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# Influence of logistics system optimization on a company value

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**Abstract** The value of a company is influenced by many factors. It depends on how we evaluate the methods we use and what data we have for the calculation. It is also important for what purpose we will calculate the company value. However, the company's management decisions, their strategy and overall direction have a significant impact on the value of the business. In the article we will deal with the impact on the value of a business's optimization of the company's transport network. Also, whether optimization affects more revenue method or equity method.

**Keywords** company value, valuation method, business assets, costs and revenues, optimization

**JEL** M41, G32

## 1. Introduction

The development and economic growth have an overall impact on constantly new requirements in relation to information and knowledge. Companies need to work with new technological advances to stay on the market to keep up with competition and meet customer expectations. "The need to have available and process an ever-increasing amount of information results in a consequent increase in demand for means and devices for transmission, i. E. for linking and exchanging data not only inside economic entities but also to their surroundings." [1]

The essence of information and communication technologies, electronic communications and telecommunications is to ensure not only the transmission of messages and information but also to ensure the flow of goods, services, persons in space.

"Network industries play a crucial role in today's life because of the interdependence and dependence of other industries on their activities. They occur in many forms and include not only material networks, e.g. transport, logistics, communication and energy, but also abstract economic, financial, social and knowledge networks." [2]

Nowadays, information technologies are a necessity for most companies and other institutions. They bring many effects to businesses that improve their production processes. They also bring benefits in logistics, control, administration. In this paper, we will consider the impact of information technology and transport, logistics, communications networks and the optimization of the networks themselves on the value of company.

## 2. Established methodological principles of company valuation

The value of a company in terms of professional literature is differently defined. According to the Commercial Code, it is "a set of both tangible and personal and intangible components of business. The company includes things, rights and other property values that belong to the entrepreneur and serve to operate the business, or because of their nature they serve this purpose." [3]

Therefore, a company is not only its property and property rights, but also personal components of business, to which employees, their qualifications and experience, and intangible components belong. [6]

For many legal acts, the book value is insufficient. An appraisal of the market value by expert activity is needed. For expert practice, the general value of a company, or part of an enterprise is defined in Decree No. 492/2004 of the Collection of Laws on the Determination of General Value of Assets as the resulting objectified value of assets, which is an expert estimate of the most likely price of the asset being valued at the valuation date at that location and time that it should usually reach on the market, including value added tax. [5]

Valuation methods are based on four main principles.

**Asset principle** – the value of a company is calculated from the value of the individual components of the company's assets from which the value of the obligation is deducted. This principle is mainly used for property and liquidation method.

**Revenue principle** – in the case of revenue principle, the value of company is determined on the basis of the deductible resources that the company will create in the future. In the decree related to the valuation methods, the revenue principle is used in the business method.

**Combined principle** – principle combines asset and revenue principles. In the decree, a combined method is based on this principle.

**Market principle** – its basis is to derive the value of a company from the value of a similar company on the market. In our legislation on this principle works comparation method. In practice this method is minimally used. [4,5]

In practice, the most widely used valuation methods are based on property and yield principles. Under the property principle, the value of an enterprise is calculated from the value of the individual components of the enterprise's assets, from which the value of the liabilities is deducted. In Decree no. 492/2004 of the Collection of Laws on the Determination of the General Value of Assets, the property and liquidation method corresponds to this principle.

This method takes into account the static view of the enterprise as a whole on a specific date. [7] To this date, the asset and liability report expert is submitted to the sponsor in detail by component, is presented to the sponsor in detail by component, i.e. detailed by asset cards, stock records, cash register and bank account details, detailed records of each claim and liability, along with relevant contracts, repayment schedules, credit agreements, and the like, depending on the company's specific structure. It requires the cooperation of experts in technical and economic expertise, the precise organization of works and their mutual continuity, provision of documents, inspection of property.

The yield principle of valuation works with data for a longer period of time, as it is necessary to analyze the past development of the company. [9] In the decree, the yield principle is used in the business method. The analysis of past developments will point to the feasibility of the business plan and the financial plan on which it is based.

Compared to the equity method, it is less laborious because it does not require such an expert team as an equity method. By this method the sponsor of an expert obtains information about the value of the enterprise as a whole, but does not know the value of individual components of assets and liabilities. This is an asset method advantage. Each of the methods based on the property or yield principle has its positives and negatives. [8] This is based on the expert's experience and also on the structure of the submitted documents and information, so that the methods are applied correctly.

In the case of a company described in more detail in the next chapter, it is possible to apply the property and business method. We will not compare the specific purpose of the assessment in the given case. However, we will compare the impact on the overall value of the business if the current logistics network is optimized and which method will affect it more.

# 3. Network optimization and cost minimization

The evaluated company is based in the Slovak Republic and is a parent company having a subsidiary in Ukraine. In addition to selling car diagnostics equipment, the company also sells spare parts and tools to repair them. The structure of the company is as follows:

**Table 1.** Assets statement

| Year | 2018 |
|---|---|
| **Assets** | **677 476** |
| **NON-CURRENT ASSETS** | **543 378** |
| Long-term tangible property | 543 378 |
| **CURRENT ASSETS** | **130 811** |
| Inventory | 4 431 |
| Short-term receivables | 117 862 |
| Financial assets | 8 518 |
| **COSTS OF FUTURE PERIODS** | **3 287** |

Source: [10]

It can be seen from the financial statements that non-current assets are represented in a higher proportion than current assets. All non-current assets consist of real estate and buildings related to warehouse space and building ownership. The current assets are mainly represented by short-term receivables.

At the end of the year, inventories are reported, which are related to their business activities. Financial assets are money in the cash register and bank accounts. Foreign sources are short-term and long-term liabilities and short-term reserves. As at 31.12.2018 no loan is reported. The equity of the company is significantly lower in relation to the liabilities, resulting in a high indebtedness of the company.

**Table 2.** Liabilities statement

| Year | 2018 |
|---|---|
| **Liabilities and equity** | **677 476** |
| **Equity** | **44 797** |
| **Liabilities** | **632 679** |
| Long-term liabil-ities | 491 211 |
| Short-term liabil-ities | 139 435 |
| Short-term re-serves | 2 033 |

Source: [10]

Most of the equipment is designed for a foreign consumer. The company does not have its own fleet. The exchange of products between the warehouse, branches and end users is done by an outsourcing logistics company abroad.

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The company's existing logistics network consists of one warehouse (in Kharkov) and five branches (in Odessa, Lviv, Dnipro and two in Kiev). The goods are transported from the main warehouse to one branch approximately every third day of the current month. The transported 1 pallet has the size of 1200 x 800 x 2000 mm (9 pcs on average per month). The total monthly transport costs of the outsourcing logistics company are shown in Table 3.

**Table 3.** Price list of transportation services

| City | Price for 1 pallet (EUR) | Price per month (1 pallet 9 times per month to 5 affiliate = 45 pallets) (EUR) |
|---|---|---|
| **Kharkov, UA** | Main warehouse | Main warehouse |
| **Dnipro, UA** | 30 | 270 |
| **Odessa, UA** | 35 | 315 |
| **Kiev1, UA** | 35 | 315 |
| **Kiev2, UA** | 35 | 315 |
| **Lvov, UA** | 47 | 420 |
| **Total EUR** | 182 | 1635 |

Source: [autor]

The company wants to minimize shipping costs. The company has a study where two possible solutions were analyzed. The first solution is to optimize the network by changing the location of the main warehouse. The second is to ensure transport by your own means of transport and not to use an external company.

Changing the main warehouse from Kharkov to Kiev has reduced shipping costs. Transport costs were also calculated if the car was transported by own vehicle. Table 4

The analysis showed that transport by own vehicle is worthwhile only when delivering more than 185 pallets per month. This is unprofitable for the company, as the company does not deliver to the warehouse to such an extent. Also, according to the financial statements, the company has a high level of indebtedness, which implies that if they were to acquire a means of transport, they would probably realize it by leasing. They do not have the funds to buy movable property.

**Table 4**. Price list of transportation services

| in EUR per month | 5 pallets for 1 time Main warehouse in Kharkov | 5 pallets for 1 time Main warehouse in Kiev |
|---|---|---|
| **Kharkov, UA** | 0 | 315 |
| **Dnipro, UA** | 270 | 315 |
| **Odessa, UA** | 315 | 315 |
| **Kiev1, UA** | 315 | 0 |
| **Kiev2, UA** | 315 | 0 |
| **Lvov, UA** | 420 | 315 |
| **Total EUR** | **1 635** | **1 260** |
| | | |
| **Road 2510 km** | **Own car up to 10 pallets** | **Own car from 10 to 30 pallets** |
| **Kharkov, UA** | | |
| **Dnipro, UA** | | |
| **Odessa, UA** | | |
| **Kiev1, UA** | | |
| **Kiev2, UA** | | |
| **Lvov, UA** | 337 | 583 |
| **Total EUR** | 3035 | 5250 |

Source: [autor]

# 4. Impact of optimization results on company value

### 4.1. Changing the location of the main warehouse

In the first case, when transporting through a logistics company abroad and changing the location of the main warehouse, this will mainly be shown by the value of the business determined by the business method. By relocating the main warehouse to the city of Kiev the cost will be cut by 375 Euros per month, according to the study. This represents a sum of 4500 Euros per year. This cost savings will be reflected in the company's financial plan for at least 5 years in advance, which can be expected to increase the company's profit. At the same time, the company is supposed to work constantly, so the permanent value will be calculated in accordance with the prescribed methodology in Decree no. 492/2004 as amended and this value has a significant impact on the overall value of the company.

If the equity method is calculated in this case, the impact could be on the receivables and liabilities between the parent company and the subsidiary abroad if they were not paid by 31.12.2018. It would also have an impact on stock levels, given the amount of goods shipped and the stock balance remaining at the parent company. Short-term receivables

represent a lower percentage of total assets when compared to the proportion of short-term liabilities to total liabilities that are deducted in the calculation. Specifically, short-term receivables account for 17.4% of total assets and 22% for short-term liabilities. When the amount of liabilities is higher than the amount of claims, the value of the company is reduced.

### 4.2. Purchasing an own vehicle

In the 2nd case, when purchasing a vehicle, if the value of the company is calculated using the yield method, it would affect the total value of the company, for example, if the company procures its own car by leasing or credit. If a company enters into a credit agreement, then it will increase its liabilities. However, liabilities are already very high in relation to assets now. In this case, the interest expense would also affect the economic result. The economic downturn would also have a negative impact on the company's plan from a cost perspective. If the company also achieved higher sales by trying to increase sales, it would be balanced. In the case of leasing, it is necessary to consider what form of leasing is appropriate and which company would prefer. There are two basic forms of leasing, namely finance lease and operating lease. The case of financial leasing is good for companies if the company wants to surrender the right. Thus, after leasing, the property becomes the property of the company. Thus, during the lease term, the owner who pays the lease is not the owner immediately, but the company that is the lessor. Getting a car is in many cases a large and demanding financial item, and few can afford it. Monthly repayment is a better option for many. Most companies require a first down payment in the form of a down payment, which the client can choose in percentage of the total price. Total lease payments cover the cost of the asset and the redemption price is usually lower than the asset's market price. The Company may assign the asset to the asset and depreciate it. It also affects the property and business method. The property method also affects the value of assets, the value of liabilities and the value of business through costs.

The second form of leasing, operational leasing, is less used by private individuals, rather by firms. The advantage of this type of leasing is that the leasing company cares for maintenance such as servicing, insurance, wear and tear, and these costs do not fall on the person repaying the monthly instalments. A down payment is not required in this case. The disadvantage is that the property after repayment remains the leasing company.

The amount of the monthly cost of the company depends on the type of lease. However, it is necessary to consider whether the company wants to become the owner of the means of transport. If the company chose a finance lease, the company could register the means of transport in the assets, but at the same time in liabilities, which are gradually reduced by monthly instalments. In this case, however, it will affect the total value of the economic result for all leasing costs. In the case of a second form of leasing, the company would report a rental cost monthly, which is lower than in the first case. However, the company will not own the means of transport. At the same time, however, it will not have increased costs for repairs, maintenance, insurance, for example

## 5. Conclusions

From the expert point of view, it is possible to apply the property method as well as the yield method. If we theoretically think about maximizing the value of a business in the first case, it is preferable to apply the business method. In particular, the method results in a management result that is reflected in the plan in the future and also affects the value of sustainability. The structure of the company's assets is reflected in the level of capitalization together with the tax rate and the level of risk. However, the essence of value is the result of the management and the related company plan. In the first case, for an asset value, the carrying amount of the asset is greater than the value of the liabilities. But it is an accounting perspective. From an expert point of view, it is necessary to assess the fair value of the asset, its wear and tear and the status at the valuation date. The value of receivables may be significantly lower if they are overdue, if customers are in bankruptcy or liquidation, or do not communicate for a long time. Also, for example, inventory levels may be lower if stocks are depreciated or unusable, and the like. It is necessary to examine in detail the value of the property not only through the documents, but also to carry out an inspection in what state the property is.

In the latter case, the second form of leasing is most appropriate for the company in such a situation, with such high liabilities. The company is in a growth phase and does not need to procure long-term means of transport for such production. When the company stabilizes and increases its sales to the maximum, it is worth considering whether to procure its means of transport. In this situation, two options need to be considered, namely whether there are higher costs for the external transport company or for the rental of the means of transport. However, this depends on which type of resource the company decides. The above mentioned options have a particular impact on the business method with the yield principle.

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# Automation of Handling Systems in the Container Terminals of Maritime Ports

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**Abstract** Automation of handling systems in the container terminals of maritime ports has become one of the most important changes that happened in maritime transport since the first voyage of a container vessel in 1956. Nowadays, new automated terminals are being built in the world. Most of them are located in Europe, then in North America and the Far East. Automated guided vehicles, automated straddle carriers or automated stacking cranes have replaced handling devices that were manipulated and were controlled by port workers in the container terminals. The basic goal of the paper is to focus on the advantages of this progressive system that is based on the increase of the output of the container terminals, the reduction of downtimes or accidents during handling of containers.

**Keywords** maritime transport, automated container terminals, automated handling devices

**JEL** L91

## 1. Introduction

Container terminals are facilities where containers are loaded, unloaded, handled, and transported by different types of container handling devices between different modes of transport. They are also stored in an open-air storage area for a few days before they are forwarded by sea or land transport to their customers. [1]

The output belongs to the most important indicators of the container terminals. It may be defined as the number of containers that are transhipped by handling devices for the monitoring period. It depends on:

- the dimensions of container vessels that sail into the terminal,
- the types of containers,
- the types of container handling devices,
- the types of container handling systems that are used in the container terminal.

During handling of containers various downtimes that decrease the output of the terminals arise. They follow from the breakdown rate and technical breaks of container handling devices, auxiliary operations that are related to the vessels such as anchoring and inspection of vessels, controls of the documents or containers.

The maritime ports have implemented various ways how to increase their output. One way how to do it is to automate handling systems in the container terminals.

## 2. Automated container terminals

Automated container terminals are terminals where some container handling devices operate without direct human interaction. Drivers of the cranes have been physically removed, or they have remained in their cabins but they are not needed for the entire duty cycle [2].

These terminals use some automated handling devices (automated guided vehicles, various automated stacking cranes or automated straddle carriers) that:

- transport containers in the water side transfer area from the wharf to the container yard (automated guided vehicles or automated straddle carriers),
- move containers between the water side transfer area and the container yard, the container yard and the land side transfer area and in the blocks of the container yard (various automated stacking cranes, automated straddle carriers),
- transfer containers in the railway terminal (station) located in the land side transfer area between semi-trailers and wagons (rail-mounted gantry cranes).

Automated container terminals differ the level of automation, the type of handling devices and systems. Some of them use only automated handling devices in the container yard. Automated stacking cranes (automated rail-mounted gantry cranes or rubber-tired gantry cranes) move and stack containers into the blocks of the container yard. These cranes can also transfer containers between the water side

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transfer area and the container yard or the container yard and the land side transfer area.

More modern automated container terminals also use automated handling devices that are located in the water and land side transfer area. Automated guided vehicles or straddle carriers that are located in the water side transfer area transport containers between the wharf and the blocks of the container yard. Automated / semi-automated stacking cranes that are located in the railway terminal in the land side transfer area transfer containers between road and railway transport. [3], [4], [5]

# 3. Automated handling devices

## 3.1. Automated guided vehicles

Automated guided vehicles (Figure 1) transport containers from the wharf to the blocks of the container yard. Their movements are controlled by the terminal computer system. They follow the reference points (transmitters) located into the floor of the water side transfer area (greed navigation system). They also use the laser navigation system that prevents their mutual accidents.

Automated guided vehicles belong to the group of the passive handling devices. They do not load, unload containers like other handling devices. They only transport containers between cranes and the block of the container yard. They can have diesel or electric engines. They are used into the container terminals due to the reduction of the accident rates, the number of port workers and the staff costs. [3], [4], [5], [6]


**Figure 1.** Automated guided vehicle in the Container Terminal Altenwerder in the port of Hamburg, source: author

## 3.2. Automated stacking cranes

In the container terminals two types of automated stacking cranes are being used and they can be located in the container yard or the land side transfer area.

The first type of cranes is used for stacking and movement of containers in the blocks of the container yard that are perpendicular to the wharf (Figure 2). They also tranship container between automated guided vehicles and the blocks of the container yard or between the blocks of the container yard and trucks.

The second type of cranes is used on receipt and delivery operations in the land side transfer area. They usually have large spans and may stack containers up to 6 tiers. They tranship containers between trucks and wagons. [3], [4], [5]


**Figure 2.** Rail-mounted gantry cranes in the Container Terminal Altenwerder in the port of Hamburg, source: author

## 3.3. Automated straddle carriers

Straddle carriers have a wheeled frame that lifts and transports containers within its framework. They can stack containers up to 3 tiers.

In the automated container terminals, they are not widespread handling device. In the world only few terminals have used them so far (automated container terminal Patrick in the port of Brisbane, Australia or terminal TraPack in the port of Los Angeles, USA). [3], [4], [5]

# 4. World Automated Container

## 4.1. European automated container terminals

In Europe there are the most automated container terminals in the world. Most of them are located in the port of Rotterdam.

The port of Rotterdam is the largest maritime port in Europe. It is the gateway for cargo transported from Asia or America to Europe. It is located on the banks of the New Meuse and the coast of the North Sea. It is also the largest container maritime port in Europe.

The automated container terminals are located in the parts called Maasvlakte 1 and 2. In Maasvlakte 1 there two automated container terminals: ECT Delta and Euromax. The ECT Delta Terminal was the first European automated container terminal. It has been using automated guided vehicles since 1992. It also uses automated stacking cranes in the container yard. The handling system (Figure 3) consists of container gantry cranes, automated guided vehicles, automated rail-mounted gantry cranes, straddle carriers and trucks. Container gantry cranes transship containers between a container ship and automated guided vehicles. These vehicles transport containers from the wharf and to the blocks of the container yard. Each block is equipped with an automated rail-mounted gantry crane that transfers containers between automated guided vehicles and the block. It also manipulates containers within the block. Straddle carriers handle the containers between the block of the container yard and trucks. In the terminal there is also a railway terminal where containers are loaded on the wagons by rail-mounted gantry cranes and are transported to the hinterland by railway transport.

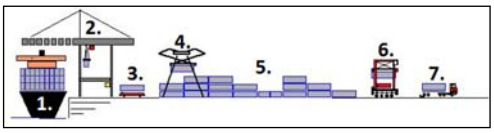


**Figure 3.** The handling system in the ECT Delta Terminal, source: http://www.ect.nl

The Euromax Terminal Rotterdam is another automated terminal in Maasvlakte 1 that uses automated guided vehicles. The basic difference between ECT Delta and Euromax is that each block of Euromax is equipped with two automated stacking cranes. The first crane transfers containers between automated guided vehicle and the block of the container yard, the second crane transships containers between the block of the container yard and trucks (Figure 4). In the land side transfer area of the terminal there is also the railway terminal (station) where containers are loaded on

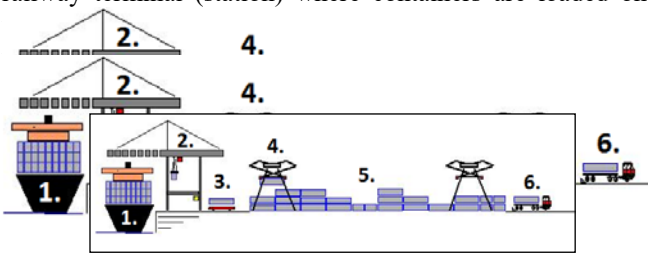


**Figure 4.** The handling system in the Euromax Terminal Rotterdam, source: http://www.ect.nl

Two new automated container terminals that are located in Maasvlakte II (APM and Rotterdam World Gateway) were opened after 2013. They also use automated guided vehicles and automated stacking cranes for handling of containers. [7], [8]

The port of Hamburg is the third important container port in Europe after the port of Antwerp. It is located on the banks of the Elbe River. In the port there four container terminals, two of them are automated terminals: The Container Terminal Altenwerder (CTA) and the Container Terminal Burchardkai (CTB).

CTA is one of the most modern terminals in the world. It was opened in the operation in 2002. It is located in the southern part of Hamburg. Four Post-Panamax ships can anchor at the wharf. The handling system of CTA is the same as the handling system of Euromax in Rotterdam and consists of gantry container cranes, automated guided vehicles, automated stacking cranes on rails and semitrailers. In the land side transfer area there is also the railway terminal where containers are handled by rail mounted gantry cranes between semitrailers and wagons.

CTB (Figure 4) uses automated handling devices in the container yard. Each block is equipped with three automated rail-mounted gantry cranes (two of them have smaller gauge, one of them has bigger gauge). The first one moves the containers between straddle carriers located in the water side transfer area and the blocks of the container yard. The second one moves the containers within the block of the container yard. The third one moves the containers between the blocks of the container yard and semi-trailers. In the land side transfer area there is also a railway terminal where rail-mounted gantry cranes transfer containers between trucks and wagons. [9]

**Figure 4.** Container Terminal Burchardkai, source: author

Automated container terminals are also located in the port of Antwerp in Belgium and port of Algeciras in Spain.

### 4.2. American automated container terminals

In Los Angeles there is an automated container terminal TraPac. The port of Los Angeles that is situated on the coast of the North Pacific is the largest port in the USA. The Terminal TraPac (Figure 5) is the first automated container terminal on the West Coast of the USA. This terminal uses automated handling devices such as automated straddle carriers and automated rail-mounted gantry cranes. The handling system consists of some container gantry cranes, automated straddle carriers, automated rail-mounted gantry cranes, semi-trailers or wagons. Container gantry cranes transfer containers between a vessel and the terminal. Then, fully automated straddle carriers transport containers from the wharf to the container yard. These automated straddle carriers are guided by terminal logistics system that consists of thousands of magnets, laser sensors and GPS for monitoring of container movements. In the container yard electrically powered rail-mounted automated stacking cranes move containers in the blocks. In the land side transfer area these cranes load containers on trucks that transport them to the hinterland. In the terminal 35 per cent of containers are transported by railway transport. [10]

**Figure 5.** The TraPac Terminal, source: www.youtube.com

Another automated container terminal is in the port of Norfolk that is located on the south bank of the Elizabeth River in Virginia.

### 4.3. Australian automated container terminal

In Australia there is the only one automated container terminal Patrick that is located in the port of Brisbane. The

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port of Brisbane is the fastest grooving container port in Australia. It is situated in the estuary of the Brisbane River. The terminal Patrick was the first terminal in the world that started using automated straddle carriers in the world. It has got two berths; Post Panamax gantry cranes that transfer containers between a container vessel and the terminal. Automated straddle carriers move containers within the land of the terminal. They do not only stack containers but they also transport and handle with them. Their advantages are their long life cycle and energy saving. [11]

### 4.4. Asian automated container terminals

In Asia there are some automated container terminals such as the Terminal International in the port of Hong Kong, the Terminal Newport in the port of Busan, the Terminal Evergreen in the port Kaohsiung, the Terminal Tobishima in the port of Nagoya and the Terminal Pasir Panjang in the port of Singapore. These terminals use some automated handling devices (automated rail-mounted gantry cranes) in the container yard.

The Terminal Tobishima uses some automated handling equipment (automated rubber tired gantry cranes and automated guided vehicles.) in other parts of the terminal.

