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# Analysis of the bus preference and bus stops in Košice

**Peter Medvid'[1], Juraj Hammer[1], Miloš Poliak[1]**

[1] Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Univerzitná 1, Zilina, 010 26, Slovak Republic

**Abstract** Systematic growth of amount of cars and vehicle ownership incites to a growth of traffic flow in locality areas and cities, especially at the traffic peak. A slowing down of traffic, increase of density on traffic areas and advance growth of delay at the crossroads, increasing of exhaust emissions, noise and vibrations is a result of these changes, which manages to traffic accidents increasing.

**Key words** preference, bus lane, Košice, buses, bus stops

**JEL** R41

## 1. Introduction

The preference of Public transport directly affects two defined areas of perception of its attractiveness and quality - travel speed and reliability. The passenger expects to be transported between the beginning and the destination for acceptable time and reasonable speed. [1, 3]

At the same time, it expects that the goal of its journey will be achieved in a timely manner independently of external circumstances. It seems that even on relatively low trips, in the case of travel by public transport, perceived more, because unlike passenger car travel, passengers traveling time and time arriving at the destination can easily compare with the timetable. [3]

Making urban transport more attractive will result in more passengers traveling through public transport, which means that more people would abandon the use of individual car transport in cities, which would contribute to improving the transport situation. In this article we focused on two components, which affect the travel speed – bus preference and situation of the bus stops in Košice. [2, 3]

## 2. Bus transport situation in Košice

The first attempts to establish a bus service in the city Košice dates back to the 1930s. However, the regular bus service began to run only in 1932. It was on the route from the railway station, via Mlynská Street, to today's Moyzes Street with the final stop at the town hall.

The bus transport in the city Kosice is nowadays an indispensable part of urban public transport. It accounts for almost 86% of the total performance. There are 29 daily lines in operation, 4 express lines, 8 "traffic peak" lines, 1 line for students, 8 "working" lines, 7 night lines.

**Table 1.** Bus transport performance in Košice (urban transport)

| Indicator | Unit | Type | 2006 | 2011 | 2016 |
|---|---|---|---|---|---|
| **Transport performance** | thousand. vehiclekilometers | *buses* | 11 006 | 10 590 | 11 728 |
| | | *overall* | 15 982 | 15 727 | 14 825 |
| | | | *68,86%* | *67,34%* | *79,11%* |
| **Number of transported persons** | a thousand persons | *buses* | 64 246 | 56 080 | 58 222 |
| | | *overall* | 99 354 | 89 332 | 83 144 |
| | | | *64,66%* | *62,78%* | *70,03%* |

*Source: processed by the authors from annual reports from DPMK* [4]

Bus lines transferred in 2016 up to 58.222 million people of the total transported people 83.144 million persons (70.03%). Bus vehicles made 11.728 million vehicle-kilometres per year out of a total of 14.825 million vehicle-kilometres per year (79.11%) in that period. The high increase caused in the share of bus transport in traffic, but also in the number of persons transported the DPMK to cease operating trolleybuses in January 2015. [4]

### 2.1. Bus preference in Košice

The preference of bus transport is very low in Košice. Buses must stay in many places in congestion, where their delay on the line is only increasing. So, in such dramatic ways, the travel speed is reduced.

If bus preference is built in the city Košice, only via BUS lanes, in the following places:

- **Magnezitárska street**

The section was set up in 2010 as a response to the ever-increasing length of traffic congestion at an exit from Sídlisko Ťahanovce. The length of this BUS lane is approximately 115 meters.

The section is located after the bus stop EcoPoint on the Magnezitárska Street. DPMK came up with a suggestion to divert on the morning transport peak of bus lines 18, 27, 36 through the village of Ťahanovce. The original route between bus stops Sofijská (last stop on Sídlisko Ťahanovce) and Tesco, Džungľa was 1.5 km long. The new route was extended to 4.4 km, but even with such a significant increase in mileage, time savings were higher.


**Figure 1**. BUS lane in Magnezitárska street [Source: Google Street View]

Currently, the same lines pass through this section, but the decision is on the drivers themselves. In many cases, there is a situation that the bus runs along the original route, and the second line on the same route will overtake it during a move across the village.

This BUS lane was the result of an unstable situation in the area and was a temporary replacement. This state persists to these days.

- **Štúrova street**

This section with BUS lane is located on the southern part of the Štúrova Street. Links from the west and south of the city to the city center go there. Lines 10, 11, 15, 16, 20L, 21, 23, 25, 32, 52, 56, 71 and 72, as well as night N2, N3, N4 and N6, pass through this section.

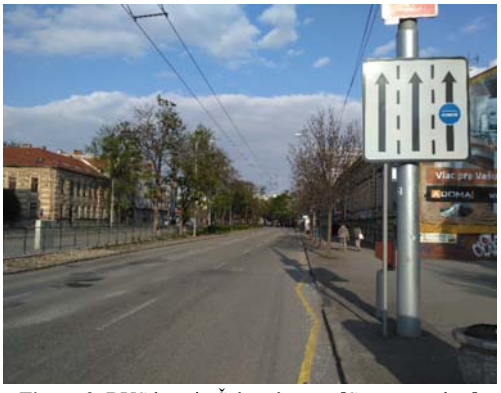

**Figure 2**. BUS lane in Štúrová street [Source: author]

A separate lane for buses (BUS lane) is located on the southern side of the Štúrova Street. It is located on the right side of the road and its start is before the bus stop Dom Umenia and ends at the stop of the bus stop Námestie osloboditeľov, behind the traffic lights. Its total length is approximately 670 meters. This BUS lane is an important element in a given segment, helping to moderate the already high delays in the city center.

**Figure 3**. BUS lane in Štúrová street [Source: author]

- **Toryská street**

In part of city Košice-Západ is also a short section reserved for buses. Every day there are (actually) bus lines 71 and 72, night N6.

It begins just before the bus stop Magistrát Mesta Košice and ends a few meters after the crossroad. Its length is approximately 100 meters. After the bus stops, the BUS lane continues, and the public transport vehicles have separate indication ("ball traffic light" - the same as that,which is used for trams).

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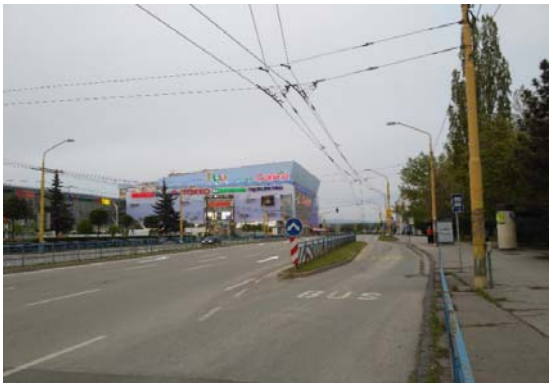


**Figure 4**. BUS lane in Toryská street [Source: author]

- **Trieda KVP – bus stop Miestný úrad, KVP**

The BUS lane is also located at Sídlisko KVP. Its length is only about 60 meters. This section passes bus lines 19, 34, 36, 71, 72 and night line N6.

A separate BUS lane starts just for the bus stop Miestný úrad KVP and ends before the crossroad. At the end of the BUS lane is placed, on the traffic light, a separate signal for buses („balls lights“).

**Figure 5**. BUS lane in Trieda KVP [Source: Google Street View]

There are also other sections in the city Košice, where the bus has easy leaving the bus stop or is preferred at the crossroad. These are:

- exit from Levočská stop, direction city center,
- earlier "free" signal ahead of ICT at the bus stop Námestie osloboditeľov (end of the bus lane),
- earlier "free" signal before of ICT at the bus stop Magistrát mesta Košice (end of the bus lane).

Vehicles are preferred to ICT and the "free" signal lights up about 5 seconds earlier. However, it has to be said that this is not an absolute preference, because there are no detectors on those places, and the signal "free" for public transport will run, however they are not present at the area.

On other places in the city Košice, buses have to travel at the same time with other vehicles in common lanes. There is no a plan for building some new BUS lanes in the near future and therefore this status remains. [5, 7]

## 2.2. Situation of the bus stops in Košice

The length of the vehicle at the stop influences also the travel speed. This means, that the state of bus stops is important. In this section we are focusing on the current state of bus stops in the city Košice.

There are 517 bus stops in the city nowadays (58 of them are also compatible with trolleybus stops). The condition many of them is not suitable. A few dozen of bus stops in the city center have been reconstructed, or a reconstruction was realized together with a repairs of communication in the blocks of flat area (the last one was a reconstruction of the bus stops at Sídlisko Ťahanovce realized together with the reconstruction of the road in summer 2016).

The big disadvantage is that in the city Košice there is practically no combined stop for tram and bus transport, although the possibility of a realization of such a stop was here at that time. Shared stops in the city center would certainly help to increase the attractiveness of public transport. The only one effort to build a shared stop was the “Spoločenský pavilón” on Bardejovska Street. However, this stop is mostly used for bus transport. Trams use this stop only they are returning to the tram depot. Bound with the MET stage 2 project, however, there is a reconstruction of the track in this area and the stop Spoločenský pavilón should be already built as a combined stop at the Trieda SNP. [9]

**Figure 6**. Wrong placed bus stop Jakabov palác [Source: author]

Partial solution could be the new project of Modernization of public transport stops and information systems. The project is based on the conclusions of the study of the transport constructions, approved by the local council in 2016, and with the reconstruction of thirty new platforms in 16 stops in six city districts. There are actually stops: Staničné námestie, Námestie osloboditeľov, SOŠ automobilová, Námestie maratónu mieru, Dom umenia, Krajský súd, Mier, Amfiteáter, Stará nemocnica, Nová nemocnica, Spoločenský pavilón, Zupkova, Železníky. [10]

The surface of the platforms and stops should to be renovated, fitted with new devices and information displays with online line tracking. From the point of view of the technical solution, should be observed the upgraded trend of the previous modernization projects, especially the solution of the surface with the drainage channel, the installation of the Kassel type curbs and the barrier-free access. There is a plan to install two 20 rows displays with online line departures both of lines at the Railway Station between

tramway stops and the passenger building of the Railway Station Košice. [10]

This project has been included, in the past, into a project storage for drawing funds from the European Union and the City of Košice, as the project holder, intends to participate in the call for applications for non-repayable financial contribution from the Integrated Regional Operational Program (IROP 2014-2020). [9]

## 3. Conclusion

Increasing of the system effectiveness of public transport and increasing of the effectiveness of financial resources from public budgets get to be more important in the present time of "tight" public budgets. [6]

The introduction of preferential measures will result in a smoother driving of public transport vehicles, which result is saving of fuel for public transport vehicles (without unnecessary stops and stays), but it will also result in savings for vehicles and staff. As a result of the increase in travel speed, it will be an increase in the circulating speed of a given line, which will decrease the number of vehicles dispatched to the line. The same transport performance can be realized with a lower number of vehicles and staff. [3, 6]

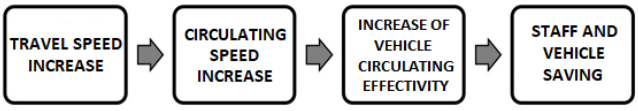


**Figure 7**. Increasing of travel speed [3]

Although vehicle depreciation and staff salary represents a significant amount of the cost of the line's transport performance, reducing of the necessary vehicles quantity can be a cause of a significant increase in line efficiency. For that reason, it is necessary to address this issue in city of Košice, because the current level of these travel speed components is very low. [6, 8]

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# The Selected Aspects of a S2B Internal Partnership

**Lucia Možuchová[1], Matej Pechota[1]**

[1] The Faculty of Operation and Economics of Transport and Communications, University of Žilina, 010 26 Žilina, Slovakia

**Abstract** In the knowledge-driven economy there is a growing need for deeper and more productive interaction between universities and industry. Science-to-business (S2B) marketing is characterized by that two different spheres meet - the academic and the business. In S2B marketing, partnership refers to the activities whose aim is to create accordance between internal and external stakeholders. Internal partnership is focused on creating an atmosphere of partnership within the organization. The aim of the paper is to propose possible changes in the implementation of the S2B internal partnership in terms of University of Žilina. In order to achieve the stated aim, an analysis of the application of the S2B internal partnership at selected universities was performed.

