumption that a 10 percent efficiency gap exists between natural gas and diesel engines, the natural gas emits 6% higher GHG than diesel under a 100-year time horizon and under a 20-year time horizon, > 30% GHG emissions than diesel (Delgado and Muncrief 2015). Actually, in India's capital city Delhi, most buses in the fleet of 5,500 utilize CNG for traction. A study concluded that, introduction of CNG buses did not change the pollution level. The study was conducted for 7 years from 2002 – 2009 (Saxena et al. 2012). Another drawback of CNG buses is that there is a drop in mileage with time. The study in Delhi, showed that within a span of six years, the mileage of buses had fallen from 2.88 to 2.63 km per kg of CNG. This is attributed mainly to newer buses having more powerful engines and growing traffic congestion leading to frequent start–stop movement. This trend is consistent with what has been noted with diesel buses in other cities as well (Roychowdhury 2017).

3. Possible solutions to reduce pollution in cities

The number of vehicles in Bengaluru has increased from about 3.49 million in 2010 to 8.05 million in 2019 (Karnataka Transport 2019). Associated with this trend is the increase in pollution level. Bengaluru city, currently, has 16 pollution monitoring stations over its 709 Sq. km area. In 14 locations the measured PM10 was higher than the National Air Quality Standard limit of 60 micrograms/m^3. The annual average of PM level at the city center has increased from 72 micrograms/m^3 in 2010 to 100.6 micrograms/m^3 in 2019. PM2.5 or PM10 were specifically not monitored in 2010. The value corresponds to suspended particulate matter whereas in 2019 it is specifically PM2.5. NOx, which is associated with vehicular traffic, increased from 72.6 micrograms/m^3 in 2010 to 111.8 micrograms/m^3 (KSPCB 2011, CPCB 2010).

All petroleum-based fuels, namely, natural gas, diesel and petrol used for traction of buses pollute the surrounding atmosphere leading to smog that hangs over cities. Especially, due to temperature inversion in winters this effect is more severe. Winters are also notorious all over world for the flu and other respiratory illnesses because of pollution.

Thus, the only sensible option that exists to control emissions is to reduce the number of fossil fuel burning vehicles on city roads. Since buses can provide the last mile connectivity in cities and can be used for mass transportation of people, it makes sense to increase the number of buses to control pollution. For example, public transport in cities in Europe carried approximately 200 million people every day that was equivalent to about 21% of total mobility (IAPTU 2011). However, using fossil fuel burning buses will not help in reducing the pollution levels and replacing the current fleet of buses with electric buses is the only way forward to combat emissions in the atmosphere. With electric buses, though there are no direct emissions from the tailpipes, the electricity consumed for charging the batteries indirectly contributes to emissions. The amount of CO_2 generated per kWh of electricity utilized is in the range 0.87–0.96 kg (CEA 2018). A detailed study on an electric bus, which was run on a trial basis, was conducted in Bangalore (Adheesh et al. 2016). The electric bus consumed 274 kWh, for recharging the battery to travel a distance of 170 km. According the Ministry of Power, Government of India (Power Ministry 2019), about 58% of the grid power in the country is generated from Coal fired thermal plants and ~8% from Gas and oil sources. Taking these numbers into account and considering an average of 0.92 kg CO_2 per kWh for fossil fuels, there is an emission of 167 kg of CO_2, that is less than the emission coming from a diesel run bus to travel the same distance, which is ~212 kg. So, annually over 25 tonnes of CO_2 emissions can be saved by replacing even a single diesel bus by an electric bus. By deploying solar panels or other renewable sources for electricity generation at the battery charging stations of the electric buses, this emission can also be prevented. Here other kinds of pollutants that come out of diesel and coal burning, like the Water vapor, NOx and SOx are not accounted for.