A new automated container terminal was also opened in China in the port of Qingdao. This terminal uses automated handling devices in the water side transfer area and the container yard. This terminal was opened in 2017. [3]

## 5. Conclusions

World automated container terminals increase the output, they reduce the downtimes of handling devices, times of container vessels in maritime ports and accidents that happen during transshipment of containers. They differ the level of automation, the type of automated handling devices that are used for handling processes and handling systems.

The most modern container terminals are located in Europe. They use automated handling devices in the water side transfer area and the container yard. Automated guided vehicles transport containers between the water side transfer area and the blocks of the container yard. Automated stacking cranes (automated rail-mounted gantry cranes) handle with containers within the blocks of the container yard or between the yard and other parts of the terminal. The port of Rotterdam that is the largest maritime port in Europe has got the most automated container terminals in the world. They are located in new parts of the port - Maasvlakte I and II.

Some world automated container terminals only use automated handling devices in the container yard. Automated stacking cranes (automated rail-mounted gantry cranes handle containers in the blocks of the yard or transship containers between the blocks and trucks / other handling devices (CTB, Hamburg).

Only a few automated container terminals use automated straddle carriers. The first one is the Terminal Patrick in Australia, where these devices carry out all operations with containers within the land of the terminal. The second one is the Terminal TraPac in Los Angeles that uses automated straddle carriers for transport of containers between the water side transfer area and container yard.

In spite of the fact that the costs for the construction are so high, new automated container terminals are being built in maritime port due to their high efficiency.

## ACKNOWLEDGEMENTS

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# Cost Analysis of Queuing System of Postal Office

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**Abstract** The paper displays cost analysis of queuing system of particular post office. The selected Post Office is Zilina 1 Post Office in Slovakia. Post office Zilina 1 provides service to almost 4 000 companies and 13 559 households. [1] This paper considers two types of costs. There are costs of services which are associated with increasing or decreasing system capacity. Additional costs are the costs of rejected customers which are costs associated with deciding customers to leave the post office. Aim of this article to indicate the methodology of costs allocation of queuing system of post office and display the costs calculation method of rejected customers. Primary research using the questionnaire and the simulation method proved to be an appropriate tool in this analysis. The results of this paper show the need to take into account the substitutability of the individual services provided at the post office and the repeated arrival of the rejected customer. In the case that a rejected customer requests a service provided also by other postal operators, the post office can deal with loss of customer.

**Keywords** costs of rejected customers, service costs, simulation, questionnaire, cost model

**JEL** C15

## 1. Introduction

The queuing system of post office is the system where customers enter the post office in the order be served. Providing services to the customers and the processes associated with it reassure total costs of post office. Calculating the costs of a queuing system includes taking into account the system's direct costs as well as the indirect costs that at first glance can seems as not related to the service provision. These are costs associated with electricity, heat, building rent, and so on. In addition to the direct and indirect costs incurred as a result of the provision of services we also consider the cost of rejected customers. The length of the queue is not limited at the post office. [5,6,7] However, it is possible that the customer is willing to wait for a certain amount of time before he/she leaves the post office. Such a customer may choose to visit another post office or even another postal operator (if the service is provided by another post operator). In this case the postal office losses the customer. Of course, this customer may return to the post office at another time when fewer people are expected to be there. However, if we look at such a situation not only in terms of cost but also in terms of the quality of the provision of postal services, such a situation is unfavorable.

## 2. Background

When calculating costs, it is advisable to use a general costing formula that can be adjusted according to the actual cost items of the system. The general calculation formula is designed predominantly for manufacturing companies, therefore, when applying to a service company such as Slovak Post, some items of the calculation formula need to be removed or replaced. In this paper the cost breakdown was based on following theory. Cost calculation is a very important process in every business. The goal of businesses is to reduce costs in different areas of their business. The first step in reducing costs is their exact allocation and calculation. [9,10,11,12,13,14] Calculation is the identification or determination of costs, margins, profits, prices or other value in a product, work or service, the activity and operation required to realize them, a business investment action or otherwise a naturally expressed unit. The calculation is a completed calculation completed by determining your own costs or price.

Calculation is a specific procedure that allows you to find out your own costs and other price components on the relevant calculation unit. [9,10,11,12,13,14]

The calculating unit is subject to calculation. It represents a specific performance that is defined by units of measure and is the holder of specific utility features.

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The costs can be divided into two types: [9,10,11,12,13,14]

- direct costs,
- indirect costs.

Direct costs are costs that are directly related to the realization of a particular performance and can be determined for one calculation unit. These include, for example, direct material, direct wages, etc. [9,10,11,12,13,14]

Indirect costs are those that are jointly spent on the entire calculated number of multiple types of performance. These include, for example, production overhead, overhead, supply overhead and so on. [9,10,11,12,13,14]

### 2.1. Generic cost scheme

The generic cost scheme determines the costs of each type of performance. Generic cost breakdown structure (Jankalová, 2014):

1. Direct material
2. Direct wages
3. Other directs costs
4. Operational costs

∑ 1. – 4. Own costs of operation

5. Administrative expenses
6. Supply expenses

∑ 1. – 6. Own costs of performance

7. Cost of sales

∑ 1. – 7. Total own costs incurred

8. Profit
9. Price

The generic cost breakdown structure re-establishes the underlying structure of a company with a production activity, supply, or sales outlet. Under another organizational structure, the cost formula is adjusted according to the cost structure of the business. [9,10,11,12,13,14]

The breakdown of direct and indirect costs is relative because it depends on specific conditions, the type of business, types of production, the choice of the calculating unit, the accuracy of records, and so on. Due to specific conditions, some items may be direct, sometimes indirect, costs. [9,10,11,12,13,14]

### 2.2. Costs of queuing system of post office

The costs of queuing system of post office are associated with the provision of the service to the customer and the costs of customer rejection. The queuing system is theoretically a system with an infinite front because the number of places in the queue is not defined and the system therefore does not have a rule that rejects the customer. [4,5,6,7,8] From the customer's point of view, however, such a case may occur. After a certain wait time in the queue, the customer can leave the unused service from the system. In this case, the customer has entered the system, but the service is not provided to him. The total costs are:

$$Total\ costs = Costs\ of\ service + Costs\ of\ rejected\ customer \quad (1)$$

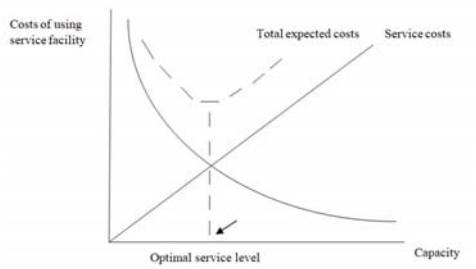


**Figure 1.** Costs scheme of queuing system of post office (Source: Cost analysis for number of servers in a bank using simulation method. Satish Varma, Dr. Sridhar K., SSRG International journal of Mechanical Engineering, volume 2, Issue 5)

Figure 1. shows the types of costs of the queuing system of post office. With the system's capacity increase (in the case of queuing system it is number of service lines), the cost of rejected customers exponentially decreases. With the increase in the number of service lines the average customer waiting time in the queue decreases, and therefore we expect fewer rejected customers. The cost of providing the service grows linearly with the increase in the number of service lines.

## 3. Objective and methodology

Aim of this article to indicate the methodology of costs allocation of queuing system of post office and display the costs calculation method of rejected customers. In order to achieve our goals, we worked with secondary and primary resources.

We used the following methods in the process of cost calculation of rejected customers:

- **Empirical methods** - serve to collect data describing the real system. To obtain the average time that customers are willing to wait at the post office, the empirical research was used. The questionnaire consists only of question regarding to waiting time.

**Table 1.** Research plan

| | |
|---|---|
| **Type of research, type and sources of data** | Research: quantitative<br>Data: primary<br>Source: customer of Post Office Zilina1 |
| **Method of data collection** | Questioning |
| **Data collection technique** | Questioning: writing, electronical<br>Place of questioning: Post Office Zilina 1 |
| **Size of research sample** | Target file: 384 respondents |
| **Data analysis method** | MS Office (Excel) |
| **Schedule** | Duration of the survey: 20.04.2018 – 15.06.2018 |

$$n = \frac{t^2_{1-\frac{\alpha}{2}} * \sigma * \sigma}{\Delta^2} \quad (2)$$

- **Exact methods** - specifically statistical methods.

The size of the research sample was calculated according to the following relationships: [3,7,14]

$$\sigma = \sqrt{p * (1-p)} \quad (3)$$

where $t_{1-\alpha/2}$ is critical value determined by tabulations, σ represents variance calculated from the standard deviation, p is variability of base file (character share) and Δ represents maximum allowable error range. For the required deviation ± 5 and the confidence interval required 95%, the sample size was:

$$n \geq 384$$

- **The simulation method** - to determine the average number of rejected customers per day, we performed several simulations of queuing system of Post office Zilina 1 in LAZARUS software. Since we have already analyzed the queuing system of Post Office Zilina 1, we have already calculated the average input flow and customer service time, i.e.: [2]
  - average customer input flow λ = 1,21 min,
  - average customer service time 1/ μ = 3,43 min.

# 4. Results

In this paper totals costs of queuing system are consider as costs related service provision and cost of rejected customer. As we mention before generic cost scheme can be adjusted according the costs of particular business. In our case, t. j. Slovak Post is the company providing services so cost scheme was adjusted as is displayed below.

### 4.1. Service costs

For the purpose of service costs allocation the costs division was processed on direct costs of the queuing system and indirect costs of the queuing system.

Direct costs directly influence the price of services and their size varies with the capacity of the system and the amount of services provided. For example direct wages of postal compartments employees depends on the capacity (number of postal compartments considering 2 employees per 1 postal compartment). At the Post office Zilina 1, at the time of the case study, there are 14 postal compartments employees with an average salary of 750 Euros per month. [1] Direct material represents office supplies used in the provision of services, such as tickets, forms, etc. Other direct costs include health and social insurance from direct wages, work training of those employees, health and safety training of those employees, depreciation, office supplies and toner for printers at each bin.

Indirect costs of the queuing system consist of operating expenses, administrative expenses and sales expenses. While operating expenses include energy consumption, building maintenance, cleaning, payroll fee, internet fee, telephone and etc. Among the administrative costs involve wage of managers of post office, postal health and social insurance of managers of post office and etc. Sales expenses represent promotion and advertising related to postal services.

### 4.1. Service costs

As we mentioned at the beginning of this paper, the queuing system of post office is not a system that rejects customers. However, and customers often choose to leave post office before they are served. The costs of rejected customers can be calculated as follows:

Costs of rejected customers = Average revenue per customer * Number of rejected customers per day

Using a questionnaire 392 responses were obtained. After evaluating customer responses, we found that they are not willing to wait more than 6,5 minutes in the queue. [2]

Based on this finding, we assume that customers waiting for more than 6.5 minutes of mail leave before the service. Several simulations were performed in the order to find out how many customer are rejected. The following table displays results of simulations. [2]

**Table 2.** Average number of rejected customers

| | Number of customers waiting for more than 6,5 minutes |
|---|---|
| Simulation 1 | 8 |
| Simulation 2 | 6 |
| Simulation 3 | 7 |
| Simulation 4 | 9 |
| Simulation 5 | 6 |
| Simulation 6 | 6 |
| Simulation 7 | 5 |
| Average number of rejected customers | 6,7 |

The average revenue per customer of Slovak Post is not publicly available data, so it is not possible to calculate actual costs of rejected customers. However, the aim of this paper was to demonstrate the methodology for calculating such costs. Although it is possible that some rejected customers are going to return to same post office, this situation reduces customer service satisfaction. It must therefore be seen as a negative state which represents a certain cost. The cost of attracting such a group of customers, such as promoting a new service, may be higher in the future than in the case of satisfied customers.

# 5. Conclusions

The costs of queuing system of post office are costs that are directly and indirectly related to customer service. Although the system does not reject the customer as such, it is possible that the customer decides to leave before becomes involved. In this case, the Slovak Post can lose customers and thus the customer's revenue. In larger risks are services provided by other postal operators such as parcel services. In the case of such services, the customer may actually use the services of another postal operator. With regard to the services provided exclusively by Slovak Post, rejected customers may be dissatisfied. As a result of the customer's dissatisfaction, higher costs may be incurred in the future. Those kinds of costs are associated with measuring the quality of postal services, introducing new services to the market, and re-attempting the satisfaction of those customers.

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# Establishing the Concept of Universal Functionality in Public Transport

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**Abstract** This article aims at providing a basic understanding of the important, but often neglected field of accessibility in public transport. Accessibility as an inclusive sustainable concept has the goal to enable all people to use the public transport system independently and self-determinedly. The implementation of accessible public transport directly affects different user groups. People who do not have temporary or permanent impairments will also benefit from simpler and more accessible systems. Consequently, the usability and comfort of public transport systems is raised for all persons. Therefore, the paper points out barriers and solutions for different target groups in public transport and discusses solutions for overcoming them. The paper concludes by showing how the consideration of accessibility already in the planning phase of a project can substantially reduce costs and improve the quality of the services, respectively leading also to better economic results.

**Keywords** public transport, accessibility, inclusion, European Accessibility Act, mobility, means of transport, stations, stops, vehicles

**JEL** L91, Z32

## 1. Introduction

This article aims, first, at providing a basic understanding of the important, but often neglected field of accessibility in public transport. Its intention is not to address or to promote a uniform design of public transport systems, but to establish universal functionality in public transport.

Universally functional solutions provide huge opportunities for all parties engaged in public transport. Solutions not only complying with necessities, but also creating added comfort beyond the required minimum standards, establish a sustainable benefit for all passengers.

Accessibility as an inclusive and sustainable concept has the goal to enable all people to use the public transport system independently and self-determinedly. Only an appropriate implementation of this can achieve the claim of public transport to provide what is often called *mobility for all*. As a consequence, accessibility should be seen as a comprehensive key concept in order to enhance attractiveness of public transport rather than a niche strategy for some smaller groups of stakeholders or even as a means of cutting the creativity of designers, architects or planners. It needs to be understood that accessibility (or universal functionality) is not a burden but rather a guarantee that the basic functions are fulfilled in accordance with the theorem "Form follows Function". It should rather boost creativity in developing good solutions and not lead to uniform concepts.

## 2. The Path from „Wheel Chair Accessible" to „Universal Functionality"

Accessibility evolved from the older and non-inclusive concept of disability justice (Freiraum, 2013). Disability justice only aimed at giving people with disabilities the greatest possible amount of participation in society. The idea of accessibility assumes that barriers, directed regardless against whom, have to be eliminated (Bundeskompetenzzentrum Barrierefrei, 2013). Accessibility is therefore conceptually much closer to the goal of an *overall inclusion* as repeatedly demanded by representatives of people with disabilities.

Additionally, the approach to eliminate barriers is different. Disability justice was intended primarily as a reactive system aimed at omitting existing barriers. Accessibility, however, is a proactive approach in this respect. It always starts beginning with the design and planning phase of projects and it is an integrated and holistic approach not shifted to the edges of the planning phase. Here, possible resulting limitations and the measures taken to avoid all kinds of barriers or even social or technical exclusion must be considered. Consequently, in the field of mobility, it is mandatory to take into account already existing problems, needs and solutions, first in order to create a basis for future concepts and decisions.

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## 3. The Legal Framework

In the process of perceiving persons with disabilities as an important group within society, a growing body of legal framework on all levels developed in recent years and decades to ensure the implementation of accessibility in general and on the domain public transport in particular. These range from international conventions to supranational (community/union) law on to specific standards regulating technical details.


**Figure 1.** Pyramid construction of the legal system in the field of accessibility

At the top of this legal pyramid is the Convention on the Rights of Persons with Disabilities (CRPD) as formulated by the UN Department of Economic and Social Affairs (DESA) in 2006 and ratified worldwide so far by 147 countries (as of August 2014) complementing and extending the Universal Declaration of Human Rights (UDHR). This convention defines the fundamental rights, non-discrimination bans and social access that a state should set-up in order to integrate persons with disabilities into daily life. One very important point covered by the convention is accessibility (Article 9). Based on this, there is a proposal in the EU to create a binding, concrete implementation of the CRPD across Europe. This was realized by means of the „European Accessibility Act" (EAA) which will be published in the Union.

On the national level, the inclusion of people with disabilities is also considered at various stages. The constitutions of the respective states form the primary basis for all other legal and normative requirements. In Germany, Austria and Switzerland, the constitutional laws include fundamental rights such as the prohibition of discrimination on grounds of disability, gender, etc. (e.g. Art. 7 B-VG in Austria). The concrete obligation to create barrier-free solutions in public spaces thereby results from legal requirements, such as the Federal Disability Equality Act (BGStG) in Austria, the Disability Equality Act (BGG) in Germany or the Disability Equality Act (BehiG) in Switzerland.

In addition to these legal obligations, numerous standards and guidelines provide mobility suppliers with help, regulations or (more or less clear) definitions for implementing accessible solutions.

## 4. Interest Groups and their Needs

In addition to the „classic" groups already covered by the concept of accessibility, such as those with motoric impairments, blind, deaf, with visual and/or hearing impairments, accessible solutions also concentrate on not commonly addressed persons. For example, this includes mothers/fathers with baby carriages, persons with heavy luggage, tourists with limited local knowledge or without local language skills, but also inexperienced passengers.

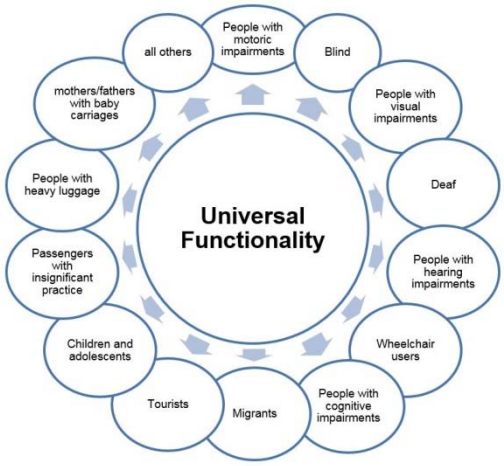


**Figure 2.** Stakeholders for accessible design in public transport

As the illustration (Figure 2) shows, the implementation of accessible public transport directly affects a large number of different user groups. Equally important and yet another essential key consideration is the fact that people, who do not belong to any of the groups listed above with temporary or permanent impairments, will equally benefit from simpler and more accessible systems. Hence, the usability and comfort of public transport systems is raised for the entity of all passengers.

For each stakeholder group it is important to clearly be aware of:

- which requirements exist in respect to the mobility services (stations, transport, information, etc.),
- what the barriers are and
- what specific measures can be taken to overcome them.

The following table gives an overview.

| Stakeholder Group | Characterisation | Requirements | Frequent Barriers | Examples for Solutions | Consideration in Laws and Standards / Reality Check |
|---|---|---|---|---|---|
| Wheelchair user | The persons are dependent on a wheelchair for physical movement.<br>They are unable to independently stand/walk and/or use their legs for movement.<br>Sometimes only the head can be moved. | Stair- and gapless access to all relevant areas of infrastructure.<br>Unobstructed areas in the means of transport for (secure) placing and turning of the wheelchair. | Height differences in entrances and exits.<br>Steps in stations and means of transport.<br>Too narrow corridors and doors.<br>Inappropriate sanitary facilities. | Ramps and lifts, elevators.<br>Personnel assisted entry and exit.<br>Minimum width for doors and corridors. | very good / good |
| Blind | Unable to perceive optical stimuli.<br>Orientation is dependent purely on tactile or acoustic stimuli or by the help of persons or an assistance dog. | Tactile guidance systems with corresponding prior information possibility on relevant areas.<br>Information in braille and tactile writing.<br>Clear and precise acoustic information. | Missing guidance systems.<br>No tactile information available.<br>Obstacles on or over guidance systems (displays, people, signs, garbage bins, etc.). No clear pathways to follow. | Milled or glued tactile guidance strips.<br>Braille on handrails.<br>Tactile environment plans. | good / good |
| Visually impaired | Perception of optical stimuli (however, restricted) is possible, visual sense is primarily used for navigation and orientation, but is limited.<br>Acoustic information is used in addition.<br>Tactile information is not used, including Braille. | Visual design of the environment, taking into account the relationship between brightness (luminance), contrast (colour), glare and materials used.<br>Corresponding font size or approachable written information. | Badly noticeable obstacles, unmarked glass surfaces.<br>Too undersized or serif fonts.<br>Too dark or too intense lighting situations (especially direct lighting).<br>Reflective surfaces (glass, polished metals).<br>Monitors mounted too high.<br>Signs and plans behind glass panels (with a distance). | Colour-contrasting design of handrails, seats, etc.<br>Contrasting glass surface markings in two differing heights.<br>Approachable information, posters and plans.<br>Matted or anti-glare monitors.<br>Ability to approach individual monitors. | sufficient / satisfactory |
| Deaf | No perception of acoustic stimuli, therefore dependent on optical information.<br>Tactile information is not used.<br>Ability to communicate mostly via sign language, possibly lip-reading. | No important information on a purely acoustic basis.<br>Ability to fulfil central procedures (ticket purchase, information procurement) without having to speak. | Pure acoustic announcements for changes of platforms or departure gates or warnings in case of malfunctions.<br>Lack of communication possibilities with employees of transport companies (unable to communicate in sign language). | Clear and consistent visual guidance systems (supported by colour components).<br><br>Staff with sign language skills. | sufficient / satisfactory |
| Stakeholder Group | Characterization | Requirements | Frequent Barriers | Examples for Solutions | Consideration in Laws and Standards / Reality Check |

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| | | | | | |
|---|---|---|---|---|---|
| Hearing impairments | Difficult perception of acoustic information, but possible with a corresponding design or technical equipment.<br>Due to the primary use of visual information, strong focus on this channel.<br>Tactile help is not used.<br>Sign language rarely known/used. | Acoustic information without interference and background noise (static, crackling). Spoken information without local idiom (dialects, language variations, etc.). Announcements/signals in an appropriate volume and without reverberation. | Poor acoustic quality of the loudspeakers (volume, noise), as well as poor alignment (lateral sound cone). Announcements without an initiation and concluding signal.<br>Announcements made in the station/halt simultaneously with incoming or passing through vehicle.<br>Too fast or poorly spoken announcements. | Inductive hearing systems at counters, entrances and exits as well as in vehicles.<br>Specially marked „listening zones“.<br>Acoustic information also visually available (display on monitors).<br>Incoming and outgoing tones to increase attention. | sufficient / satisfactory |
| People with cognitive impairments | Problems understanding complex sentences/texts.<br>Concentration problems with longer announcements.<br>Primary illiteracy is a very common problem. | Simple and clear information, reduced to the essential. | Numerous options and tariff options when buying tickets.<br>Complex information for online content. | Use of „easy language”.<br>Short and clear sentences without foreign words.<br>Repetition of information.<br>Incoming and outgoing tones in announcements. | not sufficient / not sufficient |
| People with motoric disabilities | Problems with overcoming longer distances and height differences.<br>Climbing stairs is very difficult to impossible.<br>Reduced strength and flexibility in arms and legs. | Compact design with short paths.<br>Recreation possibilities (benches) set in short intervals.<br>Same level of entries and exits.<br>Low energy effort for opening doors or pushing buttons. | Stations of various public transport possibilities with long connecting routes and without „resting places“ in-between.<br>Coin entry or payment machines placed at head height.<br>Short stops requiring fast boarding and exiting. | Ramps with handrails instead of stairs.<br>Elevators.<br>Buttons at waist level and very sensitive.<br>Non-contact payment options for vending machines. | satisfactory / good |

| Stakeholder Group | Characterization | Requirements | Frequent Barriers | Examples for Solutions | Consideration in Laws and Standards / Reality Check |
|---|---|---|---|---|---|
| Migrants with a lack of local language skills | Often poor or no language comprehension (problem of „functional illiteracy“). Often economically in a more precarious situation. Language acquisition of the national language is frequently only in progress. | Multilingual information. Simple and clear texts. | Complex information and communication problems. Often no access to online content. | Use of „easy language”. Repetition of information. Language courses or training offers. | not sufficient / sufficient |
| Tourists with a lack of local language skills | Spending only a short stay in the respective country, therefore no need to learn the language. | Information in the respective language/script | Complex tariff systems. Acoustic information incomprehensible. No foreign language information for special events (disruptions, relocation of stops, substitute transports, etc.). | Multilingual texts. Announcements also available in writing on monitors. Online content available in different languages. | Sufficient / good |
| Children | Limited vocabulary. Attention patterns differ from adults. Joy/fun as a very important factor of use. Only partial self-determined mobility (parental permission). Dependent on public transport (classic „Captive Riders“). | Rapid detectability of the central information. Fun/enjoyment of (public) mobility. | Accessibility to information. Safety aspects. | Child/youth friendly design of means of transport (bright, friendly, coloured). | Satisfactory / satisfactory |
| Passengers with insignificant practice | Rudimentary knowledge of public transport (tariffs, transfers, etc.). Public transport is often not seen as „fully satisfying“. | Simple uncomplicated use of the system public transport without the necessity of „special knowledge”. | Complex tariff systems. Transition situations (finding the right lines, entry points). | Simple tariff structures. Consistent and uniform control systems across organizational boundaries. | Not sufficient / not sufficient |

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# 5. Solutions

Possible solutions for the target groups of universally functional design are as wide-ranging as the target groups themselves. In this chapter, we will describe a few exemplary demonstrations, which should provide a rough insight into the successful designs.