**Keywords** S2B marketing, partnership, university, research activity, technology transfer office, commercialization

**JEL** I23, M31, O30

## 1. Introduction

Science-to-business marketing (S2B marketing) deals with a new concept of entrepreneurial thinking and action at universities and scientific-research institutions. S2B marketing uses modern management and marketing concepts, models and tools and needs a whole new way of thinking in today's scientific and research organizations. [1] It is a set of marketing tools linked to knowledge creation and innovation activity that takes place in a university environment. [2]

S2B marketing is based on the basic marketing principles that can be found in business-to-business (B2B) marketing or business-to-consumer (B2C) marketing. [3]

The S2B marketing mix (known as the 6P) is made up of six marketing tools: product, price, distribution, marketing communication, potential and partnership. [2]

### 1.1. S2B partnership

S2B marketing is characterized by that two different spheres meet, the academic and the business, which are different in many respects, e.g. market orientation; research motivation; use of profit, public contribution. In order to create proper synergy between the participants, special attention has to be paid to the cooperation between them, i.e. partnership. In S2B marketing, partnership refers to the activities whose aim is to create accordance between external and internal stakeholders. [2]

Authors Poyago-Theotoky, Beath and Siegel argue that if there is a positive correlation between investment and time management within the S2B relationship, R&D outputs will get much earlier. Simply put, S2B partnerships are one of the aspects for faster technology diffusion. These findings have important political implications because they confirm the logic of Bayh-Dole legacy lawmakers in the United States. [4]

According to the authors Prónay and Buzás, the S2B partnership represents activities aimed at creating synergy between external and internal actors and internal actors of universities and research institutions with each other, ensuring the effective knowledge and technology transfer to the business environment. [5]

***S2B marketing internal partnership*** is focused on creating an atmosphere of partnership within the organization. It includes the cooperation of researchers and S2B marketing managers, and related to this the provision of two-way (industry – researcher; researcher – industry) flow of information. Two methods are being developed to create an appropriate partner environment, the effective combination of which contributes to the successful knowledge and technology transfer:

- the first method is that researchers are supported by a technology transfer center and other support sites. As a result, relationships within the entire research community are developing;
- the second method is the establishment of a science park or research center where joint R&D activity is under way and supported. On this basis, partnership can also be created between research areas that are remote from each other. In addition, research centers and science parks have greater capability and a better negotiating position towards external partners in commercialization. [5]

# 2. Aim and methodology

The aim of the paper is to propose possible changes in the implementation of the S2B internal partnership in terms of University of Žilina.

In order to achieve the stated aim, an analysis of the application of the S2B internal partnership at selected universities was performed. The analysed universities are:

- Münster university of applied sciences, Germany;
- Coventry university, United Kingdom;
- Saint Petersburg State University of Information Technologies, Mechanics and Optics, Russia;
- University of Žilina, Slovakia.

The result of the analysis is the comparison of selected aspects of S2B internal partnership within analysed universities. This result is an important basis for meeting the aim of the paper.

# 3. Results

This part of the paper focuses on the analysis of the application of selected aspects of internal partnership of S2B marketing in terms of selected universities.

### 3.1. Münster University of Applied Sciences

Management of innovation and knowledge and technology transfer of the Münster University of Applied Sciences (MUAS) is based on three basic principles and communicated through the terms "thinking", "managing" and "acting". Three approaches of the MUAS innovation management concept, also known as the *„Triangle for Innovation“,* are three different MUAS organizational units working interdisciplinary. [6] Table 1. shows the three different levels within innovation production of the MUAS – strategic, analytical-scientific and operational level.

**Table 1**. “Triangle” for Innovation at MUAS

| Approach | Organizational unit | Roles |
|---|---|---|
| Strategic (managing) | Top management MUAS | Strategic planning and decisions making. |
| Analytical-scientific (thinking) | S2B marketing research centre (S2BMRC) | Market reseach and creation of support tools for MUAS management and technology transfer office. |
| Operational (acting) | Transfer agency of MUAS | Technology and knowledge transfer. |

***S2BMRC*** explores and develops new knowledge, models and tools in the field of science marketing and has extensive experience in providing advice and projects to all actors within the research and innovation ecosystem.

S2BMRC's analysis is based mainly on strategic studies such as market potential studies, market diagnostics, awareness surveys, and customer and partner satisfaction surveys. [1]

To evaluate research and technology to identify those with the greatest commercial potential, S2BMRC applies the support tool *TechAdvance™*. The TechAdvance™ concept is made up of the following elements:

- *assessing* – assessment of research projects;
- *structuring* – portfolio management & prioritisation;
- *risk management* – identification of unforeseen project issues;
- *developing* – a guide to develop the “ideal” commercialisation project. [7]

TechAdvance™ is available in the three versions mentioned in the following Table 2.

**Table 2.** Version of TechAdvance™

| TechAdvance™ version | Price |
|---|---|
| **TechAdvance™ Online** | A one year license to use the online version of TechAdvance™ is accessible for an investment of 325 €. Every extra account within the same organisation costs 80 €/year. |
| **TechAdvance™ Handbook** | Alternatively the TechAdvance™ handbook is available for use and can be purchased for an investment of 203 €. |
| **TechAdvance™ Package (1 year online license + handbook)** | If you are interested in the online version of TechAdvance™ as well as the TechAdvance™ Handbook a discount is offered of 80 € as they are both accessible for a total investment of 447 €. |

All of the MUAS´s knowledge and technology transfer processes are conducted through ***Transfer agency at MUAS***, which was established as a spin-off and belongs to the structure of MUAS. Due to the two MUAS campuses, the Transfer Agency offices are located in Münster and Steinfurt.

The specialist team of the Transfer Agency can respond more quickly and more to the needs and requirements of scientists and partners in the business environment. [1]

Based on the strategic alliance of MUAS with the district of Steinfurt, ***The Business and Innovation Park GRIPS*** was established, located in the premises of the Steinfurt campus. It offers canal and lab space for joint research and development projects, the existence of innovative businesses, and the emergence of new technology-oriented spin-offs and start-ups. [8]

The MUAS environment is governed by the slogan "Success needs strong partners", which is why MUAS has created so-called ***Society of Sponsors of MUAS***, which supports the university and helps manage its wide range of science, research, and teaching tasks. This society is operated by the MUAS Transfer Agency. It is made up of businesses, academics, students, graduates or individuals (sponsors) who have a certain connection with MUAS and want to support individual activities to achieve its goals. They undertake and strengthen solidarity with MUAS and strengthen their operations in the region where MUAS is based. Interconnection and support between sponsors is as important as MUAS financial support. Sponsors concentrate their commitment on five key areas:

- practical teaching based on scientific foundations;
- applied research;
- promoting the application of scientific findings on working life in terms of the transfer of knowledge and technology;
- improving the state of equipment in teaching, research and development facilities;

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- promoting international links to higher education institutions and companies.

The annual membership fee in this society is 150 € for businesses, 50 € for private individuals and academics. In case of interest, MUAS graduates have two years of free membership from the day of the state examinations. [9]

### 3.2. Coventry University

Within the scope of commercialization of intellectual property, University of Coventry (CU) has its structures established by the ***Intellectual Property Commercialization Office***. This workplace is responsible for the publication, registration, management and commercialization of intellectual property.

The ***Technology Park of Coventry University*** (TPCU) offers a number of modern office spaces within the entire complex of adjacent business centers. The TPCU is located in the CU campus environment. The TPCU aims to support the emergence and development of innovation-based businesses, high growth potential and knowledge. TPCU includes conference and meeting rooms, research facilities, and business incubators. [10]

Many business activities are carried out and supported through the CU subsidiary, which is ***Coventry University Enterprises Limited*** (CUE).

CUE supports the business objectives of CU´s customers and partners and seeks to maximize the commercial potential of capabilities, expertise and resources of CU. It has a comprehensive range of services to support small and medium-sized businesses to improve and expand their business.

In addition, CUE operates the *TheFutureWorks* workplace, which represents the CU personnel agency. The agency was originally established to acquire and manage the staff for various departments and faculties at CU. Currently, the Agency also works with outside businesses to provide quality, intelligent and flexible recruitment solutions for temporary and permanent employment in all sectors of industry. The agency focuses on companies in Coventry, Warwickshire and the West Midlands. [10]

Within CU there is established the centre so-called ***Enterprise Hub***, a resource for CU´s employees, students and graduates, who are interested in starting a business and setting up a business or developing a social enterprise. This Hub is a contact point for meeting CU professionals and entrepreneurs from different areas and creating a network of similarly minded and oriented entrepreneurs. [10]

### 3.3. Saint Petersburg State University of Information Technologies, Mechanics and Optics

The ***ITMO Technopark*** has been set up to develop the potentially successful activities of researchers and partners at the Saint Petersburg State University of Information Technologies, Mechanics and Optics (ITMO University). This Technopark is not in close proximity to the main campus. It is characterized by synergetic processes of interaction between educational institutions, research institutions and enterprises involved in the commercialization of the results of scientific work and development.

There are significant incubators in the Technopark premises where acceleration programs for start-up companies are provided. [11]

In the ITMO Technopark environment, an innovation department ***Department of Innovation*** has been established, which aims to help researchers work with industry and government, as well as to set up their own start-up companies.

Department of Innovation supports the creation and implementation of new projects in different research areas and includes specific support departments, which are:

- Project office at ITMO University;
- Department of Intellectual Property and scientific and technical information;
- Department of R&D marketing and commercialization;
- Centre for the promotion of youth innovation and technological entrepreneurship. [12] [13]

ITMO University has established its own venture fund ***"ITMO Venture Partners"***. This increases the commercialization potential of scientific research and contributes to the development of spin-offs in the high-tech sector. Activities within Venture Fund also contribute to the learning process of students and graduate students, forming competencies in project management and innovation management, as well as the formation of so-called "soft skills" among engineering students since they will actively participate in the processes of projects development.

Fund invests in companies based on the research results of ITMO University having gone through acceleration and incubation programs, at the seed stage of development in the three priority areas: Health care, Preservation of the human environment and Progressive production and M2M technology. [14]

### 3.4. University of Žilina

An important support department of UNIZA in the field of R&D activities is the ***Department for Science and Research***. It supports research activities of researchers, organizes professional and scientific events, provides technology transfer services, etc. The main task of this department is to coordinate scientific research activities and to ensure the gradual growth of UNIZA pedagogical and research staff. [15]

In 2015, two significant research workplaces were opened in the UNIZA campus, such as the University Park and the Research Center. These research facilities currently form the basis of the interconnection infrastructure of UNIZA's scientific environment and the business environment. In both workplaces, conditions are created for incubators of new companies and broad support for the development of the region. [16]

***University science park of University of Žilina*** (USP UNIZA) is a unique research center at the international level, which includes 15 top-class laboratories. USP UNIZA, through its work, provides opportunities for cooperation for students, researchers and researchers, as well as for entrepreneurs and businesses. The goal of USP UNIZA is to create a functional system for the transfer of research and development results into practice with long-term sustainability and

improvement of quality of life based on technological innovation.

Within USP UNIZA a ***Technology Transfer Center*** has been established, which has its services divided into five areas: intellectual property protection, technology transfer, technology incubator, research activity and education. [17]

***Research centre of University of Žilina*** (RC UNIZA) is a unique R&D workplace in which 23 research and support laboratories are built. Its mission is to act as a regional center of applied research, integrating critical research activities and achieving a synergy effect in utilizing and enhancing UNIZA's research potential. The role of RC UNIZA is not only the realization of excellent research in industrial practice, but especially the realization of research with a direct impact on the ordinary life of a person. [18]

# 4. Conclusions

UNIZA's long-term goal is not feasible without quality science, research and innovation activities in cooperation with leading research centres at home and abroad. The UNIZA's competitiveness in these areas necessarily presupposes cutting-edge instrument and space infrastructure. UNIZA is characterized by a unique research infrastructure and research background made up of several scientific and research centres.

Based on the results of the analysis, we propose to establish a similar workplace as S2BMRC in the UNIZA environment. Within this workplace, activities related to market research and creation of support tools for UNIZA top management and technology transfer centre would be conducted there.