There is an economic consideration that needs to be addressed. A diesel bus or a CNG bus costs around ₹ 8.5 million whereas an electric bus, that needs to be imported, costs around ₹ 20 -30 million. This is the upfront cost difference between the two types of buses. However, if electric buses are manufactured in the country, the unit cost would drop quite substantially. Many Indian companies like Ashok Leyland Limited, JBM Auto Limited, Deccan Auto Limited and Goldstone Infratech Ltd are entering into tie-up with industries around the world to start manufacturing electric buses (UITP India 2016). This will be a big boost to the implementation of these buses in the country. Currently, the operational cost of the electric bus was found to be ₹ 17.25 per km in Delhi. In contrast, a CNG AC bus costs ₹ 18.54 per km. On average, the electric bus ran 250 km

on a single charge. It consumed 27,368 kWh electricity in the four-month period to cover a distance of 16,915 km. With the price of CNG in Delhi is about ₹ 35.6 per kg. A CNG bus gives a mileage of 1.95 km per kg and also requires higher maintenance (TOI 2016).

The electric buses in both the locations, namely, Bangalore and Delhi, did not breakdown during the trial period, largely because there's no engine or transmission system. In the long run, only the battery needs maintenance. Essentially, electric buses score on two fronts, Zero emission and lower manpower costs because of low maintenance.

The basic issues with the present scenario of public transport in big cities in India can be summarized as:

a) Number of buses to every one million population is small. For example, Delhi Transport along with the subsidiaries operates about 5500 buses with a population of 19 million whereas Bangalore with a population of over 12 million has a little over 6500 public transport buses. Hence, people in big cities are forced to use private transportation consequently increasing the number of vehicles on the road.
b) Because the public transport buses are fewer in number, they tend to get over crowded, slow moving and do not keep up the schedule. This again encourages people to use their own means of transportation.
c) The pollution from the tailpipes of buses and other motorized vehicles causes many health-related issues for people living in big cities, especially so when the buses are not well maintained.

In addition to the pollution aspects of vehicular transportation in the cities, there is the local weather aspect that should also be considered. The temperatures within the city can be 1-3 C higher than in the outskirts, for a city of 1 million population, due to trapped heat from traffic emissions and buildings (TERI. 2017). For Bangalore, with over 12 million population, this temperature difference could be higher than 5 C and in New Delhi, it could be as high as 7-10 C.

Metro trains which run on electricity, have eased road traffic marginally in big cities like Delhi, Bangalore and Mumbai. The major problem with metros, however, is that, it is not viable to lay rail lines all across a crowded city. The roads are not broad enough to lay rail lines in most parts of the city. Drilling underground tunnels below the cities to have a wide network of metros is an expensive proposition and limitations in budgets will pose inhibitions to take up such large projects. While point to point connection on major routes is good with metros, the last mile connectivity will still depend on buses.

Thus, a combination of metro and electric buses appears to be a good solution to counter the pollution issues in big cities. The electric buses, as they cannot ply long distances on a single charge, can be engaged

in local service rather than for cutting across the city. For example, figure 1 shows the existing and planned routes of Metro in Bangalore. As can be seen between routes and between metro stations on a route, there are plenty of areas that cannot be serviced with the metro. Unless last mile connectivity is provided, citizens cannot be motivated to travel by metro. In many countries around the world, using public transport for an individual is a part of the daily routine since long and even if people have to walk a couple of kilometers, they do not mind the walk as it has become a habit. In Indian cities, public transport has been in such a bad shape all these years, to get people out of their private cars into public transport requires a big mindset change. It is easily said than done.

4. Policies to control pollution in cities

In order to improve the air quality and reduce pollution from vehicular transportation in Indian cities some major policies have to be implemented by the government and local civic bodies of these cities,

- First and foremost, requirement for Bangalore and other big cities in the country is to have a wide network of metro trains. As they run on electricity, the pollution in cities is reduced considerably. Of course, electricity generation sites will be polluting, if the electricity is generated from coal fired thermal plants which are generally located far from cities. Using cleaner ways of generating electricity will bring down the pollution associated with power generation.