The realisation of accessible mobility in public transport can be subdivided into four fields.

These are:

- Means of Transport
- Stations and Stops
- Pre and Post Travel and
- Staff

There are specific requirements and possible solutions in each of these fields presented in examples below. Also taken into account is the importance of the separate fields, which differ for the diverse stakeholders.

### 5.1 Means of Transport

A contrasting design of the interior without glaring lighting is of central importance in public transport vehicles. This ensures an accessible finding of entrances and exits, but also of seating or handrails. From the outside of the vehicles, it is necessary to warrant that doors and associated buttons are clearly visible (e.g. full-surface advertisements cause problems) and that displays announcing the destination are not mounted behind reflecting panels. Securing sufficient space for wheelchair users, mothers with pushchairs or even persons with heavy luggage is essential.

Vehicle-bound devices to overcome height differences or gaps in stations are generally preferable over station-mounted auxiliaries. This increases the flexibility of the means of transport for the public transport operator (For example, it does not have to be a certain carriage model tailored to the nature of the station.). It is also important that the systems used in the different (generations of) means of transport are as similar as possible to employ, in order to facilitate the usage for those affected.

### 5.2 Stations and Stops

Stations and stops in the public transport system have two main foundations for accessible design:

- Primarily, it is the accessibility of entry and exit areas for wheelchair users and motorically impaired persons without the use of stairs and escalators and
- Second, the provision of information and guidance systems.

The accessibility of entry and exit areas is defined relatively clearly by standards. It has already largely been implemented. There is a considerable backlog concerning the provision of information and guidance systems. Information, whether on displays or in printed form, should at least be approachable, rich in contrast and not mounted behind reflective/glaring glass surfaces. This benefits most people with visual impairments, who may also be able to use their individual aids. Correspondently, (visual) guidance systems must take care that colour schemes are clearly different from the rest of the surface structure. This clarifies the information intended for orientation/navigation and differs which information is meant for other purposes (such as advertising).

Other examples for positive solutions relating to stations and stops are:

- Accompanying tactile guidance systems with optical components increase the benefits.
- Announcements combined with the use of incoming and outgoing tones have shown to be more effective in raising attention.
- For people with hearing impairments, the installation of induction systems at counters or clearly designated areas has proven its worth too.
- A very good method to simplify information for many stakeholders utilizing public transport is „simple language“. Unfortunately, this currently is hardly being used.

### 5.3 Pre and Post Travel Solutions

Pre and post travel solutions for people with problems collecting (e.g. people with visual impairments, blind) or processing (e.g. people with cognitive problems) information are of particular importance. These groups need to plan their respective routes in advance. Thus, coordinated information on the websites of transport companies, taking into account the specific requirements of these groups, can be of great benefit here. By linking this content to smartphones, additional assistance during and after the trip can be attained. It must be noted, however, that online content can often only be accessed to a limited extent en-route. Having the opportunity to access the corresponding information offline should also be offered.

Moreover, the information provided on the internet should not be taken as a substitute for accessible information available on the premises. It cannot be assumed that all traffic users will obtain information a priori to their trip (frequent problem of passengers with insignificant practice).

### 5.4 Staff

The staff members of the transport companies make up the fourth field. They often receive very little attention. Unrightly so, as they are by far the most important part of the public transport system for many people with and without disabilities.

An effective and efficient measure to identify requirements of groups with specific mobility needs is training. In addition to theoretical contents (e.g. differences between diverse groups, specific requirements, correct handling/access), practical exercises (e.g. orientation with reduced vision, driving in a wheelchair, information not in the native language) should be provided. The schoolings should be held with the participation of persons with disabilities or other stakeholders. However, the training should not only be limited to employees with direct customer contact. It must also include the decision-making level of the company. This ensures that the appropriate knowledge is available when developing or deciding on new offers.

# 6. Conclusions

Over the recent years, a constant development and improvement towards more all-inclusive measures can be identified in the field of accessibility of public transport systems. On the one hand, this is due to the availability of systems that provide easy access to information. On the other hand, it is due to the emerging perception that accessibility is not an exclusive concept for a small group of people.

In addition, accessibility slowly is finding its way into the education and schooling of the mobility sector and amongst planners and architects. This is supported by improving enforcement opportunities. But still, there is much room for improvement. Many transport companies have not yet come to realise that the achievement of an effective barrier-free system will not only enable people with disabilities to cover their daily mobility through public transport. All other users will also greatly benefit from the ease of handling and improved comfort and satisfaction. This increases acceptance of public transport as a „main mobility supplier". Accessible solutions are also generally not or only marginally more expensive than not accessible alternatives. This is provided they are already taken into account in the planning phase and coordinated with representatives of relevant interest groups.

Against the background of increasingly restrictive legal provisions (expensive retrofits), the possibility of claiming compensation for not fully accessible situations as well as the tight budgetary situation in the public sector, this early inclusion of accessibility can lead to economic relief in the early stages. In the long term, additional returns can be generated by increased user traffic.

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# Modelling of traffic on a selected roundabout in Žilina

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**Abstract** A high-quality network is currently a prerequisite for sustainable transport systems. The sharp increase in automobile traffic has resulted in increased transport problems. The most serious transport problems include traffic infrastructure congestion, increased accident risk and of course environmental impact. Daily mobility and securing the transport of goods is one of the key transport objectives. The most critical point of the road network is the intersection. Therefore, great emphasis is placed on the vehicle to pass smoothly and safely when passing through this place. In this paper an analysis of the current status of the selected roundabout is created. Based on the survey it is proposed three solutions to improve the traffic conditions of the intersection. Aimsun micro-simulation was also used to create solutions.

**Keywords** intersection, simulation, traffic

**JEL** L90, L92

## 1. Introduction

The rising standard of living of the population has an impact on increasing the level of automobile production. This fact also affects the increase in individual car traffic. Communication capacity is often exceeded, leading to congestion. Drivers are often nervous and begin to threaten their behavior with other drivers. Despite major investments in infrastructure development, the traffic situation is deteriorating. Communication, crossroads are achieved daily. Therefore, the term "communication capacity" refers to the maximum number of vehicles that release these per time unit. The intersection is a point in the communications network where the currents of vehicles meet, connect, disconnect or intertwine. In other words, there is a place where the roads intersect or merge in the plan and at least two are interconnected. [1] The intersection must have sufficient capacity and capacity. Otherwise, the vehicles could remain at or at the intersection. It is necessary to ensure continuous, smooth and safe passage of vehicles through the intersection. Intersections can be divided into three basic groups:

Uncontrolled junction
- Roundabout
- Light-controlled junction

Using the appropriate software, it is possible to simulate different kinds of intersections. The simulation outputs can be further processed and reviewed. Traffic modeling is an interesting tool. The advantages of microscopic modeling include the assessment of the outlook, the analysis of several aspects of transport infrastructure, etc. Before selecting a suitable type of intersection, it is also necessary to analyze its position, transport significant in the area, its dimensions. The output of the simulation should be the optimal variant taking into account all the specifics of the intersection. [2]

## 2. Analysis of the traffic situation of the intersection

Žilina is located in the north of the Slovak Republic. The intersection is located on the road connecting the city center with the largest housing estate. Vysokoškolákov Street is one of the most important roads within the Žilina transport infrastructure. [3] At present, the street is characterized by three single-lane small roundabouts.

The selected junction is the second in the middle (Figure 3.). Entry number 1 leads from the city center. Entry number 2 connects the intersection with the shopping center. The other two entrances lead to the settlement of the wolfhound and surrounding villages. The roundabout has an outside diameter of 37 m. Due to frequent constipation it is necessary

to look for another type of intersection, e. g. turbo roundabout or light-controlled junction. Changing the type of

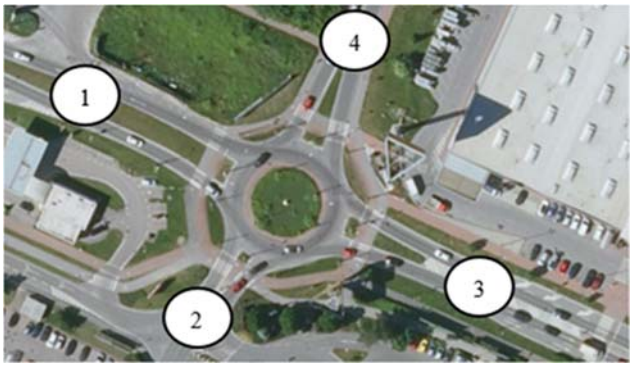


**Figure 1.** Vysokoškolákov street with a solved intersection [4]

intersection can improve the road traffic situation. In addition, it is also possible to reduce emissions because the time spent in the city center is also reduced.

# 3. Number of vehicles at the intersection and traffic survey

To find out the necessary data, a survey was carried out on 11.10.2018 in the afternoon. Data were recorded at regular intervals of 15 minutes. Subsequently, a peak hour was found that started at 3:00 pm and ended at 4:00 pm. During this time it passed a crossroads in total 2666 vehicles. The number of vehicles is shown in Table 1.

**Table 1.** Matrix of vehicle directions during peak hour [own study]

| O/D | 1 | 2 | 3 | 4 | Sum |
|---|---|---|---|---|---|
| **1** | * | 150 | 737 | 275 | 1162 |
| **2** | 252 | * | 97 | 98 | 447 |
| **3** | 592 | 40 | * | 43 | 675 |
| **4** | 244 | 88 | 50 | * | 382 |
| **Sum** | 1088 | 278 | 884 | 416 | 2666 |

For better illustration of vehicle flows from individual entrances, see Figure 2.

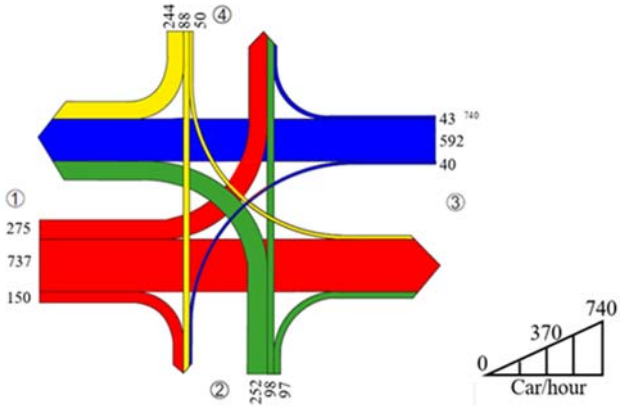


**Figure 2.** Load scheme during peak hour [own study]

# 4. Number of vehicles at the intersection and traffic survey

In order to verify and evaluate the current and prospective state, the given section of Vysokoškolákov Street was modeled in Aimsun software. Aimsun is a traffic modeling software from TSS, a Spanish company based in Barcelona. The Aimsun program enables macroscopic, mesoscopic as well as microscopic simulation. The simulation outputs are intensity, density, average speed, different speeds, travel time, delay time, stop time, number of stops, total distance traveled, total travel time, fuel consumption and emissions produced. [2,5,7]

## 4.1. Creating a transport model and using microsimulation

In total, three transport models (3 types of intersections) were drawn in the Aimsun simulation program:

- Current roundabout
- Designed light-controlled junction
- Designed turbo-roundabout

All transport models worked with the same input parameters that were obtained during peak hour traffic surveys.

The first step in creating a map layer was importing a communications network. The communications network has been imported from the Open Street Map database, which has retained the correct scale.

In total, 10 simulations were made for each model. The simulation created an average of values such as delay time, stop time, travel time, stop count, density, speed, and intensity. Delay time and travel time are also shown graphically by the types of vehicles.

## 4.2. Current status

The transport model reflects the current traffic situation (Figure 3). The resulting values of this microsimulation were compared with the resulting values of the other two proposals. An assessment of the current situation and proposals is given in the last chapter of this document (5).

## 4.3. First proposal - light-controlled junction

The first is to change the current intersection to a light-controlled intersection. The number of lanes for individual entrances and exits was created according to TP 102. We have limited one lane capacity to a maximum of 500 cars / hour. [2]. Based on this condition for entry 1, 4 lanes were

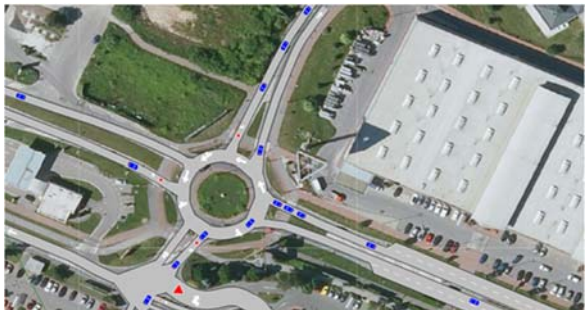

**Figure 3.** Current status in Aimsun [own study]

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created and 2 lanes were used for exit. Branch number 3 consisted of 3 entry lanes and 2 exit lanes. Branch number 2, 4 have a staggered number of lanes, entry 2, and 1 lane on the exit. (Figure 4)

Another important step is to create a light signaling plan. The greens and total number of signal groups were generated

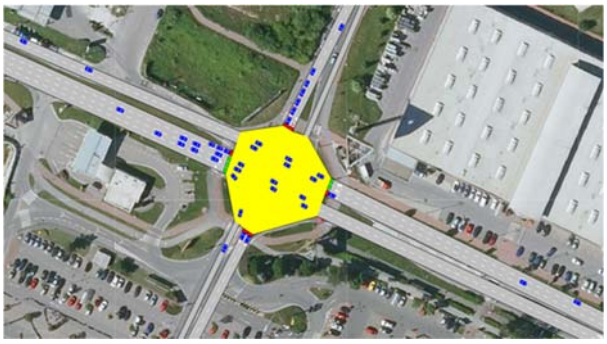

**Figure 4.** First design - light-controlled junction [own study]

according to the procedure also described in TP 102. A fixed light signaling plan was calculated with a cycle duration of 60 seconds, an offset of 2 seconds and a 3 second yellow light. The signaling plan is shown in Figure 5.

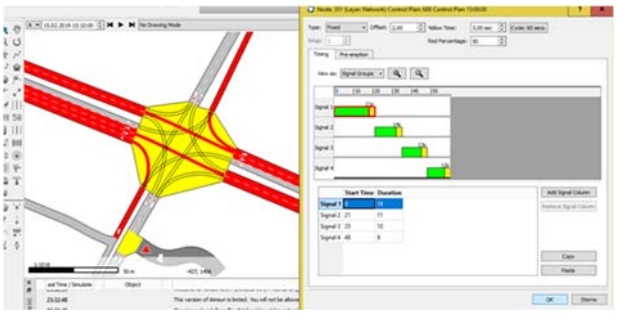

**Figure 5.** Designed light signaling plan [own study]

### 4.4. Second proposal - turbo-roundabout

The second proposal was the creation of a turbo-intersection. This type of intersection is expected to increase safety and capacity compared to classic roundabouts.

The advantage of the turbo-roundabout way the direction of lanes on the track. [6]

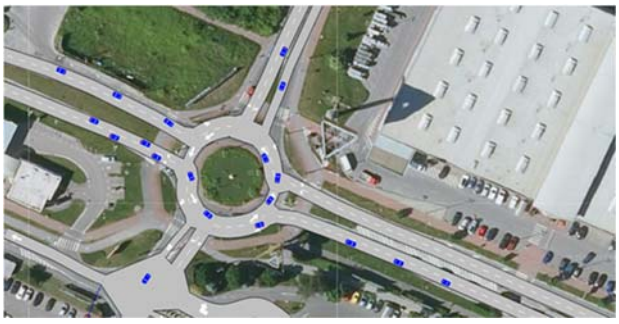

**Figure 6.** Second design - turbo-roundabout [own study]

## 5. Microsimulation of traffic models

For each traffic model, we have performed 10 simulations. From these simulations we have created average. In the previous figures (Figure 3, 4, 6) it is possible to see the running of the simulation for all three types of intersections. Output indicators that have been tracked and compared between each intersection type are stopl time, delay time, travel time, number of stops. Of course, the three main traffic flow characteristics of density, intensity and speed were also observed. All the above indicators were analyzed and then compared between the current roundabout and the two new proposals. Each simulation lasted one hour.

The following tables (Table 2, 3) compare the resulting values between the current status and the new proposals.

**Table 2.** Comparison of Simulation Result Values Current State and First Proposal [own study]

| Parameter | Current status | Traffic light | Unit | Change (%) |
|---|---|---|---|---|
| **Number of Stops** | 3,60 | 1,24 | #/veh/km | -65,56 |
| **Delay Time** | 262,37 | 142,91 | sec/km | -45,53 |
| **Stop Time** | 234,22 | 126,31 | sec/km | -46,07 |
| **Travel Time** | 332,51 | 209,60 | sec/km | -36,96 |
| **Density** | 47,77 | 15,68 | veh/km | -67,18 |
| **Speed** | 18,91 | 26,56 | km/h | +40,45 |
| **Flow** | 2500,60 | 2705,20 | veh/h | +8,18 |

**Table 3.** Comparison of Simulation Result Values Current State and First Proposal [own study]

| Parameter | Current status | Turbo-rounda-bout | Unit | Change (%) |
|---|---|---|---|---|
| **Number of Stops** | 3,60 | 1,81 | #/veh/km | -49,72 |
| **Delay Time** | 262,37 | 132,31 | sec/km | -49,57 |
| **Stop Time** | 234,22 | 103,29 | sec/km | -55,90 |
| **Travel Time** | 332,51 | 203,09 | sec/km | -38,92 |
| **Density** | 47,77 | 24,09 | veh/km | -49,57 |
| **Speed** | 18,91 | 26,75 | km/h | +41,46 |
| **Flow** | 2500,60 | 2589,80 | veh/h | +3,57 |

From the table 2 is clear, that individual parameters have significantly decreased or declined. The most noticeable decline was recorded at the density - the decrease was up 67% for first proposal. Another significant decline was recorded at the delay time and the number of stops, which fell by over 65%. Stop time and delay time decreased by over 46%, and travel time decreased by over 37%. If the first proposal is used, it can be assumed to increase performance of the junction about 8%.

Three indicators achieved lower values for the second proposal. The biggest drop reached the stop time by almost 56%. Also, travel time and delay time have been reduced compared to the first proposal. If the first proposal is used, it can be

assumed to increase performance of the junction about 3,5%.

As a result of decreasing some indicators, vehicles lose less time in traffic congestion. This fact also affects the reduction of emissions because the passage of the vehicle through the intersection is smoother.

time and delay time for the current roundabout, first proposal and second proposal. The indicators are given for three categories of vehicles (car, truck, bus) and for all vehicles.

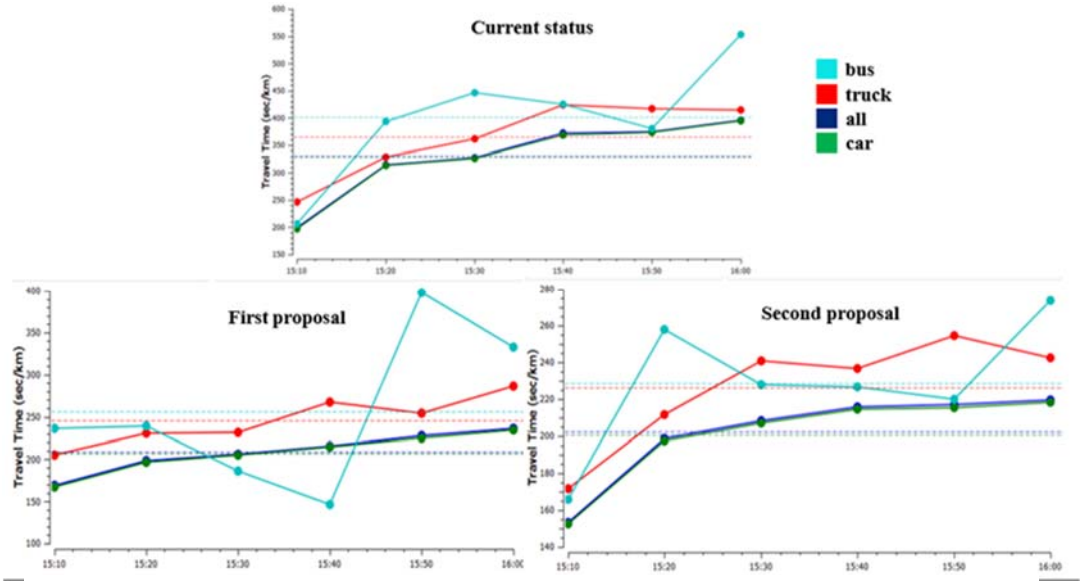


**Figure 7**. Travel time progress according to vehicle categories [own study]

Travel time is one of the most important indicators. The total average for each vehicle is much lower than the current

situation on small circular junction. This indicator has increased during the last stages of time. See figure 7.

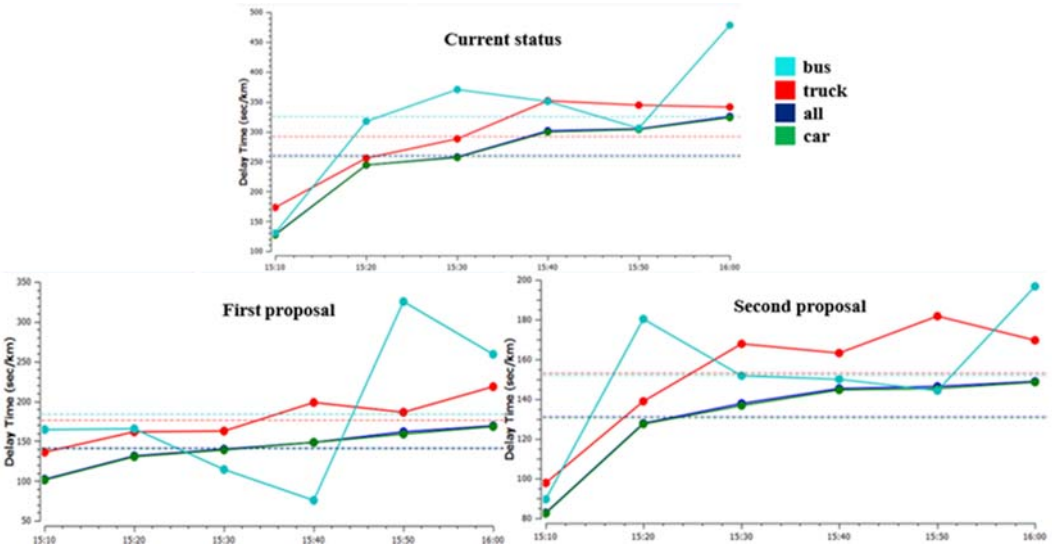


**Figure 8.** Delay time progress according to vehicle categories [own study]

Figure 8 shows the progress of the delay time. During the last stages of the simulation, the time delay has increased for buses, but the overall average is much lower

The average of the various categories of vehicles in both new designs is significantly lower than for the current roundabout, especially at the second proposal turbo-roundabout.

The following figures show two important indicators travel

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# 5. Conclusions

The aim of this paper was to evaluate the traffic situation at a selected roundabout in Žilina. The current traffic situation is difficult. Especially during the rush hour, columns are formed in front of the intersection that slow down the entire traffic flow of the vehicles. In view of this problem, two other repair solutions have been proposed - a light-controlled junction and a turbo-roundabout. Three transport models were created using microsimulation. As the simulation showed, the number of stops, density, and intensity increased significantly at the light-contolled junction. However, the turbo-roundabout has significantly reduced up to three variables, namely stop time, delay time and travel time. The simulation results showed proposal 2 as better. The results confirmed that the Transport Engineering Program can bring some benefits, especially in identifying possible transport infrastructure problems. Ultimately, it can be assumed that both proposals can improve the current traffic situation of the roundabout.