For evaluating the commercialization potential of UNIZA research projects, we propose to purchase the support tool TechAdvanceTM in the "TechAdvanceTM Package" version. This package is available for 447 EUR. The online version would be for Centre for technology transfer´s employees. The handbook would be available to all UNIZA´s employees who would like to use this handbook within their R&D activities.

It would also be appropriate to launch a Society of Sponsors in terms of UNIZA, as MUAS has it so. This Society would be operated by Centre for technology transfer and its members would be Žilina region´s businesses, academics and students of UNIZA and individuals. Society´s members would be committed to support UNIZA´s R&D and education activities, thereby increasing the competitiveness of Žilina region. Finance from paid membership fees would be used for UNIZA´s R&D activities.

In terms of USP UNIZA it would be appropriate to establish a support workplace, such CU has Enterprise Hub. This workplace would be a unique contact point for UNIZA´s employees, students and graduates interested in establish an own start-up. There would be provide a personal meetings with experts from UNIZA and with representatives of selected businesses, especially from the Žilina region.

For UNIZA, we propose to establish a workplace for its own venture fund, as well as ITMO University has ITMO Venture Fund. Priority research areas funded by this UNIZA Venture Fund would be the four USP UNIZA´s research areas: Intelligent Transportation Systems; Intelligent Manufacturing Systems; Advanced Materials and Technologies; Information and Communication Technologies. The members of this fund could be businesses focused on above mentioned research areas of USP UNIZA. Such a fund would be contribute to increasing the commercialization potential of research projects of UNIZA and development of spin-offs within selected research areas.

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# Processing of traffic sign passport on the road no. II/519 from the Prievidza city to end of the village Pribovce

**Jan Palúch[1], Kristián Čulík[1], Matúš Korfant[1], Alica Kalašová[1]**

[1]Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, Univerzity of Zilina, Univerzitna 1 Zilina, 010 26 Slovakia

**Abstract** This paper deals with an analysis of the current situation, a proposal for a new traffic sign passport and economical evaluation of our solutions. Output of our work is new traffic sign passport, which was offered to a, solutions of problematic sections are proposed, including the addition and removal of deficiencies in the selected section of the road. The final part deals with the evaluation of the design of the new road sign passport, which contains the necessary financial costs for the implementation of all modifications on route II / 519.

**Keywords** traffic signs, passport, road communications

**JEL** L92

## 1. Introduction

With the increasing traffic intensity, it is necessary to have high-quality road communications, which are marked with appropriate traffic signs. The main purpose of traffic signs is to inform road users about relevant facts related to the road traffic in accurate and early way. This issue is solved by a traffic sign passport, which significantly affects the safety and fluency of road traffic. For the high-quality traffic sign passport, it is important to analyse specific length of the road and specify dangerous sections. Next step is making of design of traffic signs placement or replacement of current traffic signs. This step can include financial costs connected with the implementation of new traffic signs. The main purpose of our report is to process the traffic sign passport on the road no. II/519. We have chosen specific length of the road - from kilometre 21.574 to 30.074 from the Prievidza city to end of village Pribovce.

## 2. Analysis of Current State

Road no. II/517 begins in Prievidza district in village Nitrianske Pravno on the junction with the road no. I/64. This road comes through border between Trencin and Zilina region to Trencianske Teplice and Martin district. The road ends behind the village Pribovce on the junction with road no. I/65. Total length of the road is 30,074 km. It is very important road that allows transport of goods and passengers between regions, districts, cities and villages. Chosen section of the road for processing traffic sign passport is 8.500 km long. The beginning of the section is on the border of Martin and Turčianske Teplice district. The road comes through villages Benice, Pribovce and around other villages - Leziachov, Turciansky Dur and Klastor pod Znievom. [1, 2, 3]

### 2.1. Problems of Traffic Signs

During the processing of the current situation, we found several deficiencies that affect the road safety. We have performed two traffic surveys. First was performed on October 28, 2017, and the second on January 27, 2018. Subsequently, we analysed both surveys. The analysis allows us to compare the chosen section of the road in autumn and winter and to capture all changes in traffic signs between the first and second survey.

One of the significant deficiencies on the road in village Príbovce is pedestrian crossing, which ends in the middle of junction. Other important deficiency in village is damaged road safety barriers. Road surface on this place is considerably damaged.

Another deficiency on the road is faded traffic signs, which affect the correct and timely awareness of road users. These traffic signs are in village Benice and also in Pribovce.

On the chosen section of the road are also damaged traffic signs, which are damaged with weather condition or damaged by vandalism. In village Benice, there are three covered traffic signs. They are covered with a tree (figure 1).

In front of the village of Moškovec the road sign D46 is missing in the direction of Prievidza. D46 is an informative road sign which indicate the kilometre of the road. This type of traffic signs is missing multiple times on the chosen section of the road.

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**Figure 1.** A sample of traffic signs which are damaged or hidden.

### 2.2. Results of Research

Table 1 shows the different types of traffic signs as well as their total number. In the table are numbers of traffic signs during first and second phase of traffic survey. The analysis of surveys shows, that some traffic signs were added during winter season. Fourteen traffic signs were added to the chosen section of the road no. II/519. Half of them were informative traffic signs.

One of the positive changes is a new warning traffic signs. These traffic signs are warning about the increased risk of ice or snow on the road and the risk of slipping. Also three traffic signs were added and they are limiting the speed of road users in front of the village Moškovec in the direction of Prievidza.

**Table 1.** Number of traffic signs and its comparison

| Type of traffic sign | Number on October 28th, 2017 | Number on January 27th, 2018. |
|---|---|---|
| Warning traffic sign | 28 | 32 |
| Prohibitory traffic sign | 12 | 15 |
| Mandatory traffic sign | 3 | 3 |
| Information traffic sign | 70 | 77 |
| Additional panels | 28 | 28 |
| **Total** | **141** | **155** |

The following table (table 2) shows the deficiencies of traffic signs during the second survey on the road no. II/519.

The total number of vertical traffic signs was found from the surveys, as well as from information provided by Slovak Road Administration. They allowed us to check their traffic sing passport for the road no. II/519. This passport was old several years and many traffic signs were missing on it. We have updated their traffic signs passport with results from our later survey, so we have recorded all new traffic signs from chosen section of the road.

**Table 2.** Type and numbers of traffic signs errors

| Deficiencies of traffic signs | Number |
|---|---|
| Faded | 3 |
| Damaged | 11 |
| Missing | 15 |

Total number of missing traffic signs was 15. The most of them indicates the distance in kilometres. The most damaged were information traffic signs – eight of them are damaged.

The correct vertical traffic signs are designed to ensure their visibility, clarity, simplicity and usefulness. Total number of correct traffic signs is 170 and unsuitable traffic signs make 17% of total amount.

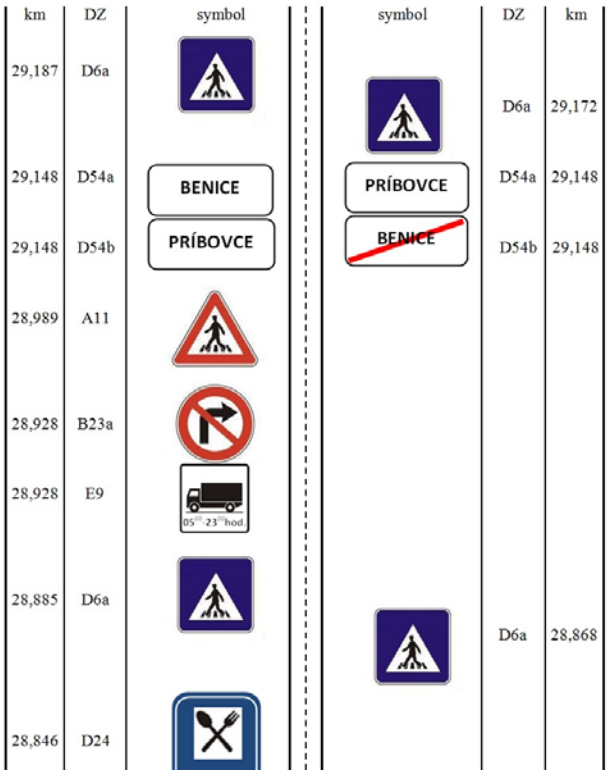


**Figure 2.** A sample part of traffic sign passport.

## 3. New Traffic Sign Passport

The new traffic sign passport includes the addition of vertical traffic signs on a selected section of the road, which can increase the safety and fluency of road traffic. On the whole section of the road there is uneven road surface and also road edges are in bad condition. For these facts it is necessary to warn road users.

The problem is also the intersection behind the village of Príbovce in the direction of Martin. It is intersection of roads no. I/65 and II/519. This intersection is very dangerous and it is the place where many traffic accidents were happen.

Plan is to completely modify this junction and making independent traffic lanes for different directions.

Other proposal is to move pedestrian crossing 10 m away from the junction. It will be necessary to remove the railing at the end of the new pedestrian crossing.

The next step to improving the awareness of road users is to place the missing traffic signs indicating the kilometre of the road. The selected section of the road should have 18 pieces of this type of traffic signs.

In the village of Pribovce, Benice and near the village of Leziachov are pedestrian crossings, which are marked with information traffic signs D6a. Visibility of pedestrian crossing can be improved with the same traffic sign, but only in a reflex version. On the chosen section of the road, there are 7 pedestrian crossings. The lighting of pedestrian crossings is provided by street lighting.

At the beginning of the village Benice speed of vehicles is changing from 90 km/h to 50 km/h. To ensure that speed is maintained in the village, it is possible to place a radar speed sign. It is possible to place it 15 metres behind the beginning of the village. The radar speed sign can measure speed of road vehicles in range from 10 to 199 km/h. It can be powered from the electrical network, solar collectors, or street lighting during night and from 12 V accumulators during day. This device can also count vehicles, which exceeded speed. Measured data are stored for 180 days. [4]

# 4. Economical evaluation

The price list of selected traffic signs and speed measuring devices was obtained from commercial suppliers. The proposal itself consists of the financial costs for:

a) relocation of pedestrian crossing in Príbovce,
b) the replacement of unsuitable traffic signs,
c) the new traffic signs and radar speed sign,
d) the new lighting of pedestrian crossings.

### 4.1. Relocation of Pedestrian Crossing

The relocation of specific pedestrian crossing means its 10 metres shifting away from the junction, so it will be closer to bus stop and village Benice. It will be necessary to apply horizontal and vertical traffic signs. The price of material, road cleaning and application of the pedestrian crossing is 34.50 €/m$^2$. The pedestrian crossing has a width of 2.0 m and a length of 7.5 m. The total price is 517.50 € without VAT. [5]

### 4.2. Replacement of Traffic Signs

Total number of insufficient traffic signs on the chosen section of the road is 29. All traffic signs have their own supporting structure, which is necessary for their correct installation. In the next table are described costs of replacing the faded, missing and damaged traffic signs. All prices of traffic signs are without VAT and they do not include transportation and installation.

**Table 3.** Financial costs for replacement of faded, missing and damaged traffic signs

| Traffic sign | Traffic sign number | Price of the tr. sign [€] | Number | Total price [€] |
|---|---|---|---|---|
| Kilometre of the road | D46a | 22.00 | 15 | 370.00 |
| Main road | D1a | 29.00 | 1 | 29.00 |
| Left turn prohibited | B23b | 42.00 | 1 | 42.00 |
| All vehicles prohibited | B2 | 33.00 | 1 | 33.00 |
| Hotel or motel | D23 | 29.00 | 1 | 29.00 |
| Restaurant | D23 | 29.00 | 1 | 29.00 |
| Directional sign | D39c | 50.00 | 2 | 100.00 |
| Directional arrow | E7 | 11.00 | 2 | 22.00 |
| Priority route configuration | E2b | 29.00 | 1 | 29.00 |
| ***Total*** | - | - | ***18*** | ***683.00*** |

Total costs of replacing the faded, missing and damaged traffic signs are 683.00 € without VAT. [6]

### 4.3. The New Traffic Signs and Speed Meter

Addition of new traffic signs and radar speed sign is based on our proposal of a new traffic sign passport. Financial evaluation of new traffic sign passport is in the table 4. All prices are without VAT and they do not include transportation and installation of traffic signs.