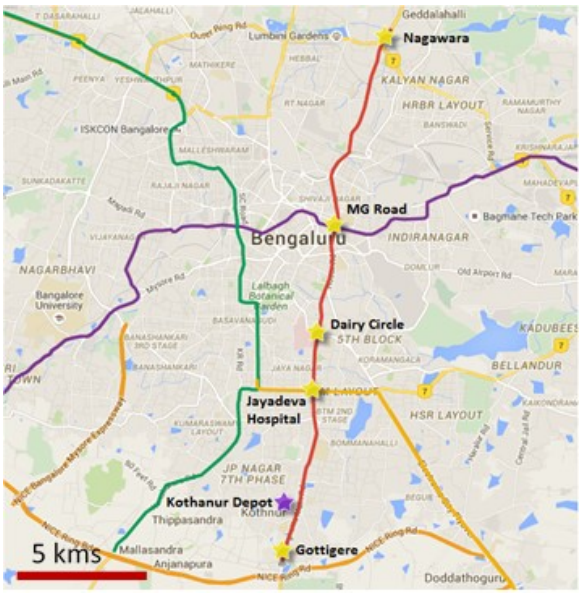

Fig 1. Existing and Planned Metro routes in Bangalore (BML 2016)

- There needs to be a well thought out network of public transport with electric buses that ferry people and act as feeders to metro stations from surrounding areas. These will provide the much needed last mile connectivity. Since the electric buses ply shorter distances on a single charge, they would be the best option for this purpose.
- In order to change the mindset of people about owning a car, private car ownership must be made difficult and discouraged.
- Private car usage, according to a study, is only 5% of the time and the other 95% of the time cars are parked (Fortune 2016). Each car occupies about 150 m^2 of parking space. In a city like Bangalore, due to lack of parking facilities inside the properties, cars are parked on roads creating congestion and leading to increase in pollution of the local atmosphere. This also impacts the available space for walking and cycling. Heavy parking fees need to be levied for parking on roads.
- Encourage shared transport to and from metro stations. The regulatory measures must ensure that cab aggregators get a fair deal for providing good service. Digitized economy provides safety for the cab aggregators by not having to deal with cash. This will ease the traffic mayhem created on the roads by thousands of private cars.

Implementing these measures can control pollution in big cities in the country. The citizens can breathe easy and healthier air. This will also bring down enormously air borne diseases among the vulnerable population of the cities. In addition, if local climate conditions have to be maintained and cut down on the air-conditioner usage, it is imperative that the government makes policies based on above recommendations and implements them.

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PROPOSAL TRANSPORT SERVICES OF THE AIRPORT LEOŠ JANÁČEK OSTRAVA

Abstract. The article deals with the issue of transport service of Leoš Janáček Airport in Ostrava utilizing public passenger transport. The topicality of the issue is the seasonal operation of the airport. The article aims to adapt the airport traffic service to passengers and airport staff. The number of connections will be dimensioned using the formula of transport services, which is based on the potential of transport services in the area. This methodology has been used on lines connecting residential areas but has never been used on lines connecting the city centre the airport.
Keywords: railway line, airport, passengers

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Introduction

Air transport is one of the most dynamically developing transport modes. Despite occasional fatal accidents, it continues to grow in popularity. At the same time, according to statistics, it is considered the safest transport mode in the world.

Ancillary elements such as the availability of the airport by public passenger transport are an essential part of the transport activity. The accessibility factor plays an important role in planning the accessibility of airports by passengers. A long-term trend in the operation of public passenger transport to the airport is the incorporation of rail transport as a key element of airport accessibility. In many developed countries, routes are now being built to their largest airports. It is up to the carrier to plan the transport service to meet the needs of both passengers and airport staff.