# ACKNOWLEDGEMENTS

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# Frequent Flyer Programs – Overview of Existing Models

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**Abstract** This paper describes three basic models of frequent flyer programs offered by airlines. Based on the definitions of these models an analysis of airline loyalty programs offered by European carriers was performed. The paper contains conclusions regarding the evolution of frequent flyer programs in Europe. The development process was assessed and prospective advances were identified.

**Keywords** frequent flyer programs, loyalty management, travel choice,

**JEL** M31, R41

## 1. Introduction

Airlines that operate in developed markets face fierce competition, which sometimes may be classified as hyper-competition. This makes it necessary for airlines to seek revenue in many ways, one of which is through building passenger loyalty. This is especially important in the high-yield segment, i.e. among business travellers [1]. Frequent flyer programmes (FFPs) have been created to allow frequent flyers accumulate points for their flights and – after they have earned enough of such points – redeem them for air tickets. How points are earned for flights and how they can be "spent" depends on the model adopted by a particular loyalty programme. Frequent flyer programmes also help in improving brand recognition and may potentially increase the market share of a particular airline [2].

Further in this paper terms "loyalty programme" and "frequent flyer programme" will be used interchangeably to describe loyalty schemes offered by airlines. The goal of the study is to examine how these loyalty programmes have evolved and investigate into differences between currently operated models.

The first loyalty programmes were introduced by airlines in the first half of the 1980's [3]. Studies suggest that the availability of a loyalty programme and perks linked with it are among the main reasons of choosing a particular airline [4]. However, this impact is most probably smaller for low-cost airlines, who offer classic frequent flyer programmes much more rarely and passenger choices in their case are driven mainly by low price of their air tickets.

This paper reviews operating models of frequent flyer programmes by identifying key components that define these programmes. The study was conducted based on desk studies and the analysis of frequent flyer programmes offered by European airlines.

## 2. Key Components of Frequent Flyer Programmes

Initially, that is at the early stages, frequent flyer programmes were principally loyalty schemes set up to encourage passengers to use services of a particular airline. An opportunity to accumulate points earned for individual travels (with the perspective to redeem them for a free air ticket after having earned enough points) increases switching costs [5] because by choosing another airline one postpones the perspective of reaching the threshold of points that would reward them with a free air travel. Jones & Sasser stress that in passenger air transport industry customer loyalty is higher than average [6]. It proves the efficiency of airline loyalty programmes as tools that enhance the competitiveness of air carriers, who - by using such programmes - foster the supply side of the market. That is confirmed by studies examining the potential of airlines that offer loyalty programmes [7] to win an extra premium in hubs. On the other hand, some authors (e.g. R. Caminal and A. Claici) indicate that in highly competitive sectors loyalty programmes increase the consumer surplus, i.e., they improve the position of the demand side of the market [8].

There are many aspects of frequent flyer programmes' models, in which they differ. From the passengers' point of view, as well as airlines that offer frequent flyer programmes[1], the crucial feature is how points (often referred to as miles) are earned and how "prices" [2] of award tickets are calculated. Based on that, two baselines models can be dis-

[1] Airline loyalty programmes can be run as independent companies, to which attention is drawn further in this paper.

[2] The price of an award ticket is the number of points that must be accrued to get such a ticket.

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tinguished: distance-based (or mileage-based) that focus on the distance covered during a trip and revenue-based (spend-based) [9] models where spending is the key factor.

Besides the principles of points accrual and award ticket "pricing", other key components that define the loyalty programme model include: customer target group(s) and programme exposure to industries from outside of the airline sector, where members can earn and redeem points.

### 2.1. Points Accrual and Redemption Mechanisms

Basic mechanisms of earning and redeeming the points (distance-based and revenue-based) may come in different options which often combine both solutions. Some loyalty programmes (until recently it was true of most of the programmes available in the market) calculate points for the flight distance (usually expressed in miles) and the booking class (which strictly depends on the airfare, i.e., the basis of the price of an air ticket): the distance is multiplied by a factor allocated to a particular booking class, which usually ranges from 10 (for low booking economy classes) up to 300% (for the first class), with some loyalty programmes awarding no points for the cheapest economy class tickets.

Besides earning and redeeming the points based on flight distance and the price of the ticket, we need to mention one more algorithm used by some loyalty programmes, in particular with regard to establishing the value of reward tickets expressed in points, that is, based on the zones. In this instance, the "price" of an award ticket depends on the regions between which the journey takes place. Regions are equivalent of continents (e.g., Europe, North America) or parts thereof (e.g., South-East Asia, South Africa).

On top of that, the "price" of an award ticket expressed in points – the same way you do with cash - depends on the booking class (economic, premium economic, business or first class). Ultimately, the cost of an award ticket offered under a loyalty programme is the resultant of the booking class and the flight distance or the regions of departure and arrival.

In the revenue-based model, the number of awarded points is directly proportional to the price of the ticket, for which points are earned; however, there can be some adjustment factors (which are, e.g., higher for premium class - business and first class – tickets and for high status passengers in loyalty programmes). Proportionally higher amount of points allocated to these passenger segments is designed to foster the loyalty of clients who generate the highest revenue for an airline. On the other hand, points accrued under this model can be redeemed for tickets available for general public, which have a concrete price. We need to stress that many loyalty schemes offer mixed solutions, e.g., points accumulated for flights are calculated under the revenue-based model while "prices" of award tickets are set depending on the distance or zones (regions).

In models, in which "prices" of award tickets are established based on the zones we can come across static and dynamic pricing strategies, i.e., the amount of points required to get a ticket can be set as constant or it can vary depending on the demand exhibited by customers who pay cash as well as loyalty programme points.

### 2.2. Exposure to Non-airline Industries

Traditional loyalty programmes offered by airlines were dedicated exclusively to their clients while points could be earned and redeemed on flights only. Since that time, most of the FFPs have evolved and nowadays, to a lesser or bigger extent, they also enable earning and redeeming points on services offered by partners from outside of the airline industry. Naturally, the first non-airline partners were enterprises selling travel-related products and services, such as hotel chains and car rental companies. Nowadays, most loyalty programmes collaborate with such partners. Another step - very important from the point of view of the users as it opens up substantial opportunities to earn additional points – was the exposure of FFPs to the banking sector, most often through credit card *co-branding*. Purchases made with cards co-issued by banks and airlines give their holders additional accrual opportunities in airline loyalty programmes. From the viewpoint of the business entity managing an FFP this is an additional (and a very important) source of revenue: banks purchase points from FFPs to award them to credit card holders [10]. A large portion of revenue of airline loyalty programmes comes from points sold to FFP users as well as partners, in particular financial institutions [11].

### 2.3. Three Basic FFP Models

In 2012 E. R. de Boer and S. V. Gudmundsson proposed a synthetic approach to how airline loyalty programmes are defined, and formulated three basic FFP models: legacy, advanced and autonomous [12]. Each programme can be assigned to one of these models based on different criteria, such as, e.g., user target groups, FFP place within the organisational structure of an airline, ownership structure, percentage of points that were earned outside the airline, etc. Detailed characteristics of the models can be found in Table 1.

Over more than thirty years since the first airline loyalty programme was launched substantial changes have taken place in FFP operating models. We also need to bear in mind that today, loyalty programmes are at different levels of development, i.e., all the three models coexist side by side.

As loyalty programmes have been evolving, we can clearly see their autonomisation visible not just in their organisational structures (a separate SBU or a separate company, reporting models, etc.) but also in how they generate customer value and thus the potential to build customer loyalty. Going away from a strictly airline programme towards a multi-industry loyalty one may make airline passengers perceive these programmes as less attractive, especially when the majority of points that they can later redeem for air travel are earned from other sources.

**Table 1.** Types of airline loyalty programmes: evolutionary approach

| | Legacy | Advanced | Autonomous |
|---|---|---|---|
| Users | Frequent flyers | Frequent flyers and credit card spenders | Frequent flyers and everyday spenders |
| Structure | Part of marketing division | Separate SBU | Separate company |
| Ownership | 100% owned by the airline | 100% owned by the airline | Owned by airline and/or external investors |
| Suitable for external investors | No | No | Yes |
| Financial reporting | On aggregate level | May report revenues separately | Income and balance sheet |
| Non-air partner accrual as percentage of overall miles accrual | Low (<20%) | Medium (>20%) | Large (>50%) |
| Partner industries to the programme | Travel related (hotels, car rentals, cruises) | Travel related and financial services (credit cards) | Travel/financial everyday spend (e.g. groceries, fuel, telco) services) |
| Rewards | Award tickets and upgrades for air travel | Air travel and limited merchendise | Air, merchandise and experiential rewards |
| Staff profile | Airline background | Airline and marketing background | Other backgrounds (airline, retail, finance, marketing and CRM) |
| Award allocation policy | Fixed – supplemented with distressed inventory | Mixed – combination of fixed and dynamic | Combination of fixed and dynamic – any seat is available for redemption at a price) |

Source: [12].

# 3. Analysis of the European Market

As part of studies on airline loyalty schemes we have identified 37 frequent flyer programmes offered by air carriers registered in European countries. Each of such programmes operates based on a model in accordance with the earlier discussed typology proposed by E. R. de Boer and S. V. Gudmundsson, who specified the features of a dominant model in each case (only a handful of programmes can be classified under a clear heading of one model or another). The models are explained in Table 2. In some cases it was not possible to identify a model in an unambiguous way based on its characteristic features. In these instances we indicated between which models a given programme ranges. In addition to a model we also specified which air carriers use a particular frequent flyer programme.

**Table 2.** Models of European airline loyalty programmes

| Airline | FFP | Model |
|---|---|---|
| Aegean Airlines, Olympic Air | Miles+Bonus | advanced |
| Aeroflot | Aeroflot Bonus | advanced |
| Aigle Azur | Azur Plus | legacy |
| Air Europa | Suma | advanced |
| Air France KLM, Tarom | Flying Blue | advanced /autonomous |
| Air Malta | Flypass | legacy |
| Air Moldova | Air Moldova Club | legacy |
| Air Serbia | Etihad Guest | advanced /autonomous |
| airBaltic | airBaltic Club | legacy |
| Alitalia | MilleMiglia | advanced |
| Aurigny | Frequent Flyer | legacy |
| Azores Airlines, SATA | SATA Imagine | advanced |
| Belavia | Belavia Leader | legacy |
| Binter Canarias | Binter Mas | legacy |
| British Airways, Iberia, Aer Lingus, Vueling, Air Italy | Avios | autonomous |
| Bulgaria Air | Fly More | legacy |
| Corsair | Corsair Le Club | legacy |
| Czech Airlines | OK Plus | legacy/ advanced |
| Dniproavia Airlines | Bonus Club | legacy |
| easyJet | easyJet Flight Club | other |
| Finnair, Nordic Regional Airlines | Finnair Plus | advanced |
| Icelandair | Saga Club | advanced |
| Lufthansa Group, PLL LOT, Adria Airways, Croatia Airlines i in. | Miles&More | advanced /autonomous |
| Montenegro Airlines | Vision Team | legacy |
| NordStar | Easy To Fly | legacy |
| Norwegian Air Shuttle | Norwegian Reward | legacy/ advanced |
| Pegasus Airlines | BolBol | legacy |
| S7 Airlines, Globus airlines | S7 Priority | advanced |
| SAS, Atlantic Airways, Widroe | EuroBonus | advanced |
| TAP Portugal | Miles&Go | advanced |
| Turkish Airlines | Miles&Smiles | advanced/autonomous |
| Ukraine International Airlines | Panorama Club | advanced |
| Ural Airlines | Wings | legacy |
| Utair | Status | legacy |
| Virgin Atlantic | Flying Club | advanced/autonomous |
| Volotea | Megavolotea | other |
| Wizzair | Wizz Discount Club | other |

Source: author's compilation.

Interestingly, only one loyalty programme exhibited dominant features of an autonomous model. Legacy model remains the most frequently applied one while the advanced model ranks second. Some programmes are currently in transition from an advanced to autonomous model, so we should expect a bigger group of programmes that fit within the framework of a model sitting at the top of the hierarchy.

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On the other hand, we need to note that most (in quantitative terms) loyalty programmes in the above typology are offered by relatively small airlines of limited range of impact, which fly relatively small numbers of passenger. Looking through the lens of the number of passengers who may potentially use individual programmes, we can see that the FFPs offered by three the biggest groups of airlines bringing together traditional air carriers in Europe belong to the transitional model from the advanced to the autonomous one or they openly exhibit dominant features of an autonomous model (Avios that belongs to IAG group). Nowadays, the transformation of operating models of the major airline loyalty programmes in Europe is very clear; recently Miles&More as well as FlyingBlue have changed the way in which miles are earned. In an attempt to establish a more direct link between the benefits and the value created by individual clients, they have shifted from a system that is based on the distance flown and the airfare to the one fully based on revenue flows generated by a passenger [13].

The analysis of differences in the operating models of frequent flyer programmes offered by European airlines would be incomplete without taking a look at low-cost carriers market. In the past the so called budget airlines did not offer any loyalty programmes, however, recently their approach has been changing although the biggest low cost airline in Europe, i.e., Ryanair, still does not offer any scheme that could be referred to as a loyalty programme. Wizzair and Volotea, in turn, offer programmes that involve purchasing a membership by the customer. This membership entitles passengers to buy air tickets and auxiliary services at discount prices.

## 4. Conclusions

Since their beginning, frequent flyer programmes have evolved on multiple occasions and the most advanced amongst them have become autonomous profit centres and cannot be any longer perceived exclusively as tools helping in solidifying passenger loyalty [11]. There are relatively few autonomous programmes and more traditional schemes that do not go beyond the airline sector continue to prevail. On the other hand, major loyalty programmes are relatively well advanced and reflect many features of autonomisation (according to the typology proposed by de Boer and Gudmundsson), meaning most passengers benefit from programmes that have reached a higher level of development.

This paper contains only an introductory review of frequent flyer program programmes. The continuation of the research in this field is recommended to carry out a more in-depth and detailed analysis of operating models of loyalty programmes offered by airlines (to examine individual components of such models). A broader geographic scope of the study covering programmes from outside of Europe would also be an interesting option.

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# Comparison of applications of Smart City concept in the capital cities of V4

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**Abstract** The article deals with the issue of Smart City concept in the capitals of the V4 countries. We have defined technical terms that are related to the issue. In the analysis of the current situation, we focused on individual areas in which the Smart City concept services are provided. Based on the analysis of the current state, we have concluded. The most frequently used applications in V4 capitals are those belonging to the three areas studied. These areas include transport, ecology and re-al-time services. We compared the individual applications provided to citizens in the capitals of the V4 countries. These applications are included in the three mentioned areas of the Smart City concept. Based on a detailed analysis, we defined the advantages and disadvantages of the three most used areas of the Smart City concept.

**Keywords** Smart City, Applications Smart City, Transport services, Environmental services

**JEL** O39, Q56, R11

## 1. Introduction

The term "Smart City" is often used in the technical field. It describes the application of complex systems that are integrated into the operation of urban infrastructure, transport, public safety, etc. We could look at the concept of Smart City as a city that try to implement innovative technologies that enable the construction and development of public infrastructure, public lighting, cycle paths, waste treatment solutions, public buildings, etc. These innovative technologies are implemented in transport, infrastructure building, service extension and security for citizens.[1]

On the other hand, we can see Smart City like the collaboration of all stakeholders. Subjects which are involved in Smart City are the inhabitants, entrepreneurs, public sector, academia and non-governmental organizations. These stakeholders co-decide on innovative urban change. It is necessary to create concept of Smart City in order to make innovations in individual cities.[2]

## 2. Analysis of the current state

We focused on areas that provide services for the Smart City concept. We focused on the specific description of service implementation, service stakeholders and individual examples of the use of the services in the monitored areas. Within the V4 countries (Slovakia, Czech Republic, Poland and Hungary), we have assessed which of the above-mentioned areas of the Smart City concept are most often used in individual countries.[1]

### An overview of smart urban services

The Smart City concept provides a wide range of individual services and applications that can be used in everyday life. In the table we can see in which areas can be concept used,which intelligent services can be provided and who can benefit from such services.[1]

**Table 1.** An overview of smart urban services

| Description | Interested parties | Examples of use |
|---|---|---|
| **General business services** | | |
| Establishing relationships between city and partners to deliver value-added services to stakeholders. | Local authorities or local government, citizens, local interest groups, suppliers and service providers, educational institutions and business communities. | • smart shopping<br>• order online services<br>• easier access to the labour market for citizens |
| **Smart buildings** | | |
| Smart buildings take benefits from integration of communications and management systems | Citizens,local authorities or local government, suppliers and service providers, business communities and environmental organizations. | • optimized air conditioning,<br>• management of general facilities |

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| | | |
|---|---|---|
| **Education, health care and social services** | | |
| Creating applications that help to improve processes in these areas. These applications also provide better access to individual services. | Educational institutions, health and social service providers, citizens, local authorities or local government, local interest groups and charities and non-profit organizations. | • telemedicine<br>• sharing medical records<br>• tracking systems for the elderly<br>• virtual exhibitions and lectures |
| **Energetics Smart lighting** | | |
| Intelligent electronic systems that connect power networks. | Energy suppliers, regulatory agency, business communities and environmental organizations. | • lighting control system<br>• smart grid apps<br>• optimize network performance<br>• compliance monitoring |
| **Smart Grid, measurement of gas, water and electricity** | | |
| Smart meter that records the use of energy, water and gas for a certain unit of time. | Citizens, business communities and company shareholders. | • wireless communication for smart metering<br>• on-line consumption information |
| **Smart Utility, Water and sewer network** | | |
| Smart water and sewage management. | Providers of water and sewerage services, local authorities or local government, citizens, regulatory agency and environmental organizations. | • smart sewer system<br>• waste bin monitoring<br>• water network management system<br>• compliance monitoring |
| **Transport services** | | |
| Smart transport solutions. | Local authorities or local government, service providers, local interest groups and transport companies. | • bike sharing<br>• applications for reporting potholes<br>• taxi-calling apps<br>• applications for reserve a parking spot in downtown |
| **Environmental policy** | | |
| Green solutions implementing through smart devices. | Citizens, local authorities or local government and environmental organizations. | • waste and recycling apps<br>• applications for air quality control<br>• electric car ordering apps |
| **Public security and crime** | | |
| Early warning system for citizens. Optimizing emergency response time and capacity. | Citizens, local authorities or local government, business communities, service suppliers and subscribers and local interest groups. | • city video surveillance system<br>• IP monitoring system<br>• distress signal |
| **Real-time localization of services** | | |
| Providing reasonable information for the needs of citizens. | Citizens, local interest groups and business communities. | • strategic placement of city-dashboard with substantial information for citizens |

The table shows services covering areas such as transport, public services, education, health and social care, ecology and public security. The development of individual applications and services is extended to various areas that help citizens in everyday life. Examples of Smart City services include smart building, smart logistics, smart public systems, and so on. If cities want to implement these services it is necessary to build, smart networks, smart homes, building automation, bring individual applications like mobile payments etc.

# 3. Methodology

The article is dedicated to the Smart City concept. We focused on defining the term Smart City. We analysed the current status of services which are part of Smart City concept after that. In practical part of this article we focused on the area's most commonly used in the Smart City concept in the V4 capitals. In these areas, we conducted a comparative analysis and found the most commonly used applications in the cities. Subsequently, we applied the method of deduction and synthesis on the basis of which we came to the individual conclusions.

# 4. Results

From the analysis of the current situation, we have reached the results that the most services are used in 3 areas: transport, ecology and services provided in real time. We focused on the most widely used applications by citizens, which are provided in the mentioned areas within the Smart City concept.

Table 2 shown that individual applications are mostly used mainly in the field of transport services. After comparing, we found out that the City of Bratislava uses applications for monitoring the current location of public transport, determining the fastest connection or downloading a public transport discount car. Prague uses applications that provide citizens a map of individual links in public transport connections, cycling routes or the possibility of reporting damaged road communications. In Budapest are being used apps which provide citizens with information on public transport links. Second most often used applications are for ordering TAXI services or bikes within the city. Warsaw offers apps that allow you to rent bicycles, choose the fastest public transport links and pay for a ticket or parking fee.

As part of the Smart City concept, individual capitals of V4 also deal with environmental services that help to improve the environment. In Bratislava, an application was created for citizens, to help recognize an unknown plant and classify it in the respective species. Such inclusion is accomplished by taking a picture of an unknown plant. Another application for environmental services is the waste sorting application. By taking picture, it is possible to find out how the trash can be recycled. In Prague, is an application that provides citizens opportunity to order an electric car for ride. Budapest offer app which can monitor air quality control or help with waste sorting.

**Table 2.** Application overview in V4 countries

| Transport services | | | |
|---|---|---|---|
| **Bratislava** | **Prague** | **Budapest** | **Warsaw** |
| **Hopin app** provides citizens to track the current location of public transport.<br><br>**UBIAN app** provides citizens the best possible transport links to their destination as quickly as possible.<br><br>**BMK digital** provides option to download of public transport card and then citizen can use necessary discounts. | **Doprava Pubtrant** provides citizens a map of the connection and the most suitable public transport connection.<br><br>**Praha na Bicykli** provides the best cycling trails and routes in Prague.<br><br>**Zmeňte to** provides the ability to report damaged roads and sidewalks, by taking a picture of a problem. | **BKK Fultár** provides citizens overview with public transport links.<br><br>**Good Guy TAXI** provides citizens ordering TAXI service and allows you to track your route and price.<br><br>**Mol BUBI** provides citizens the option to rent a bicycle (bikesharing) | **Veturilo** provides citizens the option to rent a bicycle (bikesharing)<br><br>**Jakdojade** provides citizens the fastest public transport links that get them to the desired location.<br><br>**moBilet** provides payment of ticket or parking fee. |
| **Environmental services** | | | |
| **Bratislava** | **Prague** | **Budapest** | **Warsaw** |
| **Pl@nt Net** By using a camera app can get recognized to what species the plant belongs to.<br><br>**Green Bin** If you take a picture of trash app can tell you how to recycle it. | **Lítačka** Through this app, a citizen can order an electric car for ride to support emission reduction. | **Air Visual** Provides information about air quality.<br><br>**OLIO APP** Helps citizens to separate waste and shows the map with recycle bins. | **Ekon** Through this app, citizens will be sent dates and type of waste collection.<br><br>**Milión Stromov** Through this app, citizens vote for places where should be planted trees. |
| **Real time services localization** | | | |
| **Bratislava** | **Prague** | **Budapest** | **Warsaw** |
| **City Monitor** Citizens can take a picture of malfunctioning public lighting, graphite on building etc. The photo will be sent to the local authority that will resolve the issue.<br><br>**Bratislava región** provides citizens up-to-date information about restaurants, hotels, public events in the city. | **Prague Visitor Guide** Thisapp provides up-to-date information about monuments, restaurants, hotels, public toilets and so on.<br><br>**Pražské výlety** Provides tips and information about trips in the Prague.<br><br>**Aplikácia Moja Praha** Provides citizens actual information about opening times of individual offices, pharmacy, etc.. | **Budapest City Guide** Via this app, a citizen get up-to-date information about restaurants, hotels and cafes in five areas of Budapest. | **City Paths** Provides, information and interesting facts about the sights of Warsaw.<br><br>**MPAY** this app offers"Map to pocket". Through this app, citizens have a current city map with up-to-date information. |

There are applications in Warsaw that are aimed at getting information about the dates of waste collection or the possibility of voting for the place where new trees should be planted.

Another area of apps which are V4 capitals using is real-time location services. These services provide up-to-date information that individual citizens can use in everyday life. Through these applications, citizens in Bratislava can report malfunctioning lighting, building damage and so on. Another app provides up-to-date information about restaurants, hotels, public events etc. In Prague there are created applications that provide citizens with an online guide to the city, information about the trip options, or information about the opening times of the pharmacy and medical facilities. In Budapest, there are real-time applications in the area of localization services that inform about the sights of the city. Another app provides up-to-date information about restaurants, hotels and cafes. Apps in Warsaw provide information about each city's sights. Among other applications we can include the following: map into a pocket through which a citizen gets current city maps.

Like the various research areas, the Smart City concept has some advantages and disadvantages in each of the monitored areas. For this reason, we have carried out a detailed analysis of the advantages and disadvantages of the Smart City concept in these areas.[3,4,5,6]

## Advantages and disadvantages of transport services

The advantages of transport services include:

- get up-to-date information,
- save time when travelling by searching for the fastest traffic connection,
- more transparent timetables,
- participation of citizens in enhancing the city.