**Table 4.** Financial costs of new traffic signs

| Traffic sign | Traffic sign number | Price of the traffic sign (€) | Number | Total price(€) |
|---|---|---|---|---|
| Pedestrian crossing | D6a | 160.58 | 16 | 2569.28 |
| Bus stop | A13 | 29.00 | 10 | 290.00 |
| Uneven road ahead | A5 | 30.00 | 2 | 60.00 |
| Dangerous road edge | A7 | 30.00 | 2 | 60.00 |
| Caution children | A15 | 30.00 | 1 | 30.00 |
| ***Total*** | - | - | - | ***3009.28*** |

In total, we would place 31 new vertical traffic signs on chosen section of the road. These traffic signs can increase the road safety and pedestrian protection. Not all traffic signs will need a supporting structure for installing. These structures near pedestrian crossing can be used also for new reflexive traffic signs.

The price of the radar speed sign is 1 908.30 €. The selected device is the BX-300 with a screen size of 800x600 mm. Total price of new traffic signs, BX-300 and supporting structures is 5 563,78 € without VAT. [4]

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### 4.4. New Lighting on Pedestrian Crossings

Pedestrian crossings can be illuminated by a light device called LED Crosswalk. The lifetime of LED bulbs is 50,000 - 100,000 hours according to manufacturer data. One light device is sufficient for each pedestrian crossing. The financial costs of LED Crosswalk are € 3,206.34 excluding VAT. [7]

## 5. Conclusions

Our aim was the design of a new road sign passport on the road no. II/519 in kilometers from 21.574 to 30.074 from the city of Prievidza to the end of the village of Pribovce. Analysis shows that 155 traffic signs were placed on chosen section of the road. Unsuitable traffic signs make 17% of total amount.

The total cost of removing the above-mentioned inadequacies, including the addition of additional traffic signs and speed measuring devices in the design of a new traffic sign passport on the road no. II/519 amounts to € 9 970.62 excluding VAT. The financial cost of implementing individual modifications can improve the safety and fluidity of road traffic.

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# Stratification of postal areas

**Matej Pechota[1], Lucia Možuchová[1]**

[1]Department of Communications, Faculty of Operation and Economics of Transport and Communications, University of Žilina, Slovakia

**Abstract** The postal network consists of sending points, delivery points or shipment between these points. Its separation within the selected country is important. The stratification of postal areas has an impact for example on the length of the transit time, the number of posts to be operated and the associated operating costs. Stratification of postal areas is affecting several areas. In this article, we will focus on stratifying postal areas depend from the transit time. The article proves importance of the stratification because it is one piece of real mail studies.

**Keywords** postal area, stratification, transit time, EN 13850, real mail studies

**JEL** L87, L86

## 1. Introduction

Every of the postal operator has to separate country area into the postal areas. Number of the postal areas depends on amount of sent items in the area, number of citizens and there are rules as well. We would like to present in this article, aspects that are useful for the next stage in stratification of the postal areas. Throughout this article there will be theoretical bases about the general definition of postal services, stratification based on the European standard EN 1380. More important is the methodology which we applied to program features for dynamic map of postal areas which is separated based on the rules and standard. We applied mathematics method to calculate part of amount of the sent letter mails in each postal area. Thanks to the stratification of the postal area can be improved the methodical of transit time and change will be shown real time because of the program. According to these results we can decide how to improve methodical transit time and postal services as well.

## 2. Theoretical bases

To get closer to the main topic of this article we will describe postal services as well as definition of the stratification of postal areas.

The post - is a fixed establishment designed for the selection and distribution of postal items and the sale of postal censuses. The "mail" label can only be used to indicate the access points of the public postal network and the public postal network contact points. This is without prejudice to the right to use the word "mail" in combination with other words as part of the business name of the postal undertaking or as part of the postal service's postal service name provided the distinguishing feature of the sign under the first sentence is ensured. [7]

### 2.1. Postal services

Postal services are provided by postal operators in each country. We are going to focus on national postal operators which should provide special postal services. This postal service can be called “universal service” and it means that:

“It is an offer of postal services which serves the minimal needs of all postal service users in Slovakia and to ensure accessibility to access points of the public postal network and the contact points of the public postal network under the same conditions within a specified quality at a fair price. Every working day with at least one recess and daily delivery.” [1]

Postal services topic is too big for this article; hence we should concentrate on two main services which is provided by the national postal operator. These are: [2]

#### Letter mail

Letter mail is the most popular service provided by postal operators in the selected area. Letter mail is a letter service communication or small article sent by this operator. You can send it within the domestic area or abroad. Letter mail has got some specifications which are different in every country. You can use it for sending letters, letters for the blind, direct mail (within Slovak Republic). Communications can be sent on any kind of physical media (paper, card, CD, DVD). There could be different quality standards of transit times, size and weight, but in Slovakia the specifications for letter mail are the following:

- **Letters within the Slovak Republic:**
  - 1st Class Letter - D+1 (delivery on the next working day after the day of posting),

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- 2nd Class Letter - D+2 (delivery on the second working day after the day of posting)
- Letter for blind - D+4 (delivery on the fourth working day after the day of posting),
- Direct mail - D+4 (delivery on the fourth working day after the day of posting),

- **Letters abroad**
  - assumed transit times of letters addressed abroad depend on the respective country of destination, for an expedite transit time, choose the "1st Class" Letter option [2]

Letter mail is a paid service, but every country has got different control devices which control if the price is regular for that market. There are many things which are important to set up for the right price for this service. Analysis of these topics is too large, and it is not the main area to be characterised. There is one thing which is set up for letter mail and that is the method of payment. Here are some possible methods of payment for letter mail:

- cash,
- postage stamps,
- bank transfer,
- postage credit,
- franking machine.

There are also some special services which can be added to it. It is for example: Reply service, Withdrawal of an Item from the Post at posting, Withdrawal of an Item from the Post at delivery, return to Sender immediately, do not redirect, return to Sender after ... days, do not return these special services are provided for letter mail send in domestic service. For those letter mails, which are sent abroad there are these possibilities: Reply service (up to 50 g to all countries, above 50 g to shortlisted countries), Withdrawal of an Item from the Post at posting, do not redirect, Poste restante. [2]

### 2.2. Geographical stratification

The relationship between the point of delivery and the point of delivery characterizes each shipment geographically. Both points together represent a delivery area, a delivery area, a certain distance, and the complexity of geographical postal logistics between them. Stratification according to the geographic features of shipments must reflect possible logistical differences in the distribution of shipments between different delivery, delivery and distribution distances. Geographic stratification is therefore based on the postal logistics structure. When submitting and delivering, the area must be partitioned into at least three mutually exclusive postal areas. Postal areas are derived from the logistics structure of postal operators. It must ensure a complete geographic coverage of the study. [4]

The geographical breakdown of groups must be done by random selection. The entire geographic area defined in the study area is appropriate. Sender and recipient groups must be scattered in a geographic raster to recruit group members based on postal zones operated by operators. Spread of the group must ensure that all postal areas defining geographic stratification are covered.

Postal areas must be separated into the two main groups. There are cities and local areas. City area is area where the number of citizens is 50 000 or more. City area must be independently.

Local area is area where number of citizens is less than 50 000. Local areas may be merged.

Postal areas may be merged in way where the transport of the postal items will not be worse. [3]

## 3. Methodology

Stratification of the postal areas is currently already done. We comprised current stratification due to standard and rules. Based on right methodology we could program dynamic map of postal areas.

### 3.1. Comparison

There are too many definitions of comparison. It depends of what field you would like to compare. But basically, comparison means to find some differences between something. We can compare economics, trends, marketing campaign etc. In this case I am going to compare amount of sent items. It is comparison of statistics information. In many cases, a researcher is interesting in gathering information about two populations to compare them. As in statistical inference for one population parameter, confidence intervals and tests of significance are useful statistical tools for the difference between two population parameters. In this case parameters are amount of sent items in next chapter I will compere data from five years. Comparison consists of three main steps for example:

a) Collecting data
b) Ensure consistency of information
c) Select on effect to compare

Comparison can do only when data are consistence and it is possible to compare it. You cannot compare incomparably. [5,6]

### 3.2. Merging and partitioning areas

Merging is process where the two or more areas are getting into one group. It means they form one area.

Postal area should be merge when the amount of sent or delivered items are too less. In this case postal area needs to be merge to another postal area where the amount of sent or delivered items are too less as well.

Less amount of sent or delivered items are less than 10 % per main processing centre.

Partitioning is process where in the area exist city area or where the amount of sent or delivered items are more than 10 %.

Postal city area must be separately from the other postal areas because of the real mail studies. [3,7]

# 4. Results

Due to analysis of the Slovak postal stratification we found out way how to upgrade postal areas. The postal areas are stratified at the level of district processing centers. District processing centers are postal areas, which also results in areas where the share of the total volume of leaf items is very small. This small share of the total volume of letter shipments is the reason for the merging of postal areas. Other reasons for merging postal areas include:

• insufficient distribution of urban and rural areas due to the absence of a study of actual flows;

• selected areas district processing centers have a very low share of shipments;

• from the point of view of the size of the country in which the measurement is applied is the number of postal areas - 43 for comparison. The Czech Post divides the territories into 53 postal areas (the size of the Czech Republic is 1.6 times larger than that of the Slovak Republic).

Based on the requirements of EN 13850 and the above, we have designed postal areas that comply with EN 13850 and stratification of postal areas is directly proportional to the size of the Slovak Republic. For the design of postal areas, we have defined urban and rural areas where:

• The urban area is where the population is equal to or greater than 50,000.

• The countryside is where the population is less than 50,000.

According to the data from the Statistical Office of the Slovak Republic, we found the following:

• There are 10 sites in the Slovak Republic that meet the requirement of EN 13850 to be categorized into urban areas: Bratislava, Trnava, Trenčín, Nitra, Žilina, Martin, Banská Bystrica, Poprad, Prešov and Košice,

• There are 26 District Processing Centers with a very low proportion of shipments that we propose to merge,

• Urban areas should be removed from the postal areas to be independent of actual flows.

Under the terms of the standard and the information we have acquired, we propose to merge postal areas with a low share of mail so that the logistics processes of the postal network are not compromised. At the same time, we propose to divide the postal areas where the postal city area is located, ie. the urban postal area must be a separate study of actual flows. To better visualize the merging or distribution of postal areas, an example of the postal areas served by the main processing center in Žilina.

**Table 1.** Current postal areas

| Current areas | Number of citizens local area | Number of citizens city area | Rate of letter mails % |
|---|---|---|---|
| OSS Liptovský Mikuláš | 72452 | | 8,27 |
| OSS Ružomberok | 56942 | | 8,93 |
| OSS Martin | 57414 | 55332 | 10,85 |
| OSS Púchov | 44434 | | 3,38 |
| OSS Považská Bystrica | 62810 | | 10,61 |
| OSS Trenčín | 154929 | 55593 | 15,23 |
| OSS Žilina | 139579 | 81041 | 22,05 |
| OSS Čadca | 90739 | | 8,17 |
| OSS Dolný Kubín | 137279 | | 12,5 |

In the above-mentioned district processing centers with the relevant inhabitants in the area and percentage of the consignments within the main processing center Žilina. According to the rules of urban and rural postal areas, which we defined at the beginning of this subchapter, we proposed the merger and division of postal areas. After merging and splitting the postal areas within the main processing center in Žilina, the following were:

**Table 2.** Suggested postal areas

| Postal area | Old stratification | District |
|---|---|---|
| mMT | OSS Martin | Martin city |
| mZA | OSS Žilina | Žilina city |
| mTR | OSS Trenčín | Trenčín city |
| DK, LM, RK | OSS Dolný Kubín<br>OSS Liptovský Mikuláš<br>OSS Ružomberok | Dolný Kubín<br>Liptovský Mikuláš<br>Ružomberok<br>Námestovo<br>Tvrdošín |
| vZA, CA, vMT | OSS Žilina<br>OSS Čadca<br>OSS Martin | Žilina local<br>Čadca<br>Martin local<br>Bytča<br>Kysucké Nové Mesto<br>Turčianske Teplice |
| vTR, PB, PU | OSS Trenčín<br>OSS Považská Bystrica<br>OSS Púchov | Trenčín local<br>Púchov<br>Považská Bystrica<br>Ilava<br>Bánovce nad Bebravou |

The previous table lists the postal areas we have designed. Compared to the original postal areas where the postal areas are not divided into urban and rural areas and the percentage of postal areas is low, there are a total of 9 postal areas. [8,9]

The proposal created by us has divided the postal areas into the urban and rural postal areas and we have also secured

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an increase in shipments in the postal sector. Our proposal therefore counts with 3 urban postal areas and 3 rural postal areas, a total of 6 postal areas served by the main processing center in Žilina. The difference is in the number of postal areas, the volume of postal items in the postal area, a qualitative increase in measurement of 2nd class letter shipment. The postal area map is used to view the changes.