However, there are also airports where flights are operated only seasonally, whether in the winter or summer season. This is also the case of Leoš Janáček Airport in Ostrava. The task of the article is to propose optimal airport operation all year round, considering the seasonal specifics of transport

The issue of transport service was already addressed in the article Research of passenger's demand for a travel companion as part of sustainable transport solutions. from authors J. Čamaj & J. Mašek (Čamaj, et al., 2018). The article deals with passenger demand for transport services.

1. Characteristics of Leoš Janáček Airport Ostrava

Leoš Janáček International Airport Ostrava is the third-largest airport in the Czech Republic with seasonal regular operation. It is located 5 km north of Příbor and the D1 highway.

It is situated in the territory of these municipalities (http://www.airport-ostrava.cz):

- Mošnov – 738 inhabitants,
- Albrechtičky – 708 inhabitants,
- Petřvald – 1 800 inhabitants.

Figure 1 shows distances in kilometers from the largest cities in the region to the airport.

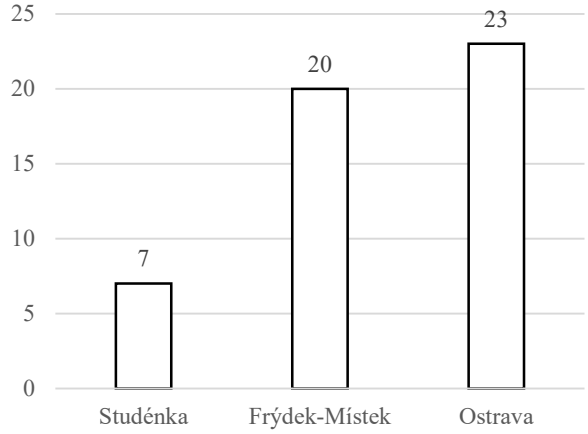

Fig. 1. Distance from the airport [km] (http://www.airport-ostrava.cz)

The airport has direct rail and bus connections from Ostrava and Studénka, but it has only a direct bus connection from Frýdek-Místek.

Leoš Janáček Airport was opened in 1959. It currently has two concrete runways, each 3 511m long (Leoš Janáček Ostrava Airport, 2019).

According to the portal www.idos.cz, the airport currently operates for the public only in the summer season. Table 1 shows individual departures with their date restrictions.

Table 1. Departures in the summer season 2020

Departure	Destination	Air company	Date restriction
9:55	Burgas	Travel Service, a. s.	from 10. 6. to 16. 9. on Wednesday
12:00	Burgas	Travel Service, a. s.	from 5. 6. to 12. 9. in Friday and Saturday
12:15	Varna	Travel Service, a. s.	from 2. 6. to 15. 9. on Tuesday
12:20	Heraklion	Travel Service, a. s.	from 27. 5. to 4. 10. on Wednesday, Thursday, Saturday, and Sunday, except for 28. and 30. 5.
12:50	Burgas	Travel Service, a. s.	from 9. 6. to 15. 9. on Tuesday
13:25	Warsaw	LOT – Polish Airlines	from 30. 3. on Monday, Thursday and Saturday
17:05	Warsaw	LOT – Polish Airlines	from 31. 3. on Tuesday and Friday
19:10	Palma de Mallorca	Travel Service, a. s.	from 30. 5. to 26. 9. on Saturday
19:20	Palma de Mallorca	Travel Service, a. s.	from 3. 6. to 30. 9. on Wednesday

The first flight from the airport this year is scheduled for 30 March. In the meantime, the airport will be used for private flights and will be maintained.
Despite seasonal operations, the airport offers the following services (Leoš Janáček Ostrava Airport, 2019):

- business lounge,
- packing of luggage in protective foil,
- luggage storage,
- complaints about lost and damaged luggage,
- children's play area and room for families with children,
- Ostrava City Information System
- meeting room,
- wi-fi,
- shops and fast foods.

Another important indicator of airport operations is the number of passengers handled. For example, the passenger´s services provided also depend on this indicator. Figure 3 shows statistics on the number of handled passengers on scheduled services for 2014-2018.