The disadvantages of transport services include:

- high cost and difficulty to implement the applications,
- the citizens of the city have to be online, if they want to using app.

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**Advantages and disadvantages of environmental services**

The advantages of environmental services are:

- involving citizens in enhancing the city and improving the environment,
- help with waste sorting and reducing the amount of poorly sorted waste,
- air quality control in the city,
- the use of electric cars reduces emissions.

The disadvantages of environmental services are:

- high cost and difficulty to implement the applications,
- the citizens must be online, if they want to using app,
- when using waste sorting applications, each waste item must be scanned separately.

**Advantages and disadvantages of real-time location service**

The advantages of real-time location service are:

- get up-to-date information,
- citizens participation on city improvement,
- obtaining information about leisure activities,
- getting to know the city's culture,
- improve orientation in the city.

The disadvantages of real-time location service are:

- high cost and difficulty to implement the applications,
- individual applications are targeted only to certain parts of the city
- the citizens must be online, if they want to using app.

The Smart City concept brings various advantages and disadvantages. When analysing the monitored areas in detail, we found that the Smart City concept has several advantages. For this reason, it is necessary to implement and participate in the implementation of modern digital cities that will help citizens in everyday life.

# 5. Conclusions

The Smart City concept is a modern way to modernize individual cities and move towards digitalization. This concept is broad-spectrum and therefore has a wide range of possibilities to use individual services in different areas. Multi-party collaboration must be created to build up such a modern city. Cooperation with IT experts, research organizations, the governments of the countries, the European Union and so on is essential. The basis for creating a Smart City is getting information from citizens who should be involved. It is important to create places that will serve citizens to increase their living standards, to improve the city's overall economy and to regulate negative environmental impacts.

As part of the analysis of the V4 capitals, we have come to the conclusion that their participation in the implementation of the Smart City concept is positive. These countries are trying to implement new ways to contribute to the development of the digital city. They use a variety of services, applications that citizens really use and are also practical for their daily lives. Compared to other foreign countries, these countries are still at the beginning of the Smart City concept. At the same time, we must state that their progress is visible. The development of the Smart City concept in the V4 countries needs to be constantly supported.

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# Selected Issues of the TCO Model for the Conversion of the Conventional Bus Fleet to Electric One

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**Abstract** National and European transport policy is now moving towards zero-emission transport. One way to achieve public transport policy objectives is to replace conventional buses with electric ones. However, due to the technical characteristics of electric buses, this process will be complicated. Tools are therefore required to support this process. The objective of the research project ERANET Electric Mobility Europe project "PLATON - Planning Process and Tool for Step-by-Step Conversion of the Conventional or Mixed Bus Fleet to a 100% Electric Bus Flee" is to support the stakeholders involved in the process of fleet renewal using an IT tool. Proper development of the tool requires the analysis of many aspects related to the process. The article presents selected elements influencing the total cost of ownership (TCO). The focus of the paper is on the technical and organizational aspects related to the replacement of bus fleet. Authors also shows the main aspects of the structure of TCO analysis.

**Keywords** electric bus, electromobility deployment, public transport

**JEL** R40

## 1. Introduction

Current developments in public transport aim at the gradual elimination of the conventional bus fleet. The achievement of the intended objectives of replacing conventional buses in public transport with electric buses can be achieved, for example, by replacing conventional with electric buses. Taking into account the provisions of strategic documents (e.g. transport policy) of cities and regions, the process of replacing conventionally driven buses with electric buses may be different from an aggressive approach, consisting in replacing all rolling stock at once, to a mild one, in which vehicles are replaced gradually. Conversion of the bus fleet with conventional propulsion (Diesel or hybrid engines) to electric drive is a process that many cities in Poland face. The fleet conversion process is a remarkably complicated, multithreaded and multifaceted task.

Proper conversion from a fleet of buses in public transport with conventional propulsion to an all-electric fleet will include an analysis of the needs for such an exchange in a given urban agglomeration, and planning future actions to develop conditions for the implementation of these plans, adapted to local needs, implemented according to the degree of importance (attractiveness) and feasibility of the assumed transport tasks. The analysis of the needs for introducing electric buses to public transport may be conducted from the point of view of the political, economic and economic environment in Poland and other EU countries, and the results of this analysis may be different, depending on the policy of a given country or agglomeration. Stakeholders who have an impact on the bus fleet need to define an exchange strategy from the first stage. By indicating, inter alia, the minimum exchange time, the process flow and the financial resources needed in a specific time period. The decisions concerning the definition of the exchange process are supported by various tools which will include the results of the current PLATON project. The development of this tool requires a description of the factors that influence the exchange process of buses.

The aim of the PLATON project is to define the process of planning the conversion of the existing fleet of conventional buses in public transport to 100% share of electric buses and the implementation of this process as an IT tool, based on open-access Internet technologies.

The technical aspects of replacing the bus fleet with electric ones primarily concerns the reliability of the components of the electric bus operation system (including bus, battery and power system, charging stations and the battery charging system, individual components of the technical charging system and the functioning of public transport).

Operational aspects of the implementation process of electric buses are to take strategic decisions on network development. The areas managed by the company are differentiated according to the area served, which takes into account land-use planning, topology and the potential for development from the point of view of the new technologies introduced.

The article discusses technical aspects, general structure of elements, operational aspects, process approach and total

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cost of ownership (TCO) analysis of the issue of urban bus fleet conversion. It is assumed that the process of fleet conversion may take place in different stages, using various means, taking into account different fleet structure, financial standardization of the company or institution implementing specific measures in the conversion process, as well as the life cycle of the implemented technologies. Within the project "PLATON - Planning process and tool for gradual conversion of conventional or mixed bus fleet into 100% electric bus fleet" it is planned to develop an IT tool to provide economic support in the planned conversion of the fleet for the transport company. Support will include: cost structure and analysis of the TCO of the electric fleet of urban buses.

The article is organized as follows, section 2 provides information about the technical aspects of replacing the bus fleet. The next section presents operation aspects of the TCO in electric buses. Section 4 contains main structure of TCO model. Section 5 of the paper contains conclusions and propositions for future work.

## 2. Technical aspects

The technical constraints of electric buses concern the following aspects:

- construction of electric buses,
- charging infrastructure and charging stations types
- type of energetic infrastructure.

Construction itself is one of the most important issues as it results in the daily available range of the bus. Electric buses are made of the same vehicle bodies as diesel buses. However, the total weight of the batteries used in electric buses can be several tons. This has a significant impact on the number of passengers to be boarded as well as on the construction of the bus. The weight of a battery is a reason for an apparent conflict between battery capacity and passenger numbers to be boarded.

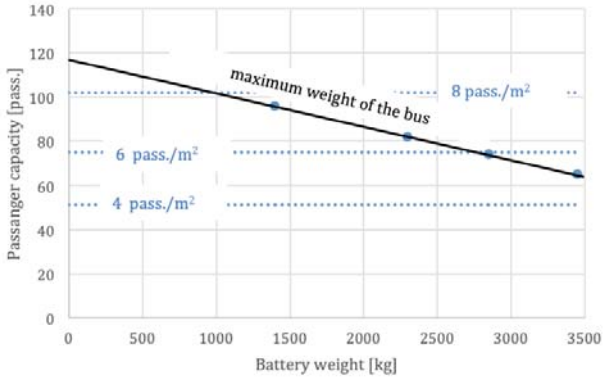


**Figure 1.** Passenger capacity of a 12 m bus as a function of added battery weight, and passenger capacity [1].

Designing the bus for a passenger capacity determined by floor space leave sample weight reserve for traction batteries even under crowded conditions, as Figure 1 illustrates for a 12 m electric bus [1]. In this example, even assuming a passenger density of 8 per square meter, we can add battery weighing above to 1 ton.

A typical electric bus configuration consists of an energy source (e.g., battery pack), a single traction motor with a controller and a final drive differential gearbox [1]. Performance parameters such as passenger capacity, vehicle unload weight, lighting system, air conditioning systems have a significant impact on energy consumption. Other bus parameters that influence the energy consumption, are – inter alia – aerodynamic shape of the bus, the thickness of insulation in walls, precent of glazing, and etc.

Batteries are another fundamental technical aspect. The basic battery parameter is energy capacity, determined in kilowatt-hours (kWh). The operating parameters of electric buses are energy consumption per kilometre (kWh/km). Most bus operators report common energy consumption per kilometre in the range from 1 kWh/km to 1.4 kWh/km for 12-meter buses, and up to 1.8 kWh/km for 18-meter buses. This parameter is often incorrect for operating situations because in usage it depends on many factors, such as route profile, number of stops, the mass of passengers, driver's driving style, activation of additional bus devices or the current weather [2, 13].

At present, the most popular types of cells that are being used in battery electric buses are:

- cells based on lithium titanium oxide (LTO)
- cells based on manganese cobalt oxide (NMC)
- lithium phosphate-based cells (LFP).

LTO cells allow to use the highest charging power of all the technologies mentioned above, but due to their relatively low density, they have the lowest capacity as well. LTO ones may be used only in opportunity charging systems, frequently implemented at important bus stations. NMC cells provide the highest capacity and high charging power, so they are proper for slow and long-term use. LFP cells can only be used in slow charging methods [3, 14].

The second main technical aspect is chargers and electric energy infrastructure. Almost all chargers are connected to the low-voltage (220-400V) power grid and the current is converted using transducers and correcting systems. As a result, at the point of connection to the battery consumption control system of the bus, there is high power current, which value is from 600 to 800V DC (direct current). It is also possible to connect chargers to the medium voltage grid (from 1 kV to 60 kV) or high voltage (from 60 kV to 200 kV). If charging stations are located near the existing tram infrastructure, it may be possible to use direct current coming directly from traction, without the need for additional transformer stations [4]. However, safety regulations may not allow this solution in some countries.

Charging a large number of buses at a time may significantly affect the energy network parameters, e.g. cause overloading of network elements. This is undoubtedly a challenge when we are to exchange a larger number of ve-

hicles, striving to a 100% electric bus fleet.

Electric buses may be charged in three major methods:

- conductive charging
  - plug-in
  - pantograph
- inductive charging
- battery swapping.

The first one – conductive – uses a physical connections between the charger and a bus. Technological solutions like plug-in or a pantograph needs this type of electrical connection. The main advantage of such a systems is their high efficiency, but tried and tested technology and relatively low price advocates for this technology. The drawbacks include maintenance costs of battery using systems. Another problem of the abovementioned technical solution is the necessity for the user to connect and disconnect during each charging cycle and the resulting potential risk of electric shock, what in combination with connection difficulties during the winter season and the possibility of destruction to the charging station by hooligans, makes conductive charging not ideal [5].

Another method is inductive charging. In this solution, electrical energy transfers by creating a magnetic field in the transmitter and then converting the magnetic field into an electric current in the receiver. The inductive charging system may provide up to 95% of the energy transmitted through a similar conductive system [8]. Such a high efficiency is achieved by short distances between the coils of the charger and the bus, precise positioning of coils in relation to each other and by frequencies reaching tens or hundreds of kHz [5].

The third method, that is also possible to be used, is battery-swapping systems. Yet for the time being, such systems are not in use. This method requires a spare battery that can be replaced at the depot. A simple version requires only mechanically and electrically trained personnel with an elevator that can lift heavy batteries on the roof of the bus or elsewhere. Otherwise, we can use a fully automated battery exchange station. Such a solution requires costly investments, including advanced vehicle automation solutions as well as a special construction of the bus in order to adapt it to the requirements of battery swapping.

# 3. Operation aspects of the TCO in electric buses

The type of bus fleet used in the organizational system of public transport determines the solutions in the range of [6, 7, 8]:

- the organisation of the technical facilities of the bus depot, the task of which is to ensure the efficient, reliable and effective day-to-day operation of the vehicles,
- the system of the bus line network in the urban area and spatial development structure,
- organization of bus work on bus lines, including the implementation of the timetable.

The process of operating electric buses is associated with problems concerning the **type of amenities of the technical facilities** necessary to operate them and the problems of spatial arrangement of **various types of supplying devices for the charging the electric buses** - on the route (for example at stops or inter-stopping points) or at end points (at end stops or loops). Analysing the functioning of bus transport, we are looking for answers to questions related to the susceptibility of existing bus lines to handling electric buses.

An important issue is the process of planning the bus transportation system (the route of the line) and the process of planning the service of bus lines with a specific fleet of buses. One of the main factors in this case is the terrain, with lines running on hillsides, which significantly increase the electric energy consumption from the battery by the drive system while driving on a hill and thus significantly shorten the range (course) of the bus between successive cycles of battery charging.

Traffic conditions also have an impact on the interval between recharging of electric bus batteries. It entails a specific profile of electricity consumption when driving at low speed and with frequently stopping of the bus in the queue of vehicles waiting at the inlet of an intersection without traffic lights and with traffic lights without priority for buses and with priority.

The advantages of electric buses due to their local lack of emissions and very low noise level predispose them to serve a specific type of area with limited or closed traffic, e.g. the city centre, the old town, the park and leisure areas. On the other hand, the additional energy consumption of on-board installations (e.g. heating in winter, air conditioning in summer and lighting together with audio-video systems) indicates the need to take into account the division into urban, suburban and urban lines - from the point of view of the location of charge points on the route.

The impact of the total mass of passengers carried on board the bus on the energy consumption of the battery is important. In this respect, the factors of influence are the dispersion of transport needs, driving frequency and capacity of the bus, in relation to the size of passenger flows - actual and forecast. As a result, when justifying the operation of specific routes by electric buses, the type of bus should be taken into account in terms of its capacity - e.g. light, one-piece, low capacity, extended driving time between energy refills or medium and high capacity, i.e. shorter driving time between recharging of batteries due to higher total weight (mass of passengers) [9].

The analysis of transport needs should also include the communication of bus routes with other transport systems using electric traction - the possibility of potential power supply from the tram, trolleybus or railway substations (including stationary chargers of bus battery or chargers built in vehicles). It is a search for the possibility of installing devices supplying electric energy to buses, also depending on the type of objects served, which are sources of traffic streams, e.g. near a shopping centre, tram terminal, railway station, bus station.

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The presented problems with the operation of electric buses affect the total costs of ownership (TCO), mainly in terms of the number and type of battery charging points and the type of buses in terms of their capacity [10, 11, 12, 15].

## 4. Main structure of TCO model

The analysis of the basic components constituting the TCO was performed. The figure 2 shows the cost components constituting of the TCO.

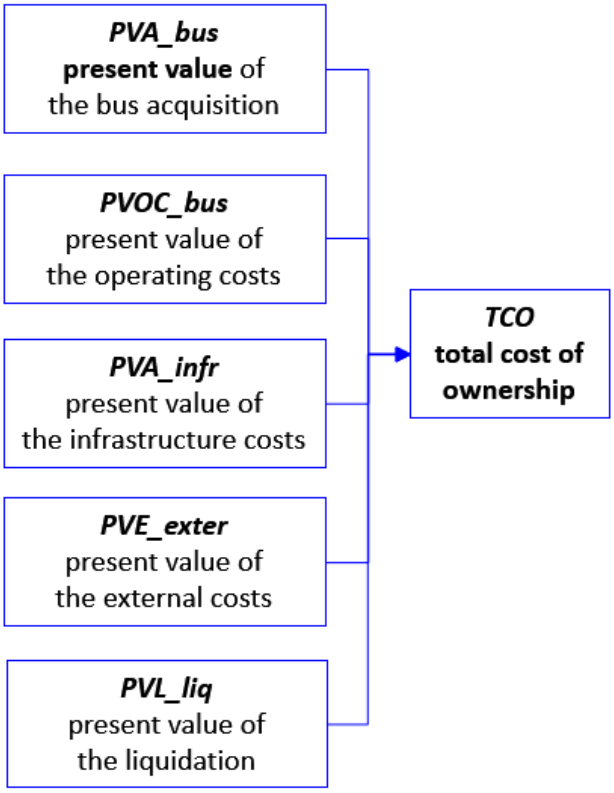


**Figure 2.** Cost components constituting of the TCO

The basic components of TCO, referring to Fig. 2) are the following:

- PVA_bus – present value of the bus acquisition,
- PVOC_bus – present value of the operating costs,
- PVA_infr – present value of the infrastructure costs,
- PVE_exter – present value of the external costs,
- PVL_liq – present value of the liquidation.

These basic components require the determination of indirect cost components. For the **present value of the bus acquisition [PVA_bus]** can contain, inter alia:

- nominal acquisition costs of bus [AC_bus_nom],
- acquisition costs with subsidies [AC_bus_sub],
- acquisition costs of bus with self-financing [AC_bus_self],
- acquisition costs with bank credit [AC_bus_kred],
- annual annuity of bank credit [AC_bus_cred_ann],
- discounted annual annuity acquisition [DAC_bus_cred],
- discounted costs of spare battery [DAC_bat2],
- self-financed costs of spare battery [DAC_bat2_self].

Determination of the **present value of the operating costs [PVOC_bus]** shall include, inter alia, the following components:

- discounted value of operating costs [DOC],
- annual energy costs [OC_ener],
- annual maintenance costs [OC_maint],
- annual daily energy supply [OC_energy_supply],
- annual insurance [OC_insur].

Determmination of the **present value of the infrastructure costs [PVA_infr]** shall include the following components:

- credit costs - as for the purchase of a bus [DAC_bat_add_cred],
- acquisition costs of battery swapping to meet the range requirement of up to 300 km per day [AC_bat_add],
- acquisiton costs of depot charging [AC_Depot],
- acquisiton costs of pantograph charging [AC_Panto],
- acquisiton costs of on bus-stop charging [AC_Stop],
- acquisiton costs of in-motion charging [AC_Induct].

Determination of the **present value of the external costs [PVE_exter]** shall include, inter alia:

- discounted value of external costs [DEC],
- costs of noise emission [Noise_Cost],
- costs of pollutant emission [Pollutant_Cost].

The last component, **present value of the liquidation [PVL_liq]**, shall include, inter alia:

- discounted value of liquidation [DVL],
- nominal acquisition costs [AC_bus_nom],
- residual value of bus [RES_bus].

It should be noted that the above-mentioned cost elements may vary according to local conditions. It may happen that some of them will not be present in some transport networks. Therefore, before proceeding with the calculations, the specificity of the area concerned should be taken into account.

The basic components and intermediate components of the model for TCO calculations mentioned above, are connected with many inputs to this model model. The most important of these - at a general level – include:

- battery capacity [Bat_cap],
- cost of battery unit capacity [Bat_unit_Cost],
- number of additional batteries [Bat_add_n],
- bus costs [Bus_Cost],
- subsidies value for bus [Bus_sub],
- rate of self-finansing [Bus_self_r],
- credit period [Bus_cred_per],
- loan interest rate [Bus_lir],
- number of interest rate [Bus_nir],
- repayment term acquisition [BusBat2_rta],
- market interest rate [BusBat2 _mir],
- battery lifetime [Bat2_life],
- useful life of bus [Bus_life],
- annual operational use [Bus_oper_ann],
- energy consumption [Ener_cons],
- energy cost rate [Ener_Cost],
- tax relief [Tax_rel],
- cost rate workshop staff [Work_Staff_C],

– supply cost rate [Energy_supply_cost_rate].

A great challenge when calculating TCO will be the fact that electric buses will in most cases be purchased in lots, but not necessarily from the manufacturer. This means that the in TCO calculations will have to be taken into account that the implementation of electric buses in the transport network will be in different phases at different timeframes. What is more, the fact that there is no commitment to a single manufacturer, may result in a multiplication of certain technical solutions used in electric buses within a single transport network.

# 5. Conclusions

The article describes some elements connected with the process of replacement of the fleet of conventional buses with electric buses. This process seems to be complex and multithreaded.

Selected technical aspects related to the construction of buses and the charging infrastructure are presented in the paper. Three ways of charging electric buses and their influence on the operation of buses in the transport system are described. The operational factors are also presented in the following section as well.

The basic analysis of operational aspects of the TCO calculation in electric buses was presented. Two main operational problems related to concerning the type of amenities of the technical facilities necessary to operate them and the problems of spatial arrangement of various types of sup-plying devices for the charging the electric buses were distinguished.

The primary structure of the total cost of ownership model is presented as well. Detailed components analysis of the five basic components of the TCO model are presented in the paper. Future works on this model will include the development of mathematical formulas for calculating the costs of individual components.

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# Software for Identifying Secondary Packaging of Medicines

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**Abstract** The article deals with the creation of software for automatic identification of secondary packaging of medicines. In the first part of the analysis we focused on the possibilities of creating software considering available equipment. The second part followed achieved results. Here we focused on the knowledge and software needed to create our solution. Based on the findings of the analysis, we started working on the software. We have tailored the software solution to fit our needs. It has been customized for the laboratory equipment while meeting our requirements. We have successfully created the software and it will be used in further research activities in the ongoing project.

**Keywords** healthcare, RFID, logistics, automation, transport unit

**JEL** R49

## 1. Introduction

The article deals with research aimed at creating a software solution. The created software is designed to help research the possibilities of using RFID tags for automatic identification of secondary packaging of medicines. By secondary packaging of medicines is meant an outer packaging, such as package for one product, for a set of products or a whole transport unit. The software is intended to provide users with features that will server to further research. Our research is based on the EUREKA Auto-ID Technology and the Internet of Things to Enhance the Quality of Health Services project, which aims to research the possibilities of using AIDC technologies in health services.

In the analysis, we dealt with the current state of the issue, with the equipment and devices in the laboratory and with the requirements on software solution. Then we evaluated the analysis and based on the results we have determined the methodology to be followed. After the analysis and methodology parts, we started developing our software solution. The results of the development are presented in the Results section.

## 2. Objective and analysis

The aim of our research was to create software that can be used to research the possibilities of labelling secondary packs of medicines with RFID labels. We had several requirements for the software that it had to meet. First of all, it had to be fully compatible with the laboratory equipment and devices. The second requirement is that it had to have a clear user interface and it should be simple to use. Furthermore, we required the software to:

- Allow data to be written to the memory of RFID tag
- Allow data to be printed on the label
- Provide a database overview
- Retrieve data from labels
- Evaluate the retrieved data
- Graphically represent the printing and reading of labels
- Include database management functions

These are the basic requirements on our software solution. Before we started the development, we did an analysis to confirm the feasibility of our requirements or to adjust them if necessary.

### 2.1. Legislative regulation

As a part of the legislation on the labelling of medicinal products, a European Commission regulation has been issued to address and regulate it.

It is the COMMISSION DELEGATED REGULATION (EU) 2016/161 of 2 October 2015 supplementing Directive 2001/83/EC of the European parliament and of the Council by laying down detailed rules for the safety features appearing on the packaging of medicinal products for human use. The regulation, inter alia, regulates the labelling of medicinal products, according to which the following indi-

cations will be added to the packaging of medicinal products from February 2019:

- Product number GTIN
- Expiration date
- Batch number
- Serial number

These data will be presented on the package of the medicinal products in human readable form as well as in the GS1 DataMatrix code. They will be used to control the originality and safety of the medicinal product. During production, the specified product data is stored in the European Central Database and in the National Registry. The DataMatrix code is read when a medicine is being sold to the patient and it is verified in the National Registry. After confirming that it is a verified medicine, it will be sold to the patient [1].

The regulation deals with a new way of labelling medicines using the GS1 DataMatrix code, in which the required data is encoded. These data have become additional requirements on our software. Based on the analysis of the European Commission Regulation, we have added to the software requirements the data that are marked as mandatory in the Regulation.

### 2.2. Laboratory equipment

We created the program in cooperation with the Laboratory of Automatic Identification of Goods and Services administered by GS1 Slovakia. Within the laboratory, there are devices and models designed to simulate the use of automatic identification elements in practice. The laboratory is divided into several sections, where GS1 standards are demonstrated, ranging from 1D and 2D bar codes to radio frequency identification standards.

We decided to create our program in a laboratory section that deals with RFID technology and the associated GS1 standards. The following devices were available within this section:

- RFID Printer ZEBRA 110PAX4
- RFID antennas Motorola AN400
- RFID reader Motorola XR480
- Conveyor belt

The listed devices were linked together through a local network that was connected to the local server. We accessed devices through a computer that was connected to this local network. Figure 1. shows the part of the laboratory in which we worked.


**Figure 1.** RFID section of laboratory

The devices were arranged in a single model, and all were connected by a conveyor belt. At the beginning, there was the RFID printer with a motion sensor. The sensor captures the incoming object and signals the printer to print the label. When printed, the label is attached to the printer applicator, and the extendable arm applies it to the object passing under the printer. It may be any object that has a flat surface to allow the label to be applied. It must also fit the conveyor belt in dimension and weight. In our case, the test involved boxes and crates that symbolized secondary packs of medicines. The box labelled with the RFID tag is further guided to the RFID gateway that reads the label. We've determined reading as the last step in the program.