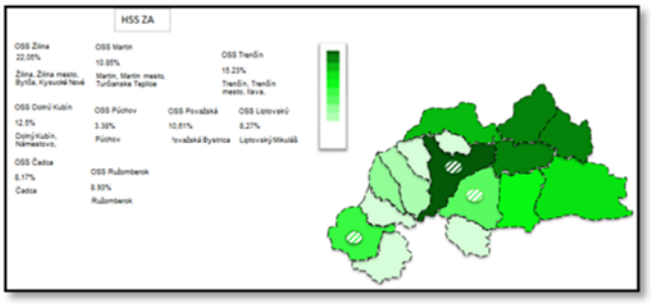


**Figure 1.** Map of the current postal areas

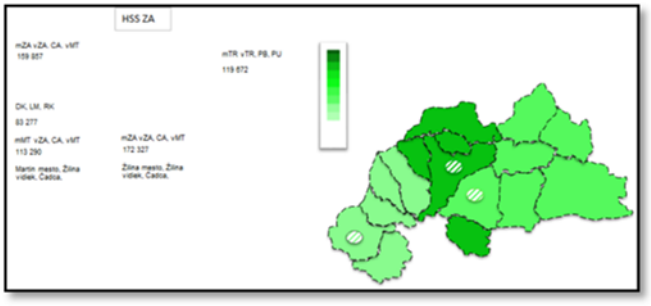


**Figure 2.** Map of the suggested postal areas

Design of suggested postal area based on the eauropean standard EN 13850 and the other rules can aplicated to all postal areas on Slovak postal market.

## 5. Conclusions

Postal stratification is important because of transit time, quality of the postal services and customer satisfaction as well. Stratification of the postal areas is just one part of real mail studies. Nowadays number of postal areas on Slovak postal market are not stratified due to rules and standard. There are missing city areas, and local areas with rate of sent of delivered items more than 10 per main processing centre. Based on this information we stratified postal areas in main processing centre of Žilina. We suggest to stratified postal areas into the three city areas and three local areas duet to rules and standard. This process can be applied on all Slovak postal market.

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# Transport costs and their impact on the expansion of cities and agglomerations

**Miloš Poliak[1], Juraj Hammer[1], Peter Medviď[1], Kristián Čulík[1]**

[1] Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Univerzitná 1, Zilina, 010 26, Slovak Republic

**Abstract** Costs as a component that represents the decision-making factor for each individual or company, we are meet every day. This article focuses on transport costs that have an impact on urban sprawl, reverting to the source of the individual's transportation target and changing the choice of transfer decision-making with respect to transport costs. Habits how to move from one place to another, in greatly affects the means of transport used by the individual. It is this factor, how to positively influence a passenger to replace individual car traffic for another mode of transport by means of transport costs this article will be dealt with. The degree of automotive has a rising character over the year. It is precisely a tool for helping to partially eliminate the negative impact of individual car traffic on society and city expanses are transport costs.

**Key words** transport cost, expansion of cities, parking

**JEL** O18, R41

## 1. Introduction

The various studies carried out in the world in the field of transport point to reality, that in spreading the radius and the area of the city to wider areas, it is necessary to use a car for transport to these more remote parts of the city, as a relocation tool. A car is just one of the most important factors affecting the shape and appearance of the city [1]. This also entails transport costs for relocation from one part of the city to another part of city. When using a car as a means of transport for convenient transportation to the destination of the chosen destination (such as employment, school, interest activities...), occur suddenly at certain time periods of the day called, intense toes, congestion. They bring you directly and are related to the costs that a car user must incur. As a result of staying in congestions, the driver and potential co-driver loses the time that could be used, for example, for labour productivity. This effect of losing time and costs associated with it is also called externality [2].

The study conducted in the US in 2003 estimates that by adding the value of the time lost to the amount of unnecessary fuel consumed due to delays and slow operation have been counted in the annual surplus of traffic congestion worth $ 63 billion [3]. It is also proven by this study, that unrequited types of roads cause an undue burden on roads and thus the spread of cities and agglomerations [4]. Little attention has been paid to the various studies of transport costs such as vehicle insurance, car maintenance charges and parking fees as factors that act on urban growth. In this article we will focus on one of the cost factors, namely the price for parking.

## 2. Price for parking

In general, for years, it was self-evident to park with a vehicle in the center of the city even without charge [5]. At this time, there has been a change in this area with the rising pace of automotive levels and there are already many restrictions on vehicle parking in city centers (for example in some cities there are emission zones, more expensive parking fees, fewer stables, and so on). The following tables show the development of a change in the growth of passenger cars respectively a change in the growth of the automotive grade in the EU Member States during 2013 – Table 1 and year 2014 – Table 2. Also, the chart shows a statistical overview of the level of automobile in years 2013 and 2014 in EU member countries. In Table 3 and the following chart shows an increase in the change of automobile in the year-on-year comparison 2013 and 2014 (Eurostat – annual report of the year 2017) [6].

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**Table 1.** Automotive degree in the EU Member States for 2013

| Country | Number of cars per 1000 inhabitants | State | Number of cars per 1000 inhabitants |
|---|---|---|---|
| **BE** | 491 | **LT** | 615 |
| **BG** | 402 | **LU** | 661 |
| **CZ** | 450 | **HU** | 308 |
| **DK** | 405 | **MT** | 602 |
| **DE** | 543 | **NL** | 471 |
| **EE** | 478 | **AT** | 546 |
| **IE** | 420 | **PL** | 504 |
| **EL** | 466 | **PT** | 430 |
| **ES** | 474 | **RO** | 235 |
| **FR** | 504 | **SI** | 516 |
| **HR** | 341 | **SK** | 347 |
| **IT** | 608 | **FI** | 574 |
| **CY** | 553 | **SE** | 466 |
| **LV** | 317 | **UK** | 468 |

*Source: processed by the authors from Eurostat statistics 2017*

**Table 2.** Automotive degree in the EU Member States for 2014

| Country | Number of cars per 1000 inhabitants | State | Number of cars per 1000 inhabitants |
|---|---|---|---|
| **BE** | 491 | **LT** | 620 |
| **BG** | 405 | **LU** | 752 |
| **CZ** | 468 | **HU** | 308 |
| **DK** | 439 | **MT** | 602 |
| **DE** | 581 | **NL** | 494 |
| **EE** | 494 | **AT** | 546 |
| **IE** | 441 | **PL** | 513 |
| **EL** | 472 | **PT** | 444 |
| **ES** | 492 | **RO** | 239 |
| **FR** | 531 | **SI** | 542 |
| **HR** | 349 | **SK** | 360 |
| **IT** | 630 | **FI** | 593 |
| **CY** | 563 | **SE** | 498 |
| **LV** | 323 | **UK** | 507 |

*Source: processed by the authors from Eurostat statistics 2017*

In Table 3 we can observe an increase in the change of automobile in the year-on-year comparison 2013 and 2014 according to statistical data provided by Eurostat. In most Member States of EU, an increased number of passenger cars can be observed within one year [7]. Slovakia is the country average in statistics with a year-on-year increase in the number of passenger cars per 1000 inhabitants with a year-on-year increase in the number of 13 passenger cars per 1000 inhabitants [8].

**Table 3.** Year-on-year increase in automotive grade in EU member countries in 2013 and 2014

| Country | Number of cars per 1000 inhabitants | State | Number of cars per 1000 inhabitants |
|---|---|---|---|
| **BE** | - | **LT** | 5 |
| **BG** | 3 | **LU** | 91 |
| **CZ** | 18 | **HU** | - |
| **DK** | 34 | **MT** | - |
| **DE** | 38 | **NL** | 23 |
| **EE** | 16 | **AT** | - |
| **IE** | 21 | **PL** | 9 |
| **EL** | 6 | **PT** | 14 |
| **ES** | 18 | **RO** | 4 |
| **FR** | 27 | **SI** | 26 |
| **HR** | 8 | **SK** | 13 |
| **IT** | 22 | **FI** | 19 |
| **CY** | 10 | **SE** | 32 |
| **LV** | 6 | **UK** | 39 |

*Source: processed by the authors from Eurostat statistics 2017*

It's just free parking that motorists have been used to in the past, significantly influenced the decision to travel an individual by an individual car transport and discouraged them from all other forms of commuting such as the use of public passenger transport, or the use of bicycles, if necessary on foot [9]. Automobile is generally defined as the level of occupation of the population by private cars [10]. It is expressed in two ways. The first is the ratio of the number of inhabitants per passenger car (Fig. 1) or the automobile is expressed as the number of passenger cars per 1000 inhabitants (Fig 2) [11]. In both cases of expressing the automobile, the annual trend increase in the number of cars is obvious of the population of the SR. The current development of automotive in Slovakia can be defined as gradually developing dynamically, where the number of passenger cars increased 3.4 times compared to 1970 to 1980, between 1980 and 1990 it was 1.6 times, between 1990 and 2000 it was 1.5 times and in the years 2000-2010 by 1.3 times. This trend in the number of passenger cars in Slovakia suggests, that we are approaching the EU average, where in 2013 passenger car equipment in 28 member countries was worthwhile 471 cars per 1000 inhabitants. This development over the years has an unfortunate impact on the number of vehicles on the road, with related congestion [12]. The higher the number of cars, the higher the economic performance of the society, but as a result it has negative impacts on transport and the associated increased transport costs.

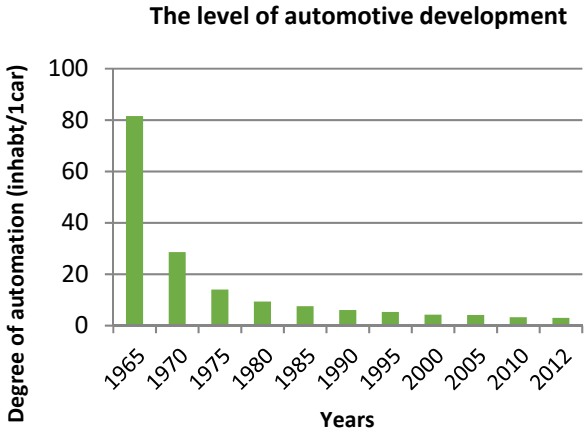


**Figure 1**. The trend of the development of the automobile degree in Slovakia, which shows the ratio of the number of Slovak citizens living on one passenger car; Source: processed by author according to ŠÚSR

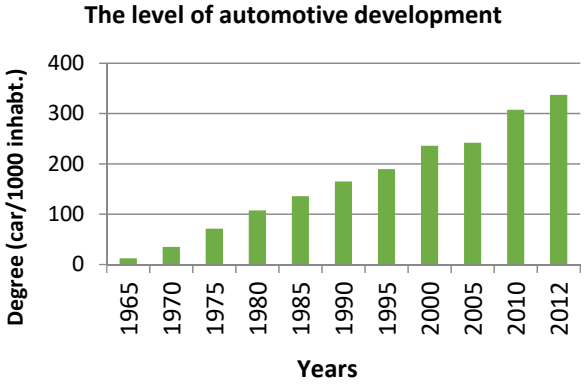


**Figure 2**. The trend of automotive development in Slovakia, which shows the number of passenger cars per 1000 inhabitants

Charging parking and deciding how much parking will be, has in competition of city leadership in the city centers. As this is a political decision, payment factor for parking, it is one of the unpopular steps to increase the cost of parking. However, it is necessary to proceed to this step, with regard to the annual growth of cars in the world. The degree of automobile, determined by the number of passenger cars per 1000 inhabitants compared to 28 countries EU, Japan, China and Russia for 2015 is shown in Figure 3.