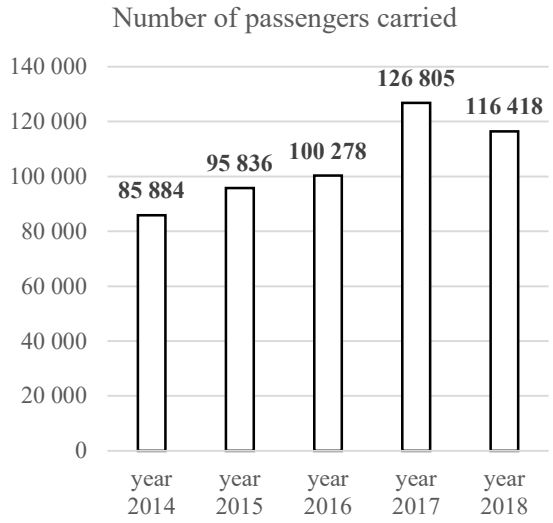

Fig. 2. The number of passengers Ostrava airport (Leoš Janáček Ostrava Airport, 2019)

From 2014 to 2017, the number of passengers gradually increased. In 2018, a decrease of 10 387 passengers was recorded compared to 2017.

2. The current state of airport transport service by rail

The railway line to Ostrava Airport was inaugurated on 13 April 2015. At that time it was the first airport to have access by rail. The railway station is called Mošnov, Ostrava airport. The railway line turns from Sedlnice station on line no. 323. This line connects Stúdénka and Veřovice [1]. The railway station and the whole line is controlled by a dispatcher from the railway station Studénka, therefore it is a remote-controlled line. There are two station tracks with a total length of 200 meters. The length of the platform is 174 meters and the whole station is fully wheelchair accessible [5]. Figure 4 shows the railway station Mošnov, Ostrava Airport.

Fig. 3. Station building (Dočkal, 2015)

Since the beginning of its operation, the carrier on this line was České Dráhy, Ltd. Until December 2015 trains operated on the route Mosty u Jablunkova - Bohumin -

Ostrava - Mosnov, Ostrava Airport [7]. When the timetables were changed in December 2015, the line was shortened and trains started to run only in the section Bohumín - Ostrava - Mošnov, Ostrava Airport [8]. All trains running to the airport have been low-floor since the start of the operation. Figure 5 shows the wheelchair

accessible passenger train set.

Fig. 4. Passenger train at the airport (Dočkal, 2015)

The carrier currently offers several services for passengers on the train during their journey.

They are [10]:

- first-class sections,
- transport of bicycles,
- carriage of immobile passengers.

The train ride to Ostrava - Mosnov, Ostrava Airport takes 23 minutes. In principle, the timetable tried to accommodate departures and arrivals at the airport. In

Osobní vlaky na přepravním rameni Bohumín - Mošnov, Ostrava Airport od 15. XII. 2019 - 12. XII. 2020

ČD, a.s., ROC Ostrava Vlak	3060	3050	3062	3064	3066	3052	3054	3056	3068	3058
	♿ 1.2.	♿ 1.2.	♿ 1.2.	♿ 1.2.	♿ 1.2.	♿ 1.2.	♿ 1.2.	♿ 1.2.	♿ 1.2.	♿ 1.2.
	o	o 12				o				o 12
ze stanice										
Bohumín	2:05	4:46				12:50		16:42		20:50
Ostrava hl.n.	2:13	4:54	7:26			12:57	14:50	16:50		20:57
Ostrava-Mar. Hory	x 2:16	x 4:57	|			x 13:00	x 14:53	x 16:53		x 21:00
Ostrava-Svinov	2:21	5:08	7:34	9:34	11:34	13:05	14:58	16:58	19:16	21:08
Polanka nad Odrou	x 2:24	x 5:11	x 7:37	x 9:37	x 11:37	x 13:08	x 15:01	x 17:01	19:20	x 21:11
Ústečník	2:28	5:15	7:41	9:41	11:41	13:12	15:05	17:05	19:24	21:15
Studénka	2:35	5:21	o 7:48	o 9:48	o 11:48	13:19	15:12	17:12	o 19:29	21:21
Sedlnice	x 2:40	x 5:26	x 7:53	x 9:53	x 11:53	x 13:25	x 15:17	x 17:17	19:34	x 21:26
Mošnov, Ostrava Airport	2:44	5:30	7:57	9:57	11:57	13:28	15:21	17:21	19:38	21:30