We found out from the laboratory analysis that the devices support network communication and that we will be able to use the existing local network. The RFID reader supports the LLRP protocol through which we can communicate with it. RFID printer is ZEBRA brand, so we will have to create print commands in ZPL. ZPL (Zebra Programming Language) is a programming language developed by Zebra for communication with its devices.

### 2.3. Used GS1 standards

Another topic we had to consider before developing the program was the standards used in program. GS1 standards have recommended use in their characteristics. Based on it, we have set the standards we have implemented in our solution.

We have decided for the GTIN standard because it is intended for labelling goods and transport units. In addition, in combination with a serial number, it creates an SGTIN code that can be written to the RFID tag via the EPC standard. We chose GTIN-13 (EAN-13), from the GTIN code family. We have added these standards to software requirements.

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#### 2.3.1. GTIN

GTIN, Global Trade Item Number, can be used to uniquely identify business items at different levels of packaging from individual pieces of goods to entire pallets. It is also possible to add a serial number to the code through which we can identify each piece produced in the production series. Assigning a serial number creates a serialized GTIN, or SGTIN. The GTIN code is unique to every company and none have the same. As a result, when reading the GTIN code in different parts of the Earth, we get a reference to the same manufacturer and to the same product. The GTIN code is divided into 4 types, namely GTIN-8, GTIN-12, GTIN-13 and GTIN-14 [2].

#### 2.3.2. EAN - 13

The EAN-13 code, European Article Number, is one of the GTIN codes (GTIN-13) and it is one of the most commonly used bar codes. It is used for labelling consumer goods, group packages, or transport units. The code is composed of 13 digits, of which the first three digits determine the country of origin, the following nine digits determine the manufacturer and the item reference, the last digit is control digit [2].

#### 2.3.3. EPC

EPC, Electronic Product Code, is a syntax for creating unique identifiers that are assigned to transport units, spaces and locations, business items, and other physical objects that are used in logistics and business chains. The EPC exists in two forms, in the printed form and in the digital form in the memory of RFID tag, which serves as its carrier. It can be expressed in several ways, e.g. in hexadecimal, where it is stored in the RFID tag memory, in decimal for users, or in binary that serves for translation between decimal and hexadecimal, and for writing into the RFID tag memory. EPC Tag Data Standard allows you to write data into RFID tag memory encoded in GS1 identification keys. The GS1 keys that can be written via EPC include, for example, GLN, SGTIN, GRAI, SSCC, ADI, and others [3,4].

# 3. Methodology

When deciding on how to develop software, we proceeded on the basis of the results of previous analyses, set goals and requirements. In the lab, we had a computer and server on which the program could be stored. Devices in the laboratory support network communication and are already connected. The printer is a ZEBRA brand and requires print commands written in ZPL language. Based on these findings, we decided to create the program as a web application. It will be divided into three parts:

- User Interface
- Middleware
- Database

The user interface serves as a connection between the program and the user. We designed it to provide all the required functionality and good user experience. We created the interface in the form of web application. We used HTML, CSS, PHP, SQL and JavaScript programming languages to create it. To create the front end, we used HTML in combination with CSS. To create the back end logic, we used PHP in combination with SQL. JavaScript was used to improve the dynamics and responsivity of the interface.

Middleware manages the communication with laboratory devices. It performs data transmission from the database to the devices as well as receiving data from the devices and writing them to the database. For middleware we chose the RFID middleware Aton AMP OnID. It is a modular middleware available to the Department of Communications for teaching and research purposes. Middleware allows you to create schemas by adding modules. These modules are used to create program logic and functions and to link to the database and to other devices.

The database serves as a repository of data inserted by users and middleware. It also serves to send commands from the user to the middleware and thus performs the management function. When creating the database, we decided to use the XAMPP program, which allows creating a local server. Its advantage is the ease of exporting and importing stored databases, which allowed us to easily move the program between computers on which it was developed.

We decided to create the software solution using the spiral software development method. Before development, we have set our self milestones. When we reached them, we analysed the results achieved and determined the next direction of development. We developed all three parts of the program at the same time to ensure their compatibility and to avoid bugs. We developed the components according to the MVVM architecture, ie Model, View and ViewModel. This architecture defines the separation of the data from the user interface and from the logic that links them. It serves to ensure the independence of those parts, so that the change in the internal structure of one does not affect others. Its aim is to reduce the strict interconnection of its parts.

# 4. Results

Based on the results of the analysis and established methodology, we started to develop software. The following chapters describe the development of each part of our software. The last chapter shows the results of our development.

### 4.1. User interface development

At the beginning of the development of the user interface, we created a basic layout. Individual parts of the interface fit into this layout. After creating the design, we created a link to the database and the basic logic of the page transition and linking. Then we started developing its content. Based on the requests we've identified from the analysis, we've divided the user interface into six pages.

- Data insertion
- Database view
- Graphic presentation
- Repeat printing
- Data edit
- Control panel

We developed each page individually based on the requirements.

#### 4.1.1. Data insertion

Data insertion serves the user to input data into the database. The inserted data will be used to print the labels and to validate the printing and writing to the memory of RFID tag. We have placed a simple form on the page through which the user can insert data into the database. The form consists of eight fields:

- Product name
- Serial number
- EAN-13
- Company prefix size
- Production date
- Expiry date
- Batch
- Number of items

We have set up the form logic so that the data is checked before it is sent to the database to meet the requirements of the used standards. After verifying, the Serial Number, EAN-13, and the Company prefix size are used to create the EPC code and the EPC data structure of bits. Number of items indicates the number of packages to be labelled. Based on its size, the Serial Number is also changed so that no packages have the same Serial Number. The data generated, along with all form data, is sent to the database where it is stored in three tables: the main table, the buffer, and the control table. After submitting the data to the database, a table appears below the form to display the user's inserted data.

#### 4.1.2. Database view

We added the Database View page to the interface to give the user an overview of inserted data. The page consists of a table and two filters. The table selects data from the database where all the inserted data is stored. Through filters, the user can view data in the database and change the displayed results in the table. We set the table to display only some selected data from the database. When you click on a table row, the app displays the Details window to the user. The Details window displays all the product's data from the database. The details window is shown in Figure 2.

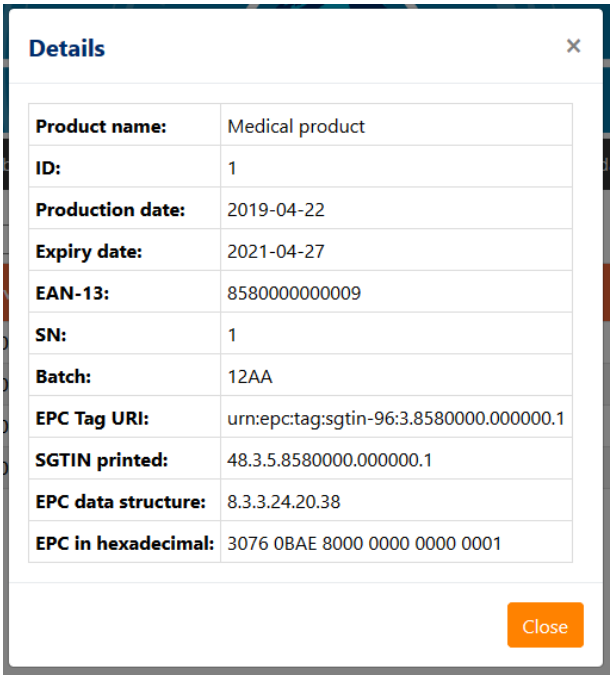


**Figure 2.** Details window

#### 4.1.3. Graphic presentation

We created the graphic presentation page for the purpose of graphic presentation of the whole process. We split the page into two columns: Print Progress and Encoding check. Both columns have been assigned a custom table in the database. The first column, Print Progress, represents the print queue. We set it up so that it immediately fills with images of boxes as soon as the print order is entered. The number of boxes depends on the number of items entered. Subsequently, after the command is sent to the printer and applied to the box, the box image also changes from unmarked to labelled. We provided this functionality in middleware, where we send feedback to the database, after the label is printed and applied. The second column communicates with the RFID gateway and displays the items that the gateway has read. We set it to compare the read items with the printed ones. If they match, the package is marked with an RFID tag, which means it's okay. If they do not match, that means that the data from the read label does not match the inserted data. The user is notified with a red colour of the box. In both columns, the serial number is displayed on the boxes to identify them. In the first column it is read from the database. In the second column, the serial numbers are decoded from the data on the RFID tags. We have set the page dynamically to show the contents of the database tables in real time.

#### 4.1.4. Repeat printing

The Repeat printing page serves the user to reprint the selected label. We placed a table, filter and a form on the page. The table contains all records of printed labels that can be sorted by filter. Once you have found the desired label, you need to enter its ID in the form and submit it. This initiates printing and the label is printed. We did not set this

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feature in our goals, but we chose to implement it as a complementary feature, because we find it useful.

#### 4.1.5. Data edit

Data edit is a page that allows users to edit data in the database. The page contains a table and two filters. Using filters, the user can choose which data is displayed in the table. Data editing is done directly in the table. After you finish editing, you'll need to confirm your changes in the last column of the table. In case of change in the GS1 standard data, the new data is firstly verified to meet the rules set by the standards. Changes will only be made after the changes have been verified and approved. This is also an additional feature.

#### 4.1.6. Control panel

The Control panel page provides the user with basic tools for managing the database, tables and middleware. By using them, the user can abort printing, clear the graphic presentation, or delete the entire database. We have protected the database delete command with a password.

### 4.2. Middleware scheme development

When creating a control scheme in the middleware, we decided to divide it into three parts: to a part linked to the printer, the part connected to the RFID reader and the control part.

We set up the printer-linked part to perform a regular query on the database in which it determines whether there are data in the buffer table. If the table was empty, the rest of the branch remained inactive. If there were values in the table, the following modules were initialized. Data processing in modules was done in the following order. First, the data was extracted from the database. These were inserted into the print order template. The command was then sent to the printer. Finally, the printed line was deleted from the buffer table. And a feedback was sent on label printing. The print command template was created in ZPL. Inserting data into the template is done through variables. We defined the variables in the middleware and placed them in the appropriate positions in the ZPL template. Figure 3. displays blank ZPL template. The variables are defined by the % character at the beginning and end of the name of variable. Database queries are executed through SQL commands and a database module that provides a database connection.

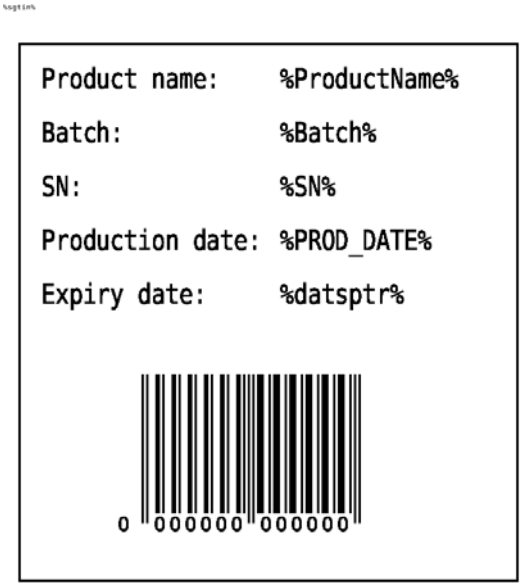


**Figure 3.** ZPL label layout

The RFID reader section provides communication between the reader and the database. After reading the label, the read data is sent to a programmable JavaScript module. In it we programmed a script that decodes the read data and retrieves the GTIN code and Serial Number from it. The read code, along with the serial number, is sent to the first gateway table in the database.

The control part resets the database and modules in the control scheme. We have configured it that it can be run both from user interface and from the middleware.

The advantage of the used middleware is its modularity. If necessary, we can add more functionality to it without disrupting current features. The entire middleware control scheme is shown in Figure 4.

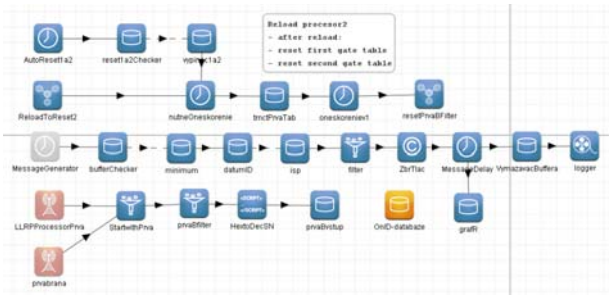

**Figure 4.** Riadiaca schema v midlvéri

### 4.3. Database development

We developed the database together with other elements of the software solution. Since it communicates with both parts, we had to ensure that it was fully compatible with them. We created the database and all tables in the utf8_unicode_ci set. Five tables were created in the database: the main table, the buffer, the RFID gateway table, the graphical interface table, and the control table.

The main table stores all the data entered into it via the user interface. It serves as a backup of all data and at the

same time provides its data to user interface features. Table buffer serves as a buffer for print queue. When the data is entered into the database, it is filled and gradually emptied as the print runs. The graphical interface table serves as a control and management table for the graphical interface. Initially, inserted data is marked as pending for printing. Once printed, this information is overwritten and marked as printed. Subsequently, they are used for comparison with the read data from the RFID gateway for verification. The gateway RFID table stores data sent to it by the middleware. The control table is used to distribute instructions from the user to middleware.

### 4.4. Software solution test

All parts together form a complex solution that is designed to provide the required functionality. As a part of the development, we have decided to test the software we created to see if it met all of the requirements.

Before testing, we did a reset of all tables and modules in the middleware. We decided to do the testing by marking the 4 boxes with labels. We chose neutral Product name: Medical product. The serial number was determined to start from 1. We used artificially created EAN-13 code: 8580000000009 The Company prefix size was set to 7. The date of manufacture is always set to the current date. We set the expiry date to 2 years after production. Batch was also artificially created. We set the number of items to 4, according to the number of boxes. With this inputs we started testing our solution.

We started the testing on the Insertion page, where we filled out the form fields according to the specified inputs. The completed form is shown in Figure 5.

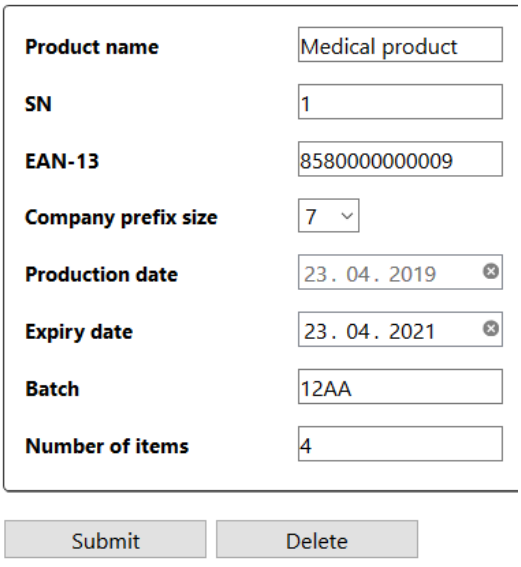


**Figure 5.** Filled input form

After submitting the form, the middleware initialized the printer and it started printing labels from the print queue. At the same time as the printing was initialized, the first column in the graphical environment was filled. Four images of unmarked boxes were added to the column. Gradually, as the labels were printed and applied to real boxes, the image of the box on the page changed from unmarked to labelled. A label and a serial number was added to the image of the box. After labelling, the box was guided by a conveyor belt to the RFID gate. The gate read labels on the boxes and the data was sent to the database by middleware. The data were then selected from the table and compared in the second column of the graphical interface. If the loaded data matched the sent data, an RFID tag image was added to the top of the box. If the data did not match, the box was coloured red. As a part of the testing, we also placed a box from previous tests on the conveyor belt. The box had different data encoded in the label. The goal was to test the verification of read data. Both columns with the test data are shown in Figure 6.

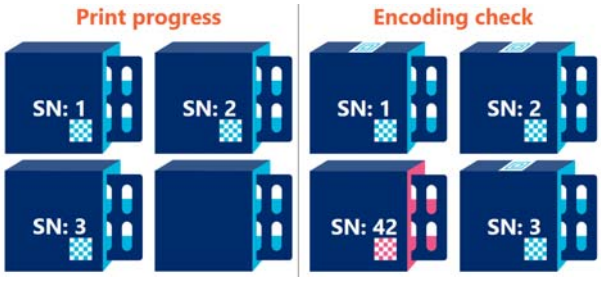


**Figure 6.** Results of testing

Reading and verification of the read data was the last step in the graphical environment. We also decided to test other user interface pages where we tested the filtering, editing and reprinting of data in the database. All performed tests were successful.

Based on the tests we have performed, we evaluate that the software solution we have developed met our goals and requirements.

## 5. Conclusions

Our research has succeeded in creating a program that meets the objectives and conditions. The created program has a simple and understandable user interface. The parts of the program are independent of each other, which we have achieved using the MVVM software development architecture. Using this program, it is possible to encode data into labels. After the labels have been printed, the program verifies data writing using RFID reader. In addition to printing and reading, the program also has additional features. It allows the user to view the data in the database, edit the stored data, perform reprinting and it also provides the user with some database management tools.

The results of our research can be used to research the possibilities of labelling secondary packaging of medicines using RFID labels. The advantage of the created software solution is its modularity. Additional functionality can be added to the program without disrupting its current features, which is useful characteristic in the case of further research.

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# The Identification Problem of Letterbox Transport Companies in the Slovak Republic

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**Abstract** The letterbox companies are a major concern of many interested parties because they can create unfair competition and potentially undermine legitimate businesses by avoiding costs other than social contributions and taxes. Therefore, to ensure that carriers are equal and eliminate unfair competition, the need to improve the checking of letterbox transport companies is essential. The paper deals with the issue of more effective provision of inspections of letterbox transport companies within the Slovak Republic. Based on the analysis of the current situation in the Slovak Republic and based on the research carried out in relation to the existence of letterbox transport companies, the paper deals with the proposals related to their prevention and subsequent determination of the procedure for their checking.

**Keywords** road transport, carrier, check, letterbox company

**JEL** R48, H40

## 1. Introduction

Many Member States do not have a definition of what is, by law, a "real" company. While labor inspectorates can identify and address illegal work practices, to test the wider issue of corporate authenticity, they usually do not have the means or powers. It is quite challenging to identify the distribution and scope of letterbox companies across the EU [5] [10]. A key benefit of defining a letterbox companies within EU Member States is facilitating the tracking and resolution process. The legal definition would also benefit the inspectorates, who would be able to obtain a mandate to declare an illegal letterbox companies and to withdraw it from the market [1] [11]. The need to checking letterbox companies is essential, to ensure equal status of carriers and to eliminate unfair competition, in the form of so-called letterbox transport companies. The control authorities must be able to check whether the company is established or not for real reasons or tries to create an artificial arrangement to avoid tax and social obligations [4]. In this case, the company should not receive the necessary certificate it needs to complete the activity in question [3] [6].

## 2. Research of Letterbox Transport Companies in the Slovak Republic

Letterbox transport companies represent a relatively significant problem in the Slovak Republic, as mentioned earlier, is among the countries that are often used by European carriers to set up this type of company [5]. Because of this issue, the detection rate of letterbox transport companies within the Slovak Republic was determined. A potential indicator to assess the requirements of Regulation 1071/2009 in relation to a true and stable place of establishment is the number of transport companies located at the same address [2]. Based on the national electronic register of road transport operators available on the JISCD portal, a database of road haulers was prepared for all regions of the SR which subsequently served as a basis for the concentration of road transport companies same city and then at the same address.

From the point of view of comparison of individual regions (Fig. 1), the Bratislava Region has the highest number of road haulage companies at the same address. For this reason, the Bratislava Region was selected for closer examination of individual addresses, with the highest number of transport companies based on one address being in the capital at Hraničná 18 and Pluhová 2 (Fig.2). Based on the data from the Commercial Register, up to 110 companies registered at Hraničná 18 were found, out of which the transport companies are 26.

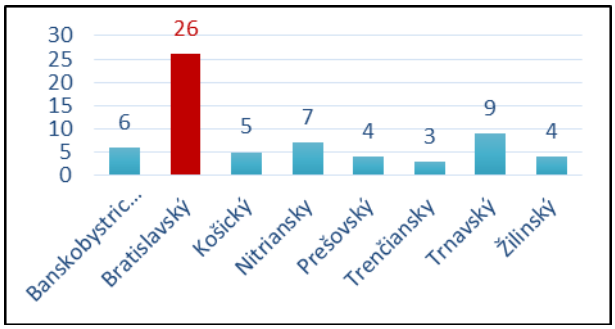


**Figure 1.** The highest number of transport companies registered per address in the respective regions of the SR

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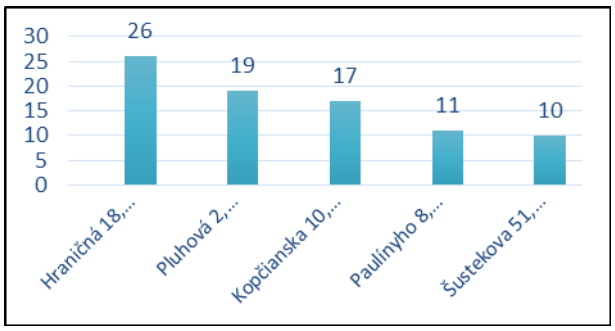


**Figure 2.** Number of transport companies registered at one address in the Bratislava Region

## 3. Checking letterbox transport companies within the Slovak Republic

Act no. 56/2012 Coll. on Road Transport regulates the so-called professional oversight that respects the law and takes responsibility for any shortcomings. In particular, professional supervision is the control of road transport operators, whether they operate road transport in accordance with this law, special regulations and international treaties governing the operation of road transport, equipment and technical competence of the vehicles operated and the technical base of carriers, drivers and other crew members and safety advisors in the transport of dangerous goods, carriers, consignors, consignees and other persons in the transport of dangerous goods. Professional surveillance is carried out by road, vehicle and technical inspections of the persons inspected [8] [9]. The professional supervision is carried out by the Ministry of Transport and Construction of the Slovak Republic, district offices in the headquarters of the region, VÚC, municipalities, police corps and customs authorities.

As far as the control of the so-called. In the Slovak Republic, the Inspectorate of Labor and the Department of State Supervision and Supervision of the Ministry of Transport of the Slovak Republic, whose role in connection with mailbox companies is:

- Perform professional supervision according to Act no. 56/2012 Coll. - international transport, transport to and from other countries, and cabotage transport on the territory of the Slovak Republic, including the transport of dangerous goods, and check that the legal requirements underlying the issuance of Community licenses, licenses, licenses, concessions, vehicle certificates taxi, driver's license and driver attestation and in the carriage of dangerous goods by carriers, consignors, consignees and other parties to the transport of dangerous goods conditions laid down by this Act and the ADR Agreement.
- To manage, supervise and direct the performance of professional supervision carried out by district offices in the Region's registered office pursuant to Act no. 56/2012 Coll.

The European Commission sends a request to the Permanent Representation of the Slovak Republic to the European Union to carry out appropriate checks on companies based in the Czech Republic. mailbox companies. These are checks in connection with Article 12 (3) of Regulation (EC) No 1782/2003 of the European Parliament and of the Council. 1071/2009. To comply with the above requirement, the statutory responsibilities are defined and distributed to the competent control authorities as follows:

- District Authorities to carry out professional supervision of the relevant carriers pursuant to Act no. 56/2012 Coll. in cooperation with the Ministry of Transport and Construction of the Slovak Republic.
- Labor Inspectorate to ensure control of transport undertakings to determine whether there is evidence of driving and rest data for selected carriers in the areas concerned (Article 5 (a) of Regulation (EC) No 847/96). 1071/2009).