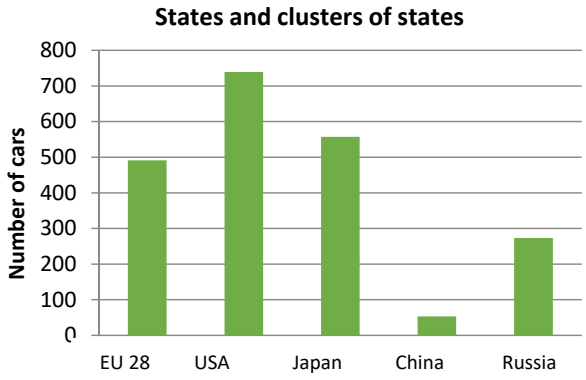


**Figure 3**. The degree of automobile, determined by the number of passenger cars per 1000 inhabitants, is compared between 28 states EU, Japan, China and Russia for year 2013; Source: processed by the authors from Eurostat statistics 2017

Obviously, when deciding the population on housing in the long run residents of the city do not consider when deciding which part of the city to choose for their residence with regard to commuting and moving to the destination selected, in terms of parking costs and their impact on these factors. But this claim is no longer valid for newly immigrated populations who are already considering what impact the rising costs of living would have, the further away from the city center. Just the cost item of the parking rate shows a change in the behaviour of immigrant behaviour in the city in terms of transport. Many studies have shown, that car drivers are aware that they will have to accept and accept additional increases in transport costs with increased parking prices [13]. This type of population, newcomers can reassess their choice of housing in suburban areas of the city and potentially decide to approach the city center, so that they can use the benefits of urban public transport system more effectively. This would reduce the need to travel to the city center by individual car transport and ultimately reduces transport costs at the cost of parking. The rise in cities also results in an increase in the level of automotive worldwide. It results from the fact that the population owning a passenger car is willing to be transported to its target location even assuming, that it will be a longer distance from the source of the starting point. This has a negative financial impact, because it accepts all transport costs, which this relocation brings with it. Long distance transport generally means increased costs for the passenger, in the form of loss of time and finances.

Single European Transport Area Plan, due to the competitiveness of the transport system efficient resource, in the so-called " The White Book is the mentioned aspect of the future development of passenger transport by 2050 [14]. It is mentioned in this document that without effective action how different costs are passed on to car users, the automobile will only grow. Passenger transport by 2030 should be increased by 34% and by 51% by 2050 [15]. Thanks to this future development, urban sprawl can also be

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expected. Transport costs and many other limitations should contribute to a reduced rate of such forecasts. It is up to the decision of the cities and authorities that have their own parking space, how they will face the cost of passing on the cost to vehicle users, whether they will be charged to a greater extent, or the cities themselves will negatively affect the expansion of cities.

## 3. Conclusion

By pointing to the current state of individual car transport, due to the spread of places can be noticed, that without balanced, effective decisions they should make the transfer of user costs will not occur. The transport costs are one of the effective tools to eliminate negative impacts of cars in city centers. Reduce the need for the use of passenger cars to a minimum or in inevitable situations for commuting people within cities and to replace the mode of transport by public transport would be an optimal scenario. It is the cost of motorists to drive them off, why in the growing cities to use the car to move. The transport costs as a parking and economic aspect will be an instrument as from city centers to reduce the number of vehicles and associated with agglomeration expansion.

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# Driver Training

**Vladimír Rievaj[1], Ján Gaňa[2], Tomasz Figlus[3]**

[1]Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina in Zilina, Zilina, 010 26, Slovak Republic
[2]LS Intertank Slovakia s.r.o., Hlboké nad Váhom, 014 01, Slovak Republic
[3]Department of Automotive Vehicle Construction, Faculty of Transport, Silesian University of Technology, Katowice, 40 019, Poland

**Abstract** Road transport has become a very important part of supply chain management. The large number of vehicles in op-eration requests large number of qualified person to operate them. The lack of young person interested in this job and obstacles in the training and qualification process result in current labour market state when large number of person are missing.

**Keywords** drivers, training, qualification

**JEL** R40

## 1. Introduction

Road transport is an inseparable part of almost every activity of human being. It's not possible to transport raw materials, semifinished products and products from a place of it's origin to a place of it's consumption without road transport vehicles. Indeed, road transport provides transport of manpower to a job or for relaxation. Disadvantages of road transport is production of green-house gasses, occupation of land for road infrastructure and production of waste that is hard to dispose in nature too.

Every vehicle has to be controlled by a human to perform it's functions. Human is not perfect in his principle so accidents caused in absolute majority by human hap-pen as an accompaniment of road traffic.

Basic requirement to minimize the number and seriousness of mistakes caused by a human while driving a vehicle is improving his manual and theoretical skills. Even experienced driver might fall into stereotype in his practice and solve situations according to his previous experiences regardless of the innovations of vehicles and road infrastructure. These changes mean pressure to improve driver's knowledge and skills. It is essential to change the way of operating the vehicle by driver to ensure higher safety and optimisation of the transport cycle, minimisation of fuel consumption and reducing the production of emissions. Driver, his knowledge and skills are the basic attributes to fulfil these targets.

## 2. Legislation and Regulation

EU issued DIRECTIVE 2003/59/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 July 2003 to improve the theoretical and practical skills of drivers that sets the initial required age of drivers of certain class of vehicles and periodic training with scope and content of driver's training to be able to perform as drivers.

According to this directive, Slovak Republic issued Act 280/2006 Coil., on the initial qualification and periodic training of drivers of certain road vehicles. This legislative act sets the initial age for driving certain class of vehicles. The initial limits based on Slovakian trans-position of the EU directive are in Table 1.

**Table 1.** Age limits and requirements for initial qualification for driving vehicles according to Act 280/2006 Coil.

| Vehicle class | 18 years | 20 years | 21 years | 23 years |
|---|---|---|---|---|
| C1 ; C1+E | 140 hours | | | |
| C ; C+E | 280 hours | | 140 hours | |
| D1 ; D1+E | 280 hours | | 140 hours | |
| D ; D+E | | 280 hours | lines up to 50km 140 hours | 140 hours |

This version is valid for Slovakia from 1 January 2016. Till then, limits were 21 years for category C and C+E and 24 years for category D and D+E.

Legislation [7] sets for vehicles:

*class B*

a) motor vehicles except vehicles of category AM, A1, A2, A and T, with maximum authorized mass of 3 500 kg, designed to transport maximum eight person except the driver. Vehicle from this category is allowed to tow a trailer with maximum authorized mass weight of 750 kg.

b) motor vehicles according to section a) with trailer with maximum authorized mass over 750 kg, total maximum authorized mass of both vehicles is less than 4 250 kg.

*class C1*

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includes motor vehicles except class D1 or D, with maximum authorized mass over 3 500 kg and less than 7 500 kg, constructed and designed to transport up to eight person except the driver. Trailer of maximum authorized mass to 750 kg might be coupled to a vehicle from this category.

*class C1E*

includes combinations of vehicles made up of a C1 class truck and a trailer with maximum authorized mass exceeding 750 kg and maximum authorized mass of this combination doesn't exceed 12 000 kg, or a combination of a class B vehicle and a trailer with maximum authorized mass exceeding 3 500 kg, total maximum authorized mass of this combination doesn't exceed 12 000 kg.

*class C*

includes vehicles other than those in class D1 or D that have been constructed and designated for transportation of no more than eight persons, excluding the driver, and whose maximum authorized mass exceeds 3,500 kg. A motor vehicle of this class may be coupled to a trailer with maximum authorized mass not exceeding 750 kg.

*class CE*

includes combinations made up of a class C motor vehicle and a trailer whose maximum authorized mass exceeds 750 kg.

*class D1*

includes motor vehicles constructed and designated for transportation of up to 16 persons, excluding the driver, and whose length does not exceed 8 m; a motor vehicle of this class may be coupled to a trailer with a maximum authorized mass not exceeding 750 kg.

*class D1E*

includes combinations made up of a class D1 towing vehicle and a trailer with a maximum authorized mass exceeding 750 kg.

*class D*

includes motor vehicles constructed and designated for transportation of more than eight persons, excluding the driver; a motor vehicle of this class may be coupled to a trailer with a maximum authorized mass not exceeding 750 kg.

*class DE*

includes combinations made up of a class D motor vehicle and a trailer with a maximum authorized mass exceeding 750 kg.

# 3. Historical overview

In past, BUS and trucks drivers were trained in driving schools according to orders from army. The new members of army were trained before they started their mandatory military service in army and got the relevant driving licence. They were drivers and got basic experience with driving the vehicles during the two year mandatory military service in army. Army had exceptions based on a valid edict in § 19. According to this, issuing of driving licences for vehicles of army and safety corps was under special regulation. Members of army and safety corps were allowed to drive also civilian vehicles with these driving licences. After the two year mandatory military service in army, they left with certain experience with driving, maintaining and servicing the vehicles. Therefore market was supplied with trained drivers every year and the missing number of drivers was easy to supply from driving schools. After the cancellation of mandatory military service, this process that supplied new qualified drivers stopped as the army employed the drivers as civil employees who don't work for transport companies in civil sector anymore.

According to [4 a 5] minimum age to get driving licence for vehicles class C in civil sector was 18 years and class D 21 years. In 2010, these limits were modified by labour law No. 144 in § 78 as follows:

18 years for applicant to get the driving licence for vehicles class C1 and C1E, 21 years for applicant to get the driving licence for vehicles class C, CE, D1 and D1E, 24 years for applicant to get the driving licence for vehicles class D and DE. This change is valid up to this day even it is in conflict with mentioned labour law No. 280/2006 with later regulations valid from January 2016.

# 4. Actual state

According to latest information from ČESMAD Slovakia in masmedia – Slovak republic is missing almost 500 BUS drivers and 1900 truck drivers. ČESMAD Slovakia is the most powerful association focused on road transport in Slovakia. It has almost 900 members, companies from national and international transport market that have around 50 % of the total transport capacity in Slovak Republic.

It is important to highlight the fact, that driver with driving licence for vehicles class C1 is not interesting for the transport sector. These vehicles are not applicable for long-distance transport, only for regional transport needs. Long-distance transport needs drivers with driving licence for vehicles class C who are available only when they become 21 years old and class D when they become 24 years old. Who will do this profession then? It is very important to realize, that young people with ability to learn leave the secondary school at age of 18. If the student doesn't continue in study on a university, he gets a job on the company market already. He can get a driving licence for vehicles class C after 3 years in job and driving licence for vehicles class D after 6 years in job. Average person gets reasonable position in his job during this period. Only those who were not successful in their job or those who would like to fulfil their dream from childhood will attempt as truck and BUS drivers. The first group will probably do the job with lack of enthusiasm and with no motivation.

When a young person wants to get a driving licence, he has to register for training in some of the driving schools. Table 2 shows prices of one important driving school in Žilina.

**Table 2.** Fees for driving license valid from January 2017

| Class | Price |
|---|---|
| B | 650 € |
| Upgrade from B to C | 850 € |
| Upgrade from B to D (without C) | 1300 € |
| Upgrade from C to D | 790 € |
| Upgrade from B to C+D | 1400 € |
| Upgrade from C to C+E | 380 € |
| Upgrade from D to D+E | 400 € |

It is clear, that significant amount of money is needed for young person to get a driving licence. Driving licence for vehicles class B = 650 €, upgrade from B to C = 850 €, upgrade from C to D = 790 €, licence to tow a trailer class E = 380 €. Every applicant has to pass health check = 50 €, psychotest = 50 €, first aid course = 30 €, basic driver qualification = 1100 €, fees for application = 150 €. Total costs to get a driving licence and all necessary documents for vehicles class C+E are 3 260 € and for class D+E are 4 050 €. Do young person have this amount of money available when average salary in Slovak republic in 2016 was 901 € brutto (before taxes)? It's important to realize, that young people want to start to their own families in this age, buy a flat and furnish it so this costs to get a driving licence are significant.