ČD, a.s., ROC Ostrava Vlak	3061	3051	3063	3065	3067	3053	3055	3057	3069	3059
	♿ 1.2.	♿ 1.2.	♿ 1.2.	♿ 1.2.	♿ 1.2.	♿ 1.2.	♿ 1.2.	♿ 1.2.	♿ 1.2.	♿ 1.2.
										12
Mošnov, Ostrava Airport	2:52	6:35	8:02	10:02	12:02	14:44	15:44	18:44	19:44	22:34
Sedlnice o	x 2:55	x 6:38	x 8:05	x 10:05	x 12:05	x 14:47	x 15:47	x 18:47	x 19:47	x 22:37
Studénka o	3:01	6:44	8:11	10:11	12:11	14:53	15:53	18:53	19:53	22:43
Ústečník o	3:07	6:51	8:17	10:17	12:17	14:59	15:59	18:59	19:59	22:49
Polanka nad Odrou o	x 3:10	x 6:54	x 8:20	x 10:20	x 12:20	x 15:02	x 16:02	x 19:02	x 20:02	x 22:52
Ostrava-Svinov o	3:15	6:58	8:25	10:25	12:25	15:06	16:06	19:06	20:06	22:56
Ostrava-Mar. Hory o	x 3:19	x 7:03			x 12:30	x 15:12		x 19:12	x 20:12	x 23:02
Ostrava hl.n. o	3:22	7:06			12:33	15:15		19:15	20:15	23:05
Bohumín o	3:30	7:15			12:42	15:24		19:24	20:24	23:14
do stanice										

12 nejede 24., 31.XII.
11 nejede 25.XII. a 1.I.
56 jede 7.VI. - 3.X.
51 nejede 25.XII., 1.I., 7.VI. - 3.X.
56 nejede 7.VI. - 3.X.

o vlak nečeká na žádné přípoje
O čas příjezdu
x zastávka na znamení - vlak zastavuje jen na znamení nebo požá

Fig 5. The current timetable is valid from 15. 12. 2019.

3. Design of transport service using railway transport as the main mode of transport

According to the valid timetable, as shown in Figure 6, a total of 10 pairs of trains operate at Ostrava-Svinov - Mošnov, Ostrava Airport. The timetable is divided into two basic parts - seasonal operation (from June 7 to October 3) and off-season. Out of season, the number of train pairs is reduced to 5 [10].

The basic factor to consider when modeling transport service is the time of arrival at the airport. In this case, it would be appropriate to arrive at the airport no later than two hours before departure. Table 2 shows departures and suitable train connections from the station Ostrava-Svinov [10].

Table 2. Transfer links between the arrival of the train and the departure of the aircraft

Departure	Final destination	The arrival of a suitable train
9:55	Burgas	7:57 – Os 3062
12:00	Burgas	9:57 – Os 3064
12:15	Varna	
12:20	Heraklion	
12:50	Burgas	11:57 – Os 3066
13:25	Warsaw	
17:05	Warsaw	15:21 – Os 3054
19:10	Palma de Mallorca	17:21 – Os 3056
19:20	Palma de Mallorca	

The worst situation is between the arrival of the train number 3066 and the departure of the aircraft in the direction of Burgas at 12:50. Passengers have only 53 minutes to check-in. For other ties between train arrivals and aircraft departures, passenger check-in times are acceptable. Table 3 shows the links between aircraft arrivals and train departures towards Ostrava-Svinov (Z Dopravy CZ, 2019).