Based on the request sent by the EU in 2014 to the Permanent Representation of the Slovak Republic to the European Union to carry out appropriate inspections of companies based in Bratislava, a list of companies in which the controls in question were carried out was drawn up. The above-mentioned professional oversight of letterbox companies check was focused on:

- verification of the requirement of a real and stable place of establishment of the carrier, pursuant to § 6 para. 2 of Act no. 56/2012 Coll. and pursuant to Article 3 (1a) and Article 5 of Regulation (EC) No 1782/2003 of the European Parliament and of the Council 1071/2009;
- verification of the security of the carrier's technical base, pursuant to Section 7 a) c) and e) of Act no. 56/2012 Coll. and § 6 of Decree no. 124/2012 Coll. implementing Act no. 56/2012 Coll.;
- verifying the integrity of the statutory body and the transport manager, pursuant to § 6 par. 3 and 4 of Act no. 56/2012 Coll. and pursuant to Article 3 (1a) (1b) Regulation (EC) No 1782/2003. 1071/2009;
- verifying the financial reliability of the road transport operator's company, stating the number of vehicles pursuant to § 6 par. 5 of Act no. 56/2012 Coll. and pursuant to Article 3 (1a) (1c) and Article 7 (2). 1 of Regulation (EC) No 1782/2003. 1071/2009;
- verifying the professional competence of the transport manager and the legal relationship between the undertaking and the transport manager pursuant to § 6 para. 11 of Act no. 56/2012 Coll. and pursuant to Article 3 (1a) (1d) and Article 8 of Regulation (EC) No 1782/2003. 1071/2009.

Labor inspectors continued to focus on:

- evaluating files downloaded from driver cards;
- consistency of data recorded in technical inspections.

The professional supervision was carried out on all companies according to a list based on a letter from the European Commission. A total of 126 companies were inspected, of which 34 were found to be deficient. Based on the deficiencies found, the authorizations to pursue the occupation of road haulage operator were withdrawn.

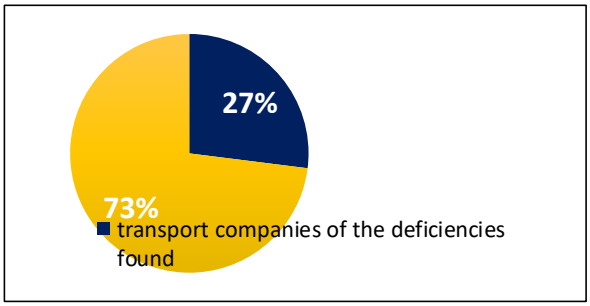


**Figure 3**. Checking of companies based in Bratislava for 2014 - 2017

**Table 1.** Results of professional supervision in transport companies based in Bratislava based on a letter from the European Commission

| Year | Number of checks | Without deficiencies | With deficiencies | Deficiencies detected | Sanctions |
|---|---|---|---|---|---|
| 2014 | 42 | 31 | 11 | *Failure to meet the requirement of a real and stable place of establishment carriers.*<br><br>*Failure to meet professional qualifications* | *Withdrawal of authorization to pursue the occupation of road haulage operator* |
| 2015 | 34 | 23 | 11 | | |
| 2016 | 36 | 28 | 8 | | |
| 2017 | 14 | 10 | 4 | | |

### 3.1 Suggestion of control of letterbox transport companies in Slovakia

*1. Does the company have a VAT number?*

In relation to the letterbox transport company, it is necessary to verify that the legal entity has a real economic link with the country in which it was established. While tax investigations focused primarily on corporate tax reassessment in the past, the decision of the Court of Justice of the European Union pointed out that the lack of a real economic presence may also have significant VAT implications. The controllers use the Financial Report Database to determine if the company has a VAT number. If the controllers verify that the company is assigned a VAT number in Slovakia, the point is not further investigated [7]. If the company is assigned a VAT number in another Member State, the controllers further verify through the European Commission database that the number is valid and then why it is in another Member State when the transport company is located in Slovakia.

*2. Is the billing address also the address of the company?*

When checking billing address, it need to focus on whether their billing address is in Slovakia or another Member State. If the controllers verify that the billing address is in Slovakia, the point is not further investigated. If it is found that the billing address is in another Member State, there is a suspicion that it may be a letterbox transport company and further requirements need to be explored related to the control of actual operations. If they find that the billing address is in another Member State, there is a suspicion that it may be a letterbox transport company and further requirements need to be explored related to the control of actual operations.

*3. Do the staffs work in this company?*

In the case of this requirement, it is no possible to check the firm through databases, but a physical check is required. As part of the inspection, inspectors verify that the drivers are in fact managed by the company and whether they work from the country of employment. If the inspectors find out that, the employees are really managed by company and they carry out their work from an address that is listed, as the seat of the transport company also in the register of carriers (www.jiscd.sk) the point is not further investigated. If the control reveals that it is not possible to manage employees (drivers) from that address, a letterbox transport company is suspected and they find out the actual place of management of the employees or their place of work. In this case, it is proposed to check:

- Who signed the employment contracts (does the name of the company owner agree with the name listed in the register or is it another foreign person?)
- Where employment contracts were signed (signed in Slovakia or in another state?)
- Who sends instructions to drivers (dispatcher from Slovakia or dispatcher from another country?)

*4. Are trucks registered in the establishment?*

In the case of letterbox transport company, it is often the case, that registered vehicles do not park at the address listed, but in a country that established this branch in Slovakia. For this reason, it is important to check the actual place of establishment. If the registered vehicles of the controlled company are located in the establishment or at the company's technical base, the point is not further investigated. However, if the company cannot prove this fact, it is necessary to examine why registered vehicles in the establishment are not located or why they are located in another Member State when the registered office is in Slovakia.

*5. Is there a logical relationship between the size of the parking area and the number of trucks?*

According to Act no. 56/2012 Coll. on road transport, in the context of the requirement to pursue the occupation of road transport operator in Slovakia, the transport company must have a technical base. First, the inspectors check that the company has a parking space. If the company does not have any parking space, there is a suspicion that it is a let-

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terbox transport company. If they verify that the company has a parking area, in pursuance of the number of vehicles and the size of the parking area in m2, they assess whether the actual area allows parking of a particular number of vehicles of the given company. If the company also meets this requirement, they check third point whether a given parking space address belongs to only one company or several transport companies. At present, the supervisory authority verifies this requirement when inspecting it when it is suspected that it is a letterbox transport company but not in a sufficient manner. The issue is listed in the following example: Company A has a parking space for 10 trucks. The controller verifies that the size of the parking area and the number of trucks is in order. Company B demonstrates that it has a parking space available for 9 trucks, while also meeting the requirement. The problem arises when the A and B company's parking space is the same area at the same address, and in reality it should provide space for 19 trucks. However, such a link is not subject to control.

*6. Is there a logical relationship between the number of operating vehicles / staffs and the need for a transport manager in the area?*

The controllers verify the presence of the transport manager or other executives directly at the place of the company. If it is confirmed that the transport manager is actually and continuously managing the transport activities of the undertaking, the point is not further investigated. If the transport manager is not in the transport company, then the reason for the absence must be ascertained. If such information is not provided to the controllers and it is not possible to contact the transport manager, it is necessary to examine the additional control requirements for a stable and actual place of establishment. There is a suspicion that this is a letterbox transport company.

*7. Is there a relationship between the size of the company and the number of trucks?*

Controllers verify the link between company size (number of employees) and number of trucks. They find out whether number of employees is real to service a given number of vehicles, as letterbox transport companies often employ more employees, while the number of trucks is considerably lower.

*8. Are the company basic data such as consignment notes CMR, contracts, travel time information available on request?*

As part of the inspection, controllers request consignment notes CMR, work mode data or other documents proving that the company carries out really transport activities. The regulation should also clarify that a firm that only records wage records or lifts the phone is insufficient. In addition, the company must carry out actual transport operations. In the case if the firm carries out really transport operations can it be regarded for a company with an efficient and stable establishment in the Member State.

*9. Are there any facilities for staff?*

Controllers check whether on the company's address is technical equipment for the management of the transport company (hardware and software) and social facilities for employees (toilets, showers). If they are not located at the company, there is a suspicion that it is a letterbox transport company and other requirements for the actual place of establishment must be investigated.

# 4. Conclusion

Letterbox transport companies have a major negative impact on other companies, especially because of the cost advantage they have against competing carriers who conduct business in accordance with the law. In order to guarantee equal status for carriers and to eliminate unfair competition, it is essential to improve the control of letterbox transport company. Some authorities emphasize the complexity of these controls and the lack of administrative capacity to control all road transport companies registered in that Member State [12]. A uniform and horizontal definition of letterbox transport company and real company would help to distinguish between companies that are artificially created (letterbox transport companies) and companies with real activities. Such a definition is lacking in the regulatory framework in all Member States. The legal definition would also benefit for the inspectorates, who would be able to obtain a mandate to declare an illegal letterbox transport company and they would withdraw it from the market. In connection with the issues of letterbox transport companies, it is also necessary to provide more efficient controls of these companies within the SR, performed by the District Authorities in the Region's headquarters. A number of transport licenses issued to the same address could serve as the reason for the check.

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# Public Transport on Martinique - Current State and Recent Developments

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**Abstract** Despite being part of the European Union, the French West Indies are not often in the focus of research. This paper aims to introduce Martinique and its public transport systems. Starting with an overview over Martinique, the present transport situation will be analysed with findings as follows: the most important suppliers of public transport services are buses in the capital area and taxi collectives on routes to/from the capital. Individual transport by (rental) car plays a major role, so road congestion is a major issue. Recent developments and innovations that may improve the present situation will be discussed as well.

**Keywords** Public transport, Martinique, bus, taxis collectifs, TCSP

**JEL** R40

## 1. Introduction

Located in the Caribbean Sea, Martinique is one of the Windward Islands in the Lesser Antilles. The east coast borders the Atlantic Ocean and the west coast touches the Caribbean Sea. It is an overseas region of France and therefore an integral part of the European Union. The currency is the EURO and all European regulations apply. The official language is French, but locals speak also Creole.

Geographically, Martinique is about 7,000 km away from France and 500 km from the South-American continent. The closest neighbouring islands are Saint Lucia in the south and Dominica in the north, which are both independent nations. Martinique is 80 km from north to south and 40 km from east to west, so it covers close to 1,000 sq. km (a little bit more than Berlin) which includes a rugged mountainous landscape with dense forests, rivers, waterfalls, rolling hills and picturesque beaches and coves. The highest point is Montagne Pelée 1,397 m in the north of Martinique.

Martinique has roughly 400,000 inhabitants; a quarter of them resides in the capital Fort-de-France. The rest of the population lives very scattered over the island. As other big agglomerations do not exist, so that e.g. La Trinité, Saint-Pierre, Le Marin or Le Francois have more the characteristics of a town than of a city. [1] With about 400 people per sq. km, Martinique has a much higher population density in comparison to France (123 people per sq. km). [15]

Due to this situation, transportation issues are a major topic in Martinique as major commercial and administrative activities take place in Fort-de-France. Many people commute between the villages and the capital. Rush hours and traffic jams are not unknown and happen regularly. Figure 1 shows Martinique with its major roads. In addition, Martinique is a famous tourist spot, main attractions are scattered over the whole island and cause dispersed traffic.


**Figure 1.** Martinique with major roads and focal traffic interchanges
Source: [2] with amendments.

Private transport contributes to the majority of movements on Martinique at present. This intensive usage of private vehicles causes traffic jams and other externalities like the problem of disposal of old and broken cars. According to the author's impression, many old cars are abandoned just at the

roadside in remote areas. Therefore, the enforcement of public transport is a major issue for Martinique's government with regard to a sustainable development of the island.


**Figure 2.** Road congestion on Martinique, Screenshot Google Maps 19.03.2019 at 8 AM local time

This article aims to illustrate the current state of public transport on Martinique and describes recent developments and projects to improve the transport situation.

# 2. Current state of public transport

With road, coastal shipping and air, only limited number transport modes are available on Martinique with road being the most important one. There is no railway existent and even no inland waterway.

Some road conditions improved substantially during the last years to improve the traffic situation; some of them even got a new alignment. An example is the new N5 between Rivière-Salée and Gros Raisin to shift through traffic out of many towns.

## 2.1. Public bus systems

In general, public transport service offers are very limited, which could explain the reason why there are approx. 205,000 cars registered at Martinique [13], which results in the highest amount per inhabitant than anywhere else in France [5] with 72.5% of all households have at least one car [12]. However, within the last years it improved considerable and became more professional.

### 2.1.1 Bus services in Fort-de-France and suburbs

The four municipalities Fort-de-France, Schoelcher, Le Lamentin and Saint Pierre are organized together in the "Central Agglomeration Community of Martinique" (CACEM). Their common company "Compagnie Foyalaise des Transports" are offering under the name "Mozaïk" public transport services in the capital area. In 2000, the Mozaïk bus network was created for Fort-de-France and in 2006 extended to other center communes.

Today the network is composed of 61 regular lines divided into three types of lines:

- Structuring lines: frequencies of 10 to 15 min
- Complementary lines: frequencies of 15 to 30 min
- Local lines: frequencies from 30 to 120 min

**Figure 3.** Mozaïk network
Source: [7]

Most lines start or end in the centre of Fort-de-France or extend structuring lines with local lines, but tangential lines are very rare. Buses from several different manufacturers like Mercedes-Benz, Heuliez and Renault are employed. [8] Travellers can choose between single trip tickets for 1.45 EUR and monthly passes for 38 EUR [9]. To meet customer requirements, Mozaïk offers a modern website like other public transport companies in Europe.

However, it is remarkable, that the airport close to Le Lamentin was so far not integrated in the bus network until 2018 (see Section 3.1), obviously due some agreements with local taxi unions [10].

### 2.1.2 Taxis collectifs (TC)

Outside the capital area, mini buses marked "TC" offer public transportation services with destinations are posted on the bus. Fares are regulated and known to be cheap, but there are no timetables existent and so transport service can be unreliable. Moreover, they do not run on Sundays and during

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the night. [5] Finally, in most cases, it is easier to return to the capital than to find a bus to the required destination and so traveling across the island requires often an interchange in Fort-de-France. [6] Figure 3 indicates the TC tariff for a single trip in 2015.

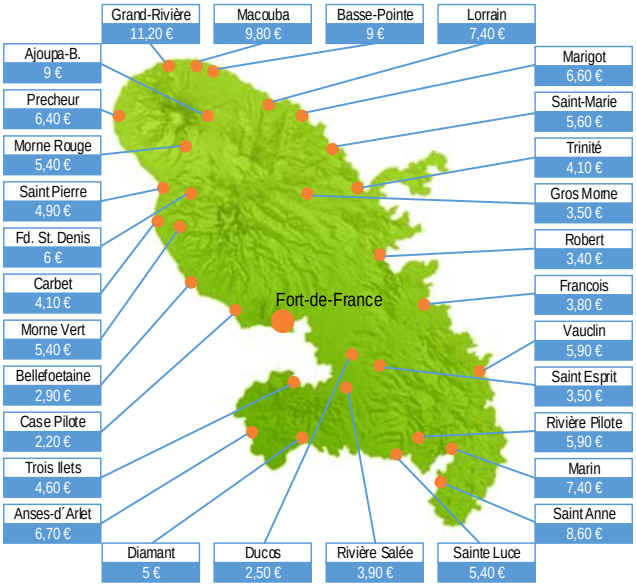


**Figure 4.** Taxis collectifs tarif as per 01.07.2014
Source: adapted from [11]

## 2.2. Taxi

Martinique has a big fleet of private taxis. The main taxi stations are at the airport, in Fort-de-France and in front of big hotels. Individual taxi service has the reputation of being very expensive. As extra surcharge during the night as well as on Sundays is common, guests should always agree the price with the driver in advance. [6]

## 2.3. Car rental

On Martinique, car rental companies are spread all over the island. Major global known companies settled down at the airport and cruise terminal. In addition to this, many smaller local companies provide car rentals in more or less every town of Martinique so that more than 288 stations are registered on Martinique for hiring cars. At the airport, three big groups control 80% of the market:

- Groupe Bernard Hayout (Europcar, Rent-a-car, Jumbo and Sixt)
- Groupe Perfect (Avis, Budget and Pop´s car)
- Groupe Laurent (Hertz)

During high seasons (mid of December to April as well as July to August), these companies provide a fleet of 5,000 rental cars at the airport area. In addition, local companies outside the airport area have smaller fleets of up to 20 vehicles. The car rental market is very competitive and so average rental rates are comparable low. However, according to many reviews on Google, it seems to be common to bill minor scratches to the customer if he has not paid for an additional insurance in advance.

In addition, private car sharing seems to become popular in Martinique. Private persons rent out their cars to tourists on the platform www.carfully.fr. [14]

## 2.4. Ferries

At present, four ferry operators provide passenger services on Martinique. Some routes connect Fort-de-France with towns and beaches on the south side of the bay of Fort-de-France. These routes are attractive for cruise tourists but also for commuters: the operating company sell monthly passes. Other services connect Martinique with neighbouring islands up to Guadeloupe. The journey to Pointe-à-Pitre takes up to 6 hours. It is remarkable, that most ferries carry passengers only. Cars can be trajected only on one ferry by Express-des-Iles operating between Martinique and Guadeloupe. Table 1 sum up available ferry connections at Martinique. Routes and frequencies are taken from corresponding websites.

**Table 1.** Ferry Services on Martinique

| Destination | Route | Company | Frequency |
|---|---|---|---|
| St. Lucia | Fort-de-France - Castries | Express-des-Iles | 5x week |
| | Le Marin - Rodney Bay | Capo Rosso | 1x day |
| Guadeloupe | Fort-de-France - Pointe-à-Pitre | Jeans for Freedom | 5x week |
| | | Express-les-Iles | 5x week |
| | St. Pierre - Pointe-à-Pitre | Jeans for Freedom | 2x week |
| | Fort-de-France - Les Saintes | Jeans for Freedom | 1x week |
| Dominica | Fort-de-France - Roseau | Express-des-Iles | 5x week |
| Martinique | Fort-de-France - different towns at south coast | Vedettes Tropicales | 20x day |
| | Fort-de-France- Case Pilote | Vedettes Tropicales | 10x day |

## 2.4. Air traffic

Martinique has a centrally located international airport named “Aimé Césaire” near Le Lamentin. Air France, Air Caraibes, Level, Corsair, XL Airways, American Airlines, Condor and Air Canada offer long-haul flights. Some of them offer services only occasionally.

The intercontinental connectivity is in relation to the quantity of airlines very limited. Only three airports in Europe have a direct connection to Martinique. Paris-Orly (ORY) the major airport for the French West Indies with many flights every day to Fort-de-France. Second European airport is Paris-Charles de Gaulle (CDG) and third is Frankfurt/Main (FRA), but only with very limited number of flights a week. According to Condor provisional flight plan, this service will be suspended in September 2019. Latest then, travelers from other European regions must change in Paris. In November 2018, Air Caraibes announced a codeshare agreement with Aigle Azur, extending their network to some selected European cities like Berlin, Moscow, Milan and Porto – however, an interchange in Paris-Orly

(sometimes overnight) is required [21]. Concerning North America, the French speaking part of Canada is connected (Montréal) and Miami.

Apart from that, medium- and short-haul flights in the Caribbean are provided mainly by Air Antilles, Air Caraibes and Ilat which fly frequent to all French speaking islands (St. Martin, Guadeloupe, Cayenne, Haiti) and a few other like Barbados, Dominica and St. Lucia. [4]

# 3. Recent developments

Due the last years, the public interest in public transport system increased. Local officials and authorities strength projects to reduce individual road traffic.

### 3.1. Navette Airport/Lamentin - Fort-de-France

On 13th August 2018 the new TCSP (transport collectif en site proper) started scheduled services with two priority lines: Line A connects Fort-de-France (Station Almadies Bô Kannal) with Lamentin-Carrère via airport; it serves in particular the international airport Aimé Césaire. This line is 12.8 km long. Line B - with 9.2 km length - connects Fort-de-France (Station Almadies Bô Kannal) with Lamentin-Mahault (see bold light blue lines in Figure 2). The service runs from 5.00 AM to 8.00 PM with departure every 8 to 15 minutes. On Friday and Saturday, operation is extended to 10 PM. Each of the 18 stations is equipped with information terminals and ticket vending machines.

14 brand-new VanHoolExquiCity bi-powered buses operate the service. They are 24 m long, equipped with a hybrid power engine (diesel/electric) and provide a high level of comfort to the passengers. Each bus has a capacity of max. 144 passengers, including 44 seats. [20]


**Figure 5.** TCSP at the end-station Almadies
Source: Florian Fèvre.

The new service aims to decongest Fort-de-France and the south of the agglomeration with Lamentin and the airport by allowing and promoting car-free travel. Therefore, the ticket prices are comparable low: the single trip cost 2.50 EUR, 4.20 EUR for one day, the monthly pass 44 EUR [18]. The system has exclusive lines with special alignment to ensure a reliable transit time. Therefore several crossings, overpasses, tunnels and bypasses had be to constructed or modified. In total, 13.9 km were built as a dedicated line. Collective taxis are not allowed to use these lines. Not only passengers to/from the airport are focussed, even commuter may probably be the biggest group of passengers. For commuters, separate parking are available in Carrère and Mahault. [19].

**Figure 6.** New exclusive lines for TCSP (orange surface)
Source: [22]

The project was initiated by CACEM (la Communauté d'Agglomération du Centre de la Martinique), CTM (Collectivité Territorial de Martinique), the syndicat mixte du TCSP and the operator CFTU in the year 2003 [16] and was planned to go live in 2013. A public-private partnership between the regional council of Martinique and the Vinci group was signed in 2013 for a period of 22 years and a value of nearly 100 mio. EUR. The total investment volume is 380 mio. EUR, which is partly financed by the EU.

Further lines towards Schoelcher in the north, Rivière-Salée in the south as well as towards Le Robert in the east are projected. [17].

### 3.2. Gondola lift Fort-de-France - Schoelcher

On the science fair in November 2018, a new project was published to improve the passenger transport situation between Fort-de-France and Schoelcher. Schoelcher is the community direct north to Fort-de-France and home of the Université des Antilles, Pôle de Martinique. The idea is to build a gondola lift to offer a fast and reliable public passenger connection. As an alternative, a tram is discussed, but the gondola seems to be more attractive from an environmental, technical and economical point of view. CTM is in charge of planning and realization of this extension of the public transport system towards Schoelcher and the university. Given challenges like difficult topography, density of buildings and probably high costs of land acquisition that make it very difficult to establish a tramway line, the CTM wants now to inquire possibility of public transport by a gondola lift as a next step and accordingly tenders a feasibility study. [3]

# 4. Conclusions

It can be summarized that Martinique is a densely populated island and with a high share of private transport causes road congestions and other externalities, which pose big problems to an envisaged sustainable development. New

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public transport systems were set up to improve the situation and new further ideas exist to reduce the need for individual transport. It is too early to state about the success of the TCSP, but within the first 10 days of operation, the TCSP already carried more than 10,000 passengers. [23] Another further idea is to integrate the commuter ferries across the bay of Fort-de-France in the public transport network of Fort-de-France.

So finally there is hope that in future Martinique will not be known any longer for its traffic congestion. But in march and April 2019 several strikes (based on payment regulations) stop or at least limit the operations of local buses in Fort-de-France, the TCSP and also Vendette Tropicales which support the image of typical transportation chaos on Martinique.

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# Toward Management Of Traffic Culture In Macedonia

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**Abstract** The World Health Organization in its agenda on sustainable development 2030 sets a goal to reduce the number of traffic-related accidents by 50% [1]. According to the trend of reducing the number of traffic-related accidents and the latest statistics report by SIA Bitola, this is a very high goal for our city and a great challenge which we could try to reach if we start acting right now by trying to rise and advance the traffic culture; to provide infrastructural facilities and elements that are planned and designed according to safety principles that correspond to the projected speed and road function, with access to frontal facilities and protective greenery as well as preserved historical and aesthetic features; to provide a safe infrastructure for pedestrians, the elderly and persons with disabilities, but primarily permanent and visually attractive; to provide a safe and continuous bicycle infrastructure; to introduce traffic calming; to exclude and limit access of freight vehicles for transit and traffic in housing zones; to improve the services of taxis and public bus transport of passengers, namely to improve everything related to safe traffic and transport in our country. The general objective of this article is presentation of the approach to raising traffic safety and improving the traffic culture in our country through field educational workshops on the example of the city of Bitola, Macedonia.

**Keywords** Traffic Culture, Road Traffic Safety, Management

**JEL** L99

## 1. Introduction

The campaign ROAD TRAFFIC SAFETY WEEK was held in six Macedonian cities and in the city of Bitola from 2nd till the 9th of September 2018. The campaign has an educational character and its main goal was to raise citizens' awareness and improve their behavior in traffic, namely in following road traffic rules and regulations. However, we also aim to encourage relevant institutions to take an organized approach to the resolution of traffic issues and to show that the safety of all traffic participants is their institutional obligation and interest of the highest level, particularly the safety of children.