# 5. Training of drivers

If a driver wants to correctly use the power of his vehicle and minimize the fuel consumption, he needs to have significant knowledge about the engine, transmission and the whole vehicle. This knowledge is supposed to be explained in the driving school and basic qualification course. In real, driver gets only partial information. Nowadays vehicles are full of electronic devices and drivers are not trained to maintain and service this devices and vehicle itself in the courses. For example a BUS driver transporting people for a ski course in France – because of a faulty strap on the high pressure air intake line from turbocharger, engine lost the air intake boost pressure. A simple piece of a metal wire could be used to fix this failure but drivers were not capable of this simple repair. In past, secondary school profession named driver/serviceman was available and this student would easily fix this failure himself.

Another problem to mention is the fact, that vehicles in driving schools are much older than vehicles that will the new drivers use on daily basis. None of the transporters will send a vehicle abroad with more than 10 years. The problem is, that the authorisation for basic driver qualification and periodic driver qualification have mostly driving schools. How do the drivers feel, when they drive daily the most modern vehicles Volvo, Mercedes, Scania, Renault etc., with maximum authorized mass up to 40 tons, when they have to pass the driver qualification in driving school with old training vehicles. They see the whole qualification training as chicane from the government.

# 6. Conclusions

To solve the age problem, it is necessary to have consistent legislation. By using the options offered in the EU directive, it is possible to introduce an age limit for driving as per Table 1.

The quality of training can be achieved only by re-establishing a vocational school that will train future professional drivers. It is hard to imagine that a vehicle worth a several hundred thousand Euro with a cargo worth about as much is being driven by a driver who has just finished his training. Back in the day, a driver would gain experience by driving vehicles during his mandatory military service. If vocational schools requiring at least 3 years of training were to be established, the knowledge of drivers would be significantly broader, as would be the practical skills that they would be able to gain during their studies. These schools could be equipped with modern vehicles and shop premises where the future drivers would acquire manual skills.

How many drivers do we need to train? When we come to realize that in Slovakia there are 322,000 trucks and 9,000 buses registered, and considering we need an average of 1.5 drivers per vehicle, Slovakia needs 483,000 drivers who hold a Class C license and 13,500 bus drivers. Taking into account the natural retirement rate, annually we need 11,000 new C Class drivers and 310 bus drivers. Such vocational schools could be established in larger district cities.

Financing of such vocational schools would be secured partly by the government in the same way it already provides financing for other vocational schools, and the rest would be supplied by taxation imposed up-on the initial vehicle registration; alternatively, the so-called dual education could come into play. Another solution could be co-financing of the studies by students which would increase their motivation to gain maximum knowledge and skills.

The graduates of these vocational schools would get a C and C+E Class license and the very best ones might be granted D and D+E Class, suspended until they reach the necessary age.

Part of the education would be language training because drivers who travel abroad as part of their job must have the ability to communicate in a foreign language; we believe English should be the language of choice here.

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# City Logistics and Air Quality

**Radovan Slávik[1], Dominika Beňová[1], Jozef Gnap[1], Ondrej Stopka[2]**

[1]Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Univerzitná 1, Zilina, 010 26, Slovak Republic
[2]Department of Transport and Logistics, Faculty of Technology, The Institute of technology and Business in České Budějovice, Czech Republic, Okružní 517, 370 01 České Budějovice

**Abstract** The paper focuses on the impact of city logistics on air quality. The first chapter focuses on the EU's transport policy for 2030-2050 to reduce greenhouse gas emissions. The second chapter focuses on air quality in the Slovak Republic and the amount of greenhouse gases in the air. The aim of the contribution is to highlight the impact of road transport on air quality and air pollution as well as the need to reduce these harmful emissions.

**Key words** city logistics, emissions from transport, reduction

**JEL** R41, R42

## 1. Introduction

Due to the growing number of people living in urban areas, there is a growing need for urban mobility and urban logistics. This growth needs an increase in vehicles moving in city streets. Some cities try to tackle the problem of increasing the number of vehicles because they have a negative impact on the environment, they affect the health of the population and also affect the quality of roads and public spaces in the city. In practice, urban mobility, with logistics associated with urban settlements, we meet two basic concepts, urban logistics and urban logistics. Although these terms may appear to be synonymous, the opposite is true.

City logistics is defined in a narrower sense only in relation to the flows of goods induced by industry and commerce, sometimes even only within the urban centre [8].

Urban logistics presents a wider view where concepts include not only logistics chains of industrial and commercial entities operating on the city's territory, agglomerations, but also logistic chains created by entities operating in the areas of communal services, healthcare, banking and insurance, as well as in the administration. [1]

City logistics is part of logistics that deals with the movement of shipments in cities. The so-called traffic hubs are used, where distribution, allocation and translation of shipments to more suitable types of vehicles results in reduced and optimized number of routes. City logistics is defined as a process of complete optimization of logistics and transport activities by private enterprises in urban areas, taking into account the environment, the transport, environment, congestion and energy consumption within the market economy. [2]

## 2. The European Transport Policy by 2030 – 2050

The EU White Paper on Transport also deals with air pollution from transport. The European Union has called on the need to drastically reduce world greenhouse gas emissions, with the goal of limiting climate change. Overall, the EU needs to reduce emissions by 80-95% below 1990 levels by 2050, in the context of the necessary reductions of the developed countries as a group, in order to achieve this goal. Commission analysis shows that while deeper cuts can be achieved in other sectors of the economy, a reduction of at least 60% of GHGs by 2050 with respect to 1990 is required from the transport sector, which is a significant and still growing source of GHGs. By 2030, the goal for transport will be to reduce GHG emissions to around 20% below their 2008 level. New technologies for vehicles and traffic management will be key to lower transport emissions in the EU as in the rest of the world.

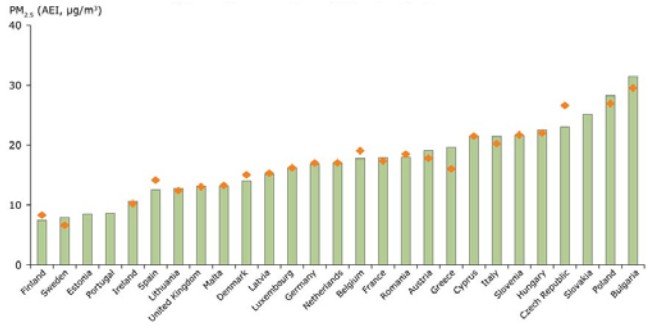


**Figure 1.** Urban $PM_{2,5}$ concentrations presented as multi-annual average in EU,2009-2011 [3]

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In the cities there are big problems with the crossing of particulate matter in the air. In Fig. 1 and 2 are the results of measurements in EU countries. Exceeded allowable values are in some Slovak cities.

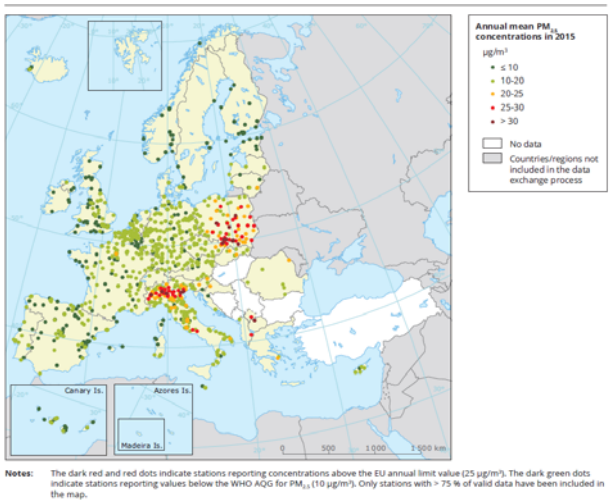


**Figure 2.** Concentrations of $PM_{2.5}$ 2015 [6]

## 2.1. Transport and Supporting Mobility While Reaching The 60% Emission Reduction Target

The challenge is to break the transport system's dependence on oil without sacrificing its efficiency and compromising mobility. In line with the flagship initiative "Resource efficient Europe" set up in the Europe 2020 Strategy and the new Energy Efficiency Plan 2011, the paramount goal of European transport policy is to help establish a system that underpins European economic progress, enhances competitiveness and offers high quality mobility services while using resources more efficiently. In practice, transport has to use less and cleaner energy, better exploit a modern infrastructure and reduce its negative impact on the environment and key natural assets like water, land and ecosystems.

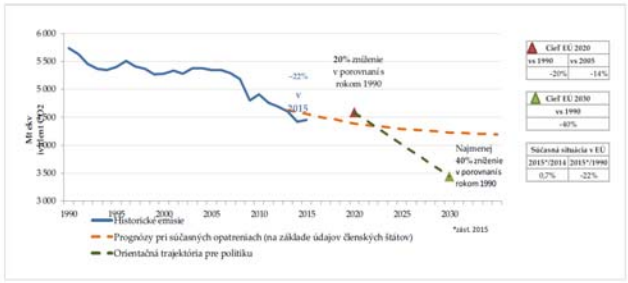


**Figure 3.** Progress towards the Europe 2020 objectives [5]

In Fig. 3 shows progress in meeting the Europe 2020 targets. As it seems, the pace of decline is not in line with the EU's 2030 goals. Unfortunately, the Slovak Republic didn´t respond much to the progress. There are no low-emission zones in the SR, although the legislation already has it. Even with government support for the procurement of electric vehicles (5000 euros) and plug-in hybrids (3000 euros), the number of these environmentally friendly vehicles in the SR did not increase significantly. Even from the disbursed subsidy of 5.2 mil. Euro exhausted just 1.85 mil in 2017 and only 445 vehicles were supported. The remaining subsidy will be available until the end of June 2018.

## 2.2. Clean Urban Transport and Commuting

Urban transport is responsible for about a quarter of CO2 emissions from transport, and 69% of road accidents occur in cities. The gradual phasing out of 'conventionally-fuelled' vehicles from the urban environment is a major contribution to significant reduction of oil dependence, greenhouse gas emissions and local air and noise pollution.

The interface between long distance and last-mile freight transport should be organised more efficiently. The aim is to limit individual deliveries, the most 'inefficient' part of the journey, to the shortest possible route. The use of Intelligent Transport Systems contributes to real-time traffic management, reducing delivery times and congestion for last mile distribution. This could be performed with low-emission urban trucks. The use of electric, hydrogen and hybrid technologies would not only reduce air emissions, but also noise, allowing a greater portion of freight transport within the urban areas to take place at night time. This would ease the problem of road congestion during morning and afternoon peak hours.

The goals European Union are halve the use of 'conventionally-fuelled' cars in urban transport by 2030; phase them out in cities by 2050; achieve essentially CO2-free city logistics in major urban centres by 2030. The European Commission will ensure a reduction in greenhouse gas emissions from transport by at least 60% in 2050 in order to increase the competitiveness of transport.

## 2.3. EU Framework For Urban Road User Charging

Develop a validated framework for urban road user charging and access restriction schemes and their applications, including a legal and validated operational and technical framework covering vehicle and infrastructure applications.

## 2.4. A Strategy For Near- 'Zero-Emission Urban Logistics' 2030

The strategy includes the following objectives:

- produce best practice guidelines to better monitor and manage urban freight flows (e.g. consolidation centres, size of vehicles in old centres, regulatory limitations, delivery windows, unused potential of transport by river),
- define a strategy for moving towards 'zero-emission urban logistics', bringing together aspects of land planning, rail and river access, business practices and information, charging and vehicle technology standards,
- promote joint public procurement for low emission vehicles in commercial fleets (delivery vans, taxis, buses…).