Table 3. Transfer links between the arrival of the aircraft and the departure of the train

Arrival	From the direction	The departure of a suitable train
1:25	Palma de Mallorca	2:52 – Os 3061
11:00	Bourgas	12:02 – Os 3067
12:00	Bourgas	14:44 – Os 3053
12:50	Warsaw	
14:30	Bourgas	
16:30	Warsaw	18:44 – Os 3057
16:45	Varna	
18:20	Heraklion	
	Palma de Mallorca	
18:40	Varna	19:44 – Os 3069
19:55	Heraklion	22:44 – Os 3059

The table shows that the links between aircraft arrivals and departures of trains are worse addressed. This is due to the short transfer times, which can not be used in flight delays. The highest risk of losing the connection is where the passenger has less than an hour to transfer. It is

appropriate to introduce a basic waiting time between air and rail traffic to ensure the continuity of the train when the aircraft is delayed. The compensation to passengers in cases of delay of modes of transport is enshrined in article Possibilities and solutions of compensation for the delay of passenger trains and their economic impacts by the authors Nedeliaková Eva, Lalinská Jana & Čamaj Juraj (Nedeliaková, et al., 2015).

There are train connections in the timetable that have no connection to any flight. These run to the airport empty. Most passengers get out evenly along the route. Table 4 lists the connections that do not follow any flight.

Table 4. Connection not linked to any flight

Arrival	From the direction	Departure	Direction
2:44	Bohumín	6:35	Bohumín
5:30		8:02	Ostrava-Svinov
13:28		10:02	
19:38	Ostrava-Svinov	15:44	
21:30	Bohumín		

These trains are designed primarily for airport staff, respectively. for passengers of adjacent villages. It is questionable how many employees use them.

The modified methodology of Ing. Milan Dedík, which was used in the article Determining the necessary extent of regional rail passenger transport in the selected area, will be used to calculate the number of trains. This article was published at the conference Future of Regional Transport 2020 in Týn nad Vltavou. The fundamentals of the methodology are represented by a computing relation dealing with the calculation of the potential coefficient.

$$K_p = \frac{\frac{A_n}{D_n}}{L} \qquad (1)$$

where:

- Kp – potential coefficient,
- An – the number of inhabitants in the n-th settlement of the monitored area expressed in thousands,
- Dn – availability of the n-th railway station from the center in km.
- L – transport distance (from A to B)

According to available data, 200-249 employees work at Ostrava Airport [11]. For the article, we will assume in the model situation that 230 employees work at the airport.

Model distribution of employees and distance from the railway station to the cente (km):

- Ostrava - 157 employees and 4,6 km
- Polanka nad Odrou - 16 employees and 2,6 km,
- Jistebník - 9 employees and 1,8 km,
- Studénka - 35 employees and 2,2 km,
- Sedlnice - 13 employees and 3,7 km.

After substitution into the formula, we got a potential coefficient of 2.48. Besides, a higher proportion of airport staff commutes to work by car. Table V shows the parameters of the range of transport services outside the flight season.

Table 5. Range of transport services

Range of transport services	Result value range	The optimal number of train pairs	The optimal number of seats
I.	0 – 700	4	up to 500 seats

At the same time, it will be necessary to adapt the transport service to individual work shifts of employees.

These measures will also result in a reduction in revenue from the rail infrastructure charge. This issue is addressed in article Charging railway infrastructure models and their impact to competitiveness of railway transport (Čamaj, et al., 2017).

Conclusion

The transport service of the airport is an important part of the quality of passenger services. At a time of enormous growth in individual motoring, it is important to build a transport service on ecological "green" transport. And this mode of transport is rail transport.

The article aimed to determine the optimal transport service of the airport in the period out of regular air operation. It is very disadvantageous for a region, as a rail transport customer, to order trains whose transportation potential is very low. It can be stated that 4 pairs of trains that will be prioritized for airport staff are sufficient.

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