All of the activities planned were carried out in the field, "directly involved with the citizens". The activities included: measures to increase children's safety through the workshop School Pavements Are For Children, Not Vehicles, as well as measures to deter and reduce illegal parking, Measures to improve street signalization, particularly in the area of horizontal signalization, Measures to improve cycle traffic (routes, cycle routes, ramps) and the promotion of cycle parking lots at three new locations in the city (Javor, At Pazar and near the Officers' Hall)- all three a donation from DPN CITY PARKING LOTS, Bitola. A workshop to improve the taxi service and the public transport service, particularly the condition of bus stops, alcohol patrol, and so on.


ROAD TRAFFIC SAFETY WEEK- BITOLA

AGENDA

Most of the workshops will be repeated on other days as well to increase efficiency!

**Figure 1.** The General Agenda of the campaign

## 2. Workshop-School Pavements Are For Children, Not Vehicles

Every mistake comes at a price; however, mistakes in traffic can result in the loss of a child's life! It is high time that we, all of us, take a share of the responsibility and make a personal contribution to greater safety of children in road traffic.

Through the workshop SCHOOL PAVEMENTS ARE FOR CHILDREN, NOT VEHICLES, which take part in all

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municipal primary schools, we aim to educate and inform pupils and their parents/guardians on how to find the safest route to get to school and back home. However, we were also trying to send a special message to drivers of motor vehicles, particularly the drivers who park illegally on pavements beside schools, about the risks and danger they are causing.

We distributed the message directly and we had handed out many educational flyers and leaflets to children, parents/guardians and drivers as well as additional door hangers giving an Excellent 5 grade to parents who use a booster seat and safety seatbelts, to drivers who carefully choose where to park their vehicle near schools and to drivers who slow down their vehicle near schools and who stop at pedestrian crossings to let school children pass, while an Insufficient 1 grade was given to all vehicles parked on pavements or who, with their lack of traffic culture, forced students to walk on the street and roads thus directly putting their safety at jeopardy.


**Figure 2.** Photo moments of the workshop "School Pavements Are For Children, Not Vehicles"

## 3. Workshop- SAFE Parking

The public functional space reflects the basic character of each city, through which Bitola should remain recognizable and remembered. However, mobility, the rapid growth-rate and the high level of motorization have led to supply being higher than demand both in the dynamic and in the stand-still traffic. European research shows that 30% of pollution emissions in the central areas in cities comes from vehicles that circle the streets in search of a parking spot, and as a measure by the same EU experiences, a gradual limitation and reduction in the number of available parking spaces in city centres is suggested as opposed to increasing the capacities of public parking garages, located at the entrance to the centre of the city. In our city, there is a problem with lack of parking spaces in housing and school zones, while demand is especially pronounced in the central core due to the concentration of various activities. The main threat is that approximately 70% of the journeys are realized with passenger vehicles and there is a high percentage of illegal street parking that entails reduced capacity and safety on the streets [1].


**Figure 3.** Photo moments of the workshop "Safe Parking".

## 4. Workshop- SAFE STREETS

The WORLD HEALTH ORGANIZATION in its agenda on sustainable development 2030 sets a goal to reduce the number of traffic-related accidents by 50%, [2]. According to the trend of reducing the number of traffic-related accidents and the latest statistics report by SIA Bitola [3], this is a VERY HIGH GOAL for our city and a great challenge which we could try to reach if we start acting right now by trying:

- TO provide infrastructural facilities and elements that are planned and designed according to security principles that correspond to the projected speed and road function, with access to frontal facilities and protective greenery as well as preserved historical and aesthetic features,
- TO provide a safe infrastructure for pedestrians, the elderly and persons with disabilities (signalized, with pedestrian overpasses and underpasses, with 3D foot passages, creative, with sensors and lighting), but primarily permanent and visually attractive,
- TO provide a safe and continuous bicycle infrastructure (signaled, lit up),
- TO introduce low traffic zones (ZONE 30) and to limit the speed for motor vehicles,
- TO exclude and limit access of freight vehicles for transit and traffic in housing zones,
- TO improve the services of taxis and public bus transport of passengers.



**Figure 4.** Photo moments of the workshop "Safe Streets".

For this workshop, the Republic Council on Road Traffic Safety- RCRTS donated 100 liters of white paint used for horizontal signalization. The teams of PE Civil Engineering and PE Komunalec come in the field with the necessary resources, working on the stretch between Filip II Makedonski St., Stolarska St. and Boulevard 1vi Maj by restoring the pedestrian crossings in front of the emergency clinic, near Bezisten and in front of Javor. For the next few days we plan to mark the pedestrian crossings at two more locations, in front of Hotel Epinal, on the street intersection between Leninova St. and Dimitar Ilievski Murato St. and the pedestrian crossing in front of the entrance of the City Hospital on Partizanska St. As part of the campaign, PE Civil Engineering introduced a telephone and email service where citizens can report damages to the vertical signalization.

## 5. Workshop - TOWARD SAFE CYCLE INFRASTRUCTURE

European experiences show that improvements to cycling infrastructure allow for 45% less vehicles and faster public transport. That is why today we have asked the question, why not Bitola, too? If for instance, Ljubljana, with 270000 residents, can have around 150 km of cycling routes or the "green city" Freiburg, which numbers 220000 residents and 30000 students, can have 420 km of cycling infrastructure and realize 30% of trips by bike, why not Bitola, too?

Bitola is one of the cities whose size, favorable topographical location and weather conditions throughout the year allow for the development of excellent cycling infrastructure. The disadvantages are the tight geometrical profiles of the street network and the need to take away space from the motorized traffic of pedestrian traffic and also the fact that the bicycle has been neglected for a long time when planning the city infrastructure. Another drawback is the lack of awareness and tradition of its use, so that comprehensive planning of the cycle network is needed by adjusting the existing infrastructure and designing a new one.


**Figure 5.** Photo moments of the workshop "Safe Cycle Infrastructure".

To execute the primary activity, predicted for the 5th day of the campaign- CYCLING DAY, as well as the campaign in general, we received a tremendous amount of support from Bitola on Bikes, with whom at 17.00 at the Magaza, part of the NI Institute and Museum Bitola, we prepared

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and opened the exhibition CYCLE PHOTOGRAPHS, created by Bitola on Bikes. In addition, we also presented the map SUGGESTED CYCLE ROUTES (primary network).

Later same day, together with Mayor Natasha Petrovska, MA, we cycled with Critical Mass 52- SAFE CYCLE INFRASTRUCTURE.


**Figure 6.** Photo moments of the workshop "Safe Cycle Infrastructure", part2.

The fifth day of the campaign, dedicated to BICYCLE TRAFFIC, was enriched by the promotion of three bicycle parking lots near Javor, At Pazar and the Officers' Hall (locations approved by the department of communal activities and landscaping of public land within the Municipality of Bitola).


**Figure 6.** Bicycle parking lots "before and after"

## 6. Workshop - SAFE TAXI TRANSPORTATION AND MOBILITY

Incentive schemes and subsidies have proven effective in the process of improving the current situation, therefore we organize awarding discount VOUCHERS for Casco insurance to the taxi vehicles and the vehicles of the Public bus transport service who meet the required terms according to the planned code.

Namely, it has become evident that the taxi service in Bitola is not uniformed! And it should be, in appearance- both in the color of vehicles and the uniform- the color of the clothes of the taxi drivers, and above all in the quality of the service provided (technically functional and clean vehicles).

These terms and conditions are stated in the Regulation of the Municipal Council, however, they are not followed. We also listened to the problems and the requests of the taxi drivers and in the following activities we will try to meet their needs, however, we did point out their responsibilities as well!

On this workshop PE Komunalec-Bitola which supports of the Campaign in full helped in cleaning up some of the bus stops in the city from advertising and other material under the message I AM NOT AN ADVERTISEMENT BOARD, (Figure 8).


**Figure 7.** Photo moments of the workshop "Safe taxi transportation and mobility".

## 7. Conclusions

Conclusions of the campaign ROAD TRAFFIC SAFETY WEEK, were stated at the round table that was held at the FACULTY OF TECHNICAL SCIENCES-BITOLA, another one of the institutions that fully supported the initiative I

WANT THE CITY SAFE, in order to develop an open discussion and eventually decide on quality and specific RECOMMENDATIONS to the Council of the Municipality of Bitola, so that they could take measures that would resolve some of the traffic issues as well as improve the image of road traffic in the city.

The meeting was attended by Professors-experts in various areas of traffic and transport engineering and the Dean of the Faculty Of Technical Sciences-Bitola, authors of [2], Representatives of the City of Skopje who unreservedly shared with us their experiences from the implementation of certain traffic regimes in the City of Skopje, Representatives of the Republic and Municipal Council on Road Traffic Safety, Representatives of SIA Bitola [3], Representatives of the Municipality of Bitola, Representatives of the Committees within the Council of the Municipality of Bitola, Representatives of Public Enterprises in Bitola-Civil Engineering and Komunalec, a representative of Bitola on Bikes and a representative of the regional geographic society GEOSFERA-Bitola.


**Figure 8.** Photo moments " I'am not an advertisement board!".

We received exceptionally specific and clear SUGGESTIONS which were turn into RECOMMENDATIONS for certain draft-measures, and was passed on for further processing and coordination to the relevant Committees within the Council of the Municipality of Bitola.

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# Towards Interoperability of the Electronic Road Toll Systems in the European Union. Case of Poland

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**Abstract** The road toll is a significant tool of transport politics due to its economic and social characteristics. Both of those fields search for integrity in activities for a balanced transport. While the road toll is an attempt of the country for internalisation of external transportation costs, the method of collecting the toll is a factor of improvement of public roads. The electronic road toll system (EETS) fulfils those purposes, under the condition of interoperability. The article describes the functionality of the road toll, its meaning for the internalisation of external costs, the interoperability of systems which collect road tolls in EU, and the results of incorporation of the electronic road toll systems in Poland. Subject literature, EU law regulations and institutional data were used in the elaboration.

**Keywords** road toll, interoperability, electronic road toll

**JEL** R42, R48

## 1. Introduction

The road toll system is nowadays considered as an effective tool for limiting negative effects of industrial and social acceptance for car transportation. Road tolls originated as a tool for securing the means for construction and maintenance of the transport infrastructure. As K. Button observes [13], among the three economical functions – allocative, informative, and profitable –road tolls serve mostly as a tool for the last of the mentioned functions. However, the dynamic development of car transportation forces changes in the attitudes towards road tolls. Nobel-prize winner R. Coase stated that [13], policies such as road pricing are not market solutions, but the most effective way of achieving an externally determined target traffic flow. In result, the road tolls are currently used for achieving wider goals of transportation politics such as change of behaviour on transport users, optimisation of infrastructure usage, limitation of natural resources usage, reduction of external costs, and prevention of congestion. The need for internalisation of the external costs generated by the car transport is a great justification for expansion of the road toll systems across EU and for improvement of means of tax collection.

The internalisation of external costs is a tool used to induce transformation on the market branches connected with transport services, to change the level of demand, and to set up the profiles of mobility [8]. As a political goal, it is included in the so called transport pricing, being a part of the entirety of subjects concerning the establishment of prices in transportation. While the rates of transport services are dictated by free market rules (with exclusion of public transport), the external effects of transport distort those rules. Therefore, the issue of transport pricing is considered as a need to equalise the competitiveness outside and inside of the branch and the influence of the external effects of transport. The tolls for exploitation of transport infrastructure are the essence of the transport pricing.

Considering internalisation as a tool of transport politics it is possible to indicate many favourable results for roads users and for society. Beside the general aim to lower the environmental inconvenience of transport, it is believed that the empowerment of external costs will bring the following results [8]:

- reduction of traffic in most congested roads, mostly in city centres,
- increase of movement speed,
- lowering of accident rates,
- branch displacements in transport,
- rise of attractiveness (mainly in prices) of public transportation in view of the need to commute.

When it comes to the selection of internalisation tools, the clear vision was presented by J.E. Stiglitz [12], who stated that economists endorse solutions connected with the market mechanisms, while governments support direct regulations since they provide higher certainty of results.

The sustainable development strategy of transport utilises three rules of charging transport users: polluter pays, user pays and full costs recovery. Those rules allow conducting the right postulates, among others, providing a direct connection between the access to common resources and payment for them, to ensure better usage of the available resources, to eliminate the distortions in competitiveness, to

reduce external costs and to acquire means for modernisation of the sector [1].

The aim of this article is to emphasise the meaning of interoperability of the toll collection systems in EU for realisation of the goals of the EU transportation politics. The theoretical layer of the article is based on Polish and foreign literature on the subject. In the pragmatic part the diversity of the electronic road toll systems in EU and the law regulations for interoperability of those systems have been described. The empirical data concerns the effects of introduction of the electronic road toll system in Poland.

## 2. Interoperability of road toll systems

Lack of interoperability of road toll systems in the European Union is a significant problem for the users of roads, and for those who manage them. Interoperability is defined as 'a characteristic of a product or system, responsible for ability of different systems to cooperate'. This term can be understood as interoperability in the context of technical systems, or more broadly, as a cooperation of systems with social, political and organisational significance. The Polish regulation of 2012 concerning the National Interoperability Framework [13] determines the methods of achieving interoperability in frames of three activities: unification (by utilisation of compatible standards and procedures), interchangeability (by ability to replace the product, process or service), and conformity (suitability of products or services, fulfilling determined conditions).

Interoperability in reference to the electronic road toll systems is an act happening on two levels: national and international. The first one concerns the integration of national road toll systems with systems of concession sections of the roads. The second, international, is connected with higher level of complexity in view of many factors. Nevertheless, interoperability is possible by incorporation of external on-board units, which will provide the ability to exchange information between different systems.

The European Electronic Toll Service (EETS) is a response to the need for interoperability of the electronic road toll system. This system allows for use of electronic road toll on the areas of EETS, by using one on-board unit (OBU), one user account in the system and one contract with the provider of the service [6]. The service involves: a) providing the users with OBU device, adjusted to their needs and its maintenance; b) guaranteeing that the subject collecting the toll will receive the tolls charged from the users; c) sharing the methods of payment with the users, or accepting the existing method; d) collecting fees from the users; e) managing consumer relations with the users; and f) implementing and complying with strategies of data security and protection in systems of electronic road tolls [6].

The issue of the interoperability of road toll systems is an important area of many scientists' research. This subject has been studied (among others) by Mertner and Skov [11] in the context of harmonisation and standardisation of the road toll systems in three fields: technical-procedural, operational and institutional. The interoperability of the road toll systems was also studied by Hamilton and Eliasson [3], who indicated harmonisation or adaptation as a method of achieving interoperability. The subject of implementation of the European electronic road toll was described in elaboration of Van Haaften, Van Engers [21] and Maes [22]. Analyses of road tolls were included in Polish literature in works of Siergiejczyk, Rosiński [15], Muślewski, Lewalski, Skibicki, Bojar [14] and Lewandowski [18]. The economic and technical aspects of interoperability in accordance to the implemented EETS were described in the elaborations of Nowacki, Mitraszewska, Kamiński, Potapczuk, Kallweit [10].

## 3. Regulations for interoperability of electronic road toll systems

Since the 90s, electronic systems of road tolls have been implemented on local and national levels. Lack of cooperation on international level caused them to be not interoperable. It leads to the generation of additional costs, and creation of obstacles for the users of roads, which are obliged to buy and assemble different OBU devices in their vehicles, in order to make collection of the road toll in different European systems possible.

Directive 2004/52/WE of 29 April 2004 [7], concerning the interoperability of the electronic road toll systems in the European Union, was the first attempt to harmonise the systems. The directive established conditions for ensuring the interoperability of electronic road toll systems, narrowed the range of utilised technologies to DSRC (dedicated short range communications), mobile network (GSM) and satellite localisation (GPS). It also established the conditions for implementation of the European electronic road toll.

The Decision of the European Committee 2009/750/WE of 6 November 2009 [5] defined the European service of road toll (EETS). It was incorporated into the national legal order [3] as a service, that allows the users of roads in the European Union to fulfil the duty of payment for using the roads on which the tolls are being collected (with use of electronic road toll system), on the bases of the contract with the EETS provider.

The most recent regulation of the European Union in the elaborated subject is a Directive of the European Parliament and of the Council (2019/520) of 19 March 2019 [6] on interoperability of electronic road toll systems and facilitating the cross-border exchange of information on the failure to pay road fees in the Union. It is applicable only to the road toll systems based on travelled distance, charged after passing the particular point. It does not concern fees connected with time of use (vignettes) and parking fees. The important goal of this regulation is to simplify recovery of failed payments, by introduction of a new system of data exchange.

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# 4. European road toll systems

The road toll as defined by the EU regulation [5] refers to a fee that should be paid by the road user for use of the given road, road network, object (such as a bridge or a tunnel) or a ferry. In fact, the charge is based on the distance (distance-based charges), time (time based charges) or on the particular point (cordon fee). In example, truck users in EU meet the following forms of road tolls:

- euro vignettes, vignettes (time-based fees),
- passing fees (depends on the distance and the type of vehicle),
- fees for crossing bridges and tunnels,
- fees for entering cities,
- fees for entering low emission zones.

In existing road toll systems utilised in the EU member states, the most common is the electric road toll system with a high level of diversification (Table 1).

**Table 1.** Road toll systems in EU member states, for trucks

| Road toll system | Utilised technology | Country |
|---|---|---|
| Free-flow | GNSS with ARTR or DSRC | Hungary, Slovakia, Belgium |
| Free-flow | GNSS with infrared mode or DSRC | Germany |
| Free-flow | DSRC | Austria, Czech Republic, Poland, Portugal, Great Britain (Dartford Crossing) |
| Free-flow | ARTR | Great Britain (Dartford Crossing) |
| Free-flow | ARTR and DSRC with use of on board devices | Portugal (A22, …, A25) |
| Network of fee collection points | DSRC | Croatia, France, Greece, Ireland, Italy, Poland, Portugal, Spain, Great Britain |
| Vignette | Electronic euro vignette | Denmark, Luxembourg, Holland, Sweden |
| Vignette | Electronic euro vignette | Great Britain, Latvia |
| Vignette | sticker | Bulgaria, Lithuania, Romania |

The most common technology is that of dedicated short range communication, based on two directional communication between the fixed devices on the side of the road and the on-board devices. Devices on the side of the road have to identify the user of the road (and his vehicle) in order to charge the fee. In Bulgaria, Lithuania and in Romania traditional vignettes in the form of a window sticker are used [15]. This technology is also used in the Polish system of electronic road toll. The new Polish system should be based on the satellite communication, but currently it is allowed to use the mobile connection system, based on the GSM-GPRS standard and on radio waves [2].

EETS should work in three technologies mentioned above. The service is offered by the provider, who is a legal entity providing the EETS user with access to the service. The user can choose services of any provider, regardless of his nationality, place of registration and place of vehicle registration. In the European Union the following providers of EETS service have already been registered:

- Czech Republic: Eurowag
- France: Axess SAAS, Eurotoll, Total Marketing Services S.A.;
- Germany: AGES EETS GmbH;
- Italy: Telepass S.A.;
- Poland: Telepass S.A.

In Poland, the section of the motorway A4 from Katowice to Balice (around 60km) is covered with EETS, which is a little percentage of roads on which the toll is charged. The payment is charged by the General Inspectorate of Road Transport, who has been managing the electronic road toll system since November 3, 2018. The electronic toll constitutes income for the National Road Fund.

# 5. Electronic road toll system in Poland

The Polish electronic road toll system – ViaTOLL - was introduced in Poland on July 2011. It was created by Austrian group Kapch Telematic Services Ltd. In the first phase, there were 1565 km of national roads, expressways and motorways which the General Director for National Roads and Motorways covered with the toll obligation. Currently (April 2019), the length of paid roads equals around 3660 km, of which 1080 km are motorways, 1275 are expressways and 1155 km are highways (Figure 1).

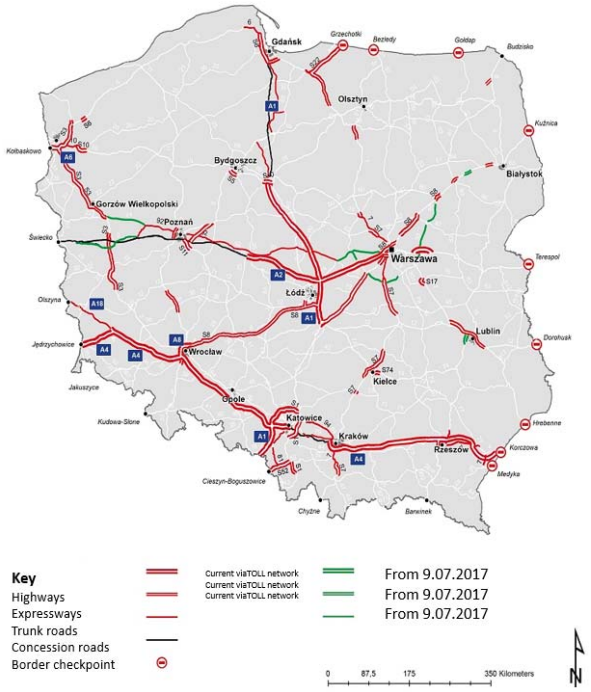


**Figure. 1.** Map of the toll road network in Poland.

One of the functions of road tolls, which is dependable on the level of interoperability of electronic road toll systems, is to provide financial income to the country budget and internalise external transport costs.

Income from road toll goes to the National Road Fund (KFD – Krajowy Fundusz Drogowy), which supports road investments in Poland. The National Road Fund was established on the grounds of the Act of 27 October 1994, on Toll Motorways and the National Road Fund [3]. The main goal of the Fund is to bring together the asset which can be used for construction and reconstruction of the road infrastructure, and to cover expenses connected with payments for the operators of toll motorways as well as for the creation and exploitation of road in toll systems. Management of the Fund means is presented Figure 2.

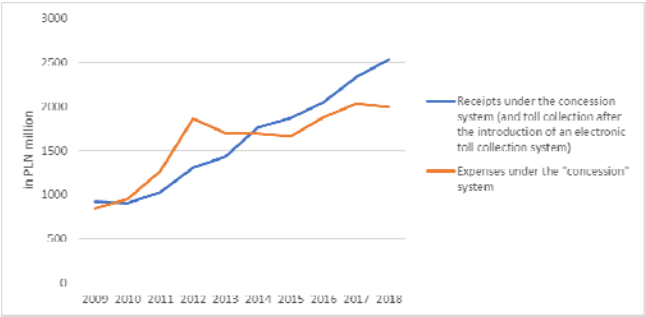


**Figure. 2.** Amount of receipts and expenses to KFD during 2009-2018 for the maintenance of road toll systems in Poland

In 2009, income to the Fund for the maintenance of the concession system amounted to PLN 922 million and that amount doubled in 2016 (PLN 2047.6 million). The biggest increase in revenue can be seen between 2011 and 2012. During this period, exactly on July 1, 2011, the electronic road toll system was introduced. At the same time the expenses on the road toll system had been increasing up to 2012, because the electronic road toll system was being constructed at that time. Since 2014, income from the road toll system in Poland has been bigger than the expenses on the system's maintenance.

The responsibility for the electronic road toll system lies on the General Inspectorate of Road Transport. It is planned to create the National Electronic Toll System, with priorities on the public side such as:

- the system should be based on the latest global solutions, with utilisation of GNSS technology, data transmission in mobile systems (LTE/5G) and Big Data,
- the system should be open for new functionalities, by expansion with use of new modules,
- the system should contain sensitive data within the area of Poland, and should grant supervisory services with access to that data without mediation of private companies,
- the system will use the existing road toll infrastructure,
- the system will cooperate with other road toll systems in the European Union.

The new system ought to cooperate with other toll systems utilised in the European Union.

Currently in Poland there is one section on the A4 motorway, with a length of 61 km, on which the EETS service is available. The concessionaire has made an agreement with the Italian provider Telepass, resulting in the possibility to use the toll section with the use of devices provided by the EETS provider.

## 6. Conclusions

The effectiveness and usefulness of road toll systems is a complex issue due to the profitable and allocative function of those fees. The discussion on road pricing has a long story. Despite the common attitude to the issue expressed by EU transport politics, according to studies in UE, road pricing still has national characteristics. Creation of a framework for the interoperability of electronic road toll systems is an appropriate step towards making easier use of toll roads and countering the rising congestion. It also serves for the fiscal goals of the member states. However, it does not solve the general problem of internalisation of external expenses on car transport. A valuable indication for further work on the issue is to adopt the dynamic pricing rule, which allows to maximise the attractiveness of the road network to users.

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