### 2.5. A regulatory framework for innovative transport

Identify the necessary regulatory framework conditions through standardisation or regulation:

- Appropriate standards for CO2 emissions of vehicles in all modes, where necessary supplemented by requirements on energy efficiency to address all types of propulsion systems;
- Vehicle standards for noise emission levels;
- Ensure that CO2 and pollutant emissions are reduced under real-world driving conditions by proposing at the latest by 2013 a revised test cycle to measure emissions;
- Public procurement strategies to ensure rapid up take of new technologies;
- Rules on the interoperability of charging infrastructure for clean vehicles;
- Guidelines and standards for refuelling infrastructures;
- Interface standards for infrastructure-to-infrastructure, vehicle-to-infrastructure, and vehicle-to-vehicle communications;
- Access conditions to transport data for safety and security purposes;
- Specifications and conditions for transport related smart charging and payment systems;
- Better implementation of existing rules and standards.

In Fig. 4 is an ex post impact assessment of the EU ETS, renewable policies, taxation and other policies on $CO_2$ emissions from incineration.

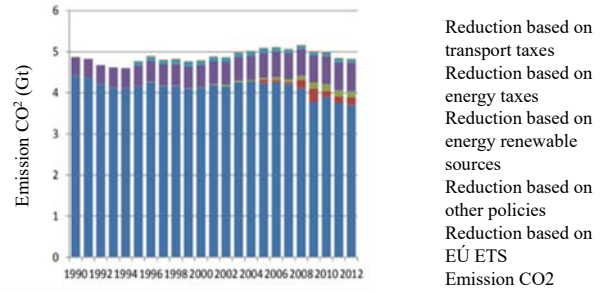


**Figure 4**: Ex post impact assessment of EU ETS, renewable policies, taxation and other policies on CO2 emissions from combustion [5]

## 3. Air Quality In Slovak Republic

The reason for these mentioned measures within European cities is, in particular, the pursuit of achieving the cleanest environment in the areas where thousands of people move daily. They get to direct contact with traffic and its externalities, basically every day, so it is important to eliminate these negative phenomena as much as possible. Among the worst within European cities is just air pollution and this fact is not avoided even in towns and villages in the territory of the Slovak Republic.

Quality of air is generally determined by the level of pollutants in the air, including nitrogen oxides, sulphur dioxide, carbon monoxide, PM10 and PM22,5, benzene, as well as various hazardous metals such as nickel, cadmium, lead and so on. The Decree of the Ministry of the Environment of the Slovak Republic sets limits and target values for these substances in the air. The basis for the air quality assessment is the results of measurements of the concentration of pollutants in the air. These are realized by the Slovak Hydrometeorological Institute (SHMU) through their stations of the National Air Quality Monitoring Network. For area air quality evaluation, mathematical modelling methods are used.

The most dangerous pollutants from transport, from a human health perspective, are PM10 and PM2,5 particles. These come from different sources of pollution, but about 5-15% of the total emissions of these particles come from mobile sources – which including transport, whereby the largest polluter is road transport. However, the share of air pollution from mobile sources is higher in the Bratislava and Košice agglomerations, where it represents 11-25%.

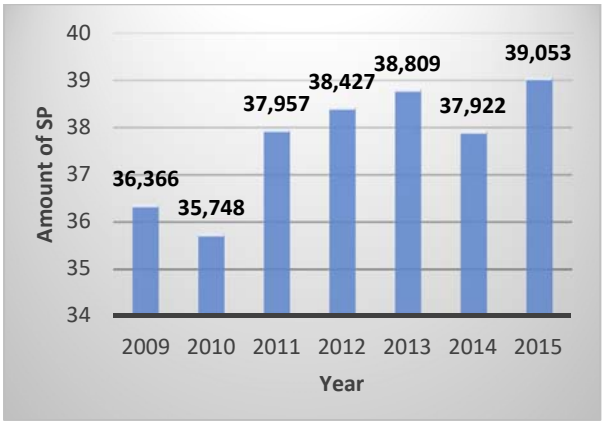


**Figure 5.** Graph of the total amount of solid pollutants (SP) in the air [7]

Regarding the total level of pollution of the territory of the Slovak Republic, whether PM10 or PM2,5, in both cases, this level in Slovakia achieves good results and the established limit value of the annual concentration of these particles has not been exceeded. The average annual concentration of both types of particles in the air is slightly declining. This is the case for the absolute amount of solid pollutants, PM10 and PM2,5 in the air. In this case, the level of these substances is fluctuating, with a slight increase compared to 2014 and 2015, as shown in figure 5.

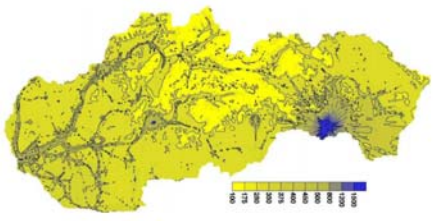

**Figure 6.** Maximum daily 8 – hour rolling average CO concentrations [$\mu g.m^{-3}$] per year 2015. [7]

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Figure 6, which shows the nationwide distribution of the maximum 8 - hour rolling average CO concentrations in 2015, shows the road network as a line source in terms of the dominance of mobile resources. The highest concentration can be seen in the vicinity of major road trips - the D1, D2, R1 highways and first-class roads in south-western Slovakia. Large concentration is also in the surroundings of the city Košice, but this is due to emissions from U.S Steel Košice company. [7]

## 4. Conclusion

Air pollution is a key environmental and social problem and, at the same time, is a complex issue, which has many implications for the management and mitigation of harmful pollutants. The setting of the current Emission Control System for motor vehicles has not produced the required results [10].

Air pollution continues to have a significant impact on the health of the European population, particularly in urban areas. The most serious pollutants in Europe are PMx, NO2 and ground-based O3 in terms of human health damage.

The air in Slovakia is over-polluted from the point of view of the European Union. The main reasons of air pollution are the high share of solid fuels, including biomass used in households, and the use of lower-quality internal combustion engines in passenger transport. It is therefore necessary to take concrete steps in the Slovak Republic to reverse this contrarious situation.

One of the actions to get this issue into the program is to monitor the air condition and inform it about it in real time (see Figure 7).


**Figure 7**. Monitoring of air pollution in the city of Prievidza building of the City office (SK); Source: J. Gnap

Even in the Slovak Republic, it is necessary to take concrete steps to reverse this unfavourable state. The greatest effectiveness of the actions will be reflected in the cities and therefore it is necessary to take concrete actions also in the Slovak Republic. This can be greatly helped by managed and constantly improved city logistics.

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# The Impact of Using Trailers on the Fuel Consumption

**František Synák[1], Vladimír Rievaj[1], Štefánia Semanová[1], Ján Palúch[1]**

[1]Department of Road and Urban Transport, Faculty of Operation and Economics of Transport and Communications, University of Zilina, Univerzitná 1, Žilina, 010 26

**Abstract** The amount of fuel consumed may also be influenced by driving style, speed as well as by the need for the use of passenger car trailers. This paper deals with the impact of using such trailers on the amount of fuel consumed. Measurement of the impact of the passenger car trailer on fuel consumption was carried out during driving at constant speed and during acceleration. The measurements were performed by driving test on a flat road. The first part of the paper deals with the driving resistances which influence fuel consumption during driving at constant speed and during acceleration on the flat road. The second part describes the vehicle used for measurements and measuring equipment. The conclusion of the paper includes the principles to reduce the impact of passenger car trailers on the amount of fuel consumed.

**Keywords** air resistance, carbon dioxide, fuel consumption, global pollution, rolling resistance, trailer,

**JEL** L92

## 1. Introduction

The total of 2.5 kg of CO2 is produced by combusting 1 l of petrol. By combusting 1 l of diesel, it is even 2.7 kg of CO2 [1]. Within the European Union, road transport produces about 20 % of carbon dioxide [2], of which about 75 % is produced by passenger cars [3]. Transport, as one of sectors with growing amount of CO2 produced, has a great potential to contribute to the emission reduction and meet the obligations arising from the Paris Agreement [4]. Not only vehicle manufacturers have the obligation to contribute to the reduction of this greenhouse gas production based on the legislation [5], but there is also a moral obligation for every driver to contribute to meeting this goal as much as possible. The requirement for compliance with eco-driving principles is also included in White Paper where Annex I states that it is necessary to include ecological way of driving into the future revisions of the driving licence directive and take steps to accelerate the deployment of ITS application in support of eco-driving [6]. The purpose of this paper is to assess one of principles of eco-driving which represents considering the use of passenger car trailers in such cases when it is possible to store transported goods in the vehicle luggage compartment. For this reason, the paper focuses on increasing fuel consumption due to attaching the passenger car trailer.

The driving resistances are increased by connecting a trailer to a towing vehicle [7]. A vehicle engine must then overcome these driving resistances [8]. Therefore, the engine must consume a certain amount of energy contained in the fuel to produce sufficient power [9]. The trailer increases air drag [10] and rolling resistance during driving at constant speed [11]. Air drag depends on driving speed, vehicle frontal area, aerodynamic drag coefficient, and air pressure [12]. It may be expressed by the following formula:

$$\mathbf{R_{aero} = 0,5 \cdot v^2 \cdot S \cdot c_x \cdot \rho} \quad (1)$$

*v – driving speed [m·s$^{-1}$]*
*S – vehicle frontal area [m$^2$]*
*$c_x$ – aerodynamic drag coefficient [-]*
*ρ – air density [kg.m$^{-3}$] [13]*

The rolling resistance depends on the vehicle weight which is dependent on the vehicle mass and coefficient of rolling resistance [14]. The rolling resistance may be calculated as:

$$R_f = G \cdot f \quad (2)$$

*G – vehicle weight [N]*
*f – coefficient of rolling resistance [-] [15]*

During acceleration, the trailer increases also the resistance to acceleration. The value of this resistance to accelerate is influenced by the vehicle mass, the resistance of rotating parts to acceleration, and range of acceleration or deceleration. The resistance to acceleration may be expressed in a simplified manner by the following formula:

$$R_a = m \cdot \delta \cdot a \quad (3)$$

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*m – vehicle mass [kg]*
*δ – coefficient of the resistance of rotating parts [-]*
*a – acceleration [m·s$^{-2}$] [16]*

The aim of this paper is to ascertain a change in values of driving resistances due to the use of the passenger car trailer based on the measurements performed. The impact on the amount of fuel consumed is also examined.

# 2. Methods

The measurement of the impact of the passenger car trailer on the change in fuel consumption was carried out in two variants. The first variant represented measurements at constant speed 50 km·h-1 and 90 km·h-1. In the second variant, measurements were carried out during vehicle acceleration from zero speed to 50 km·h-1 and 90 km·h-1.

## 2.1. Vehicle Used for Measurements

The vehicle used for the measurements was Škoda Octavia 1. Technical specifications are given in Table 1.

**Table 1** Technical parameters of the vehicle

| | |
|---|---|
| Modification (Engine) | 1.9 TDi, PD |
| Production year | 2008 |
| Engine power | 74 kW . 4000 rpm |
| Torque | 240 Nm 1900 rpm |
| Number of gears | 5, manual transmission |

The trailer used for the measurements was Agados and its technical specifications are given in Table 2.

**Table 2** Technical parameters of the trailers

| | |
|---|---|
| Dimensions | 1250 x 2060 x 350 |
| Kerb weight | 136 kg |
| Total weight | 500 kg |
| Highest allowed speed | 100 km·h$^{-1}$ |
| Production year | 2008 |
| Tyre | 175/65 R13 |
| Energy efficiency class of tyres | „C“, 7,8 ≤ RRC ≤ 9,0 |

The trailer in complete assembly is shown in Figure 1.


**Figure 1** The passenger car trailer used for the measurements

The transported cargo weighed 275 kg and it is shown in Figure 2.

**Figure 2.** Transported cargo.

In case that the trailer was not used, cargo was placed in the vehicle luggage compartment as it is shown in Figure 3.


**Figure 3.** Placement of cargo in the vehicle luggage compartment

## 2.2. Measurement Tools

Weather station Irox HRS 70 was used to measure the air flow velocity. The air pressure was recorded at the level of 1030 hPa and air temperature was from 20°C to 21 °C.

The driving speed, amount of fuel consumed, engine speed, accelerator pedal movement and driving time were determined by using VAG V.C.D.S 15.7.1 software. A connection between VAG diagnostic software and the vehicle control unit was ensured by the use of a special HEX CAN cable. Work environment of the program is shown in Figure 4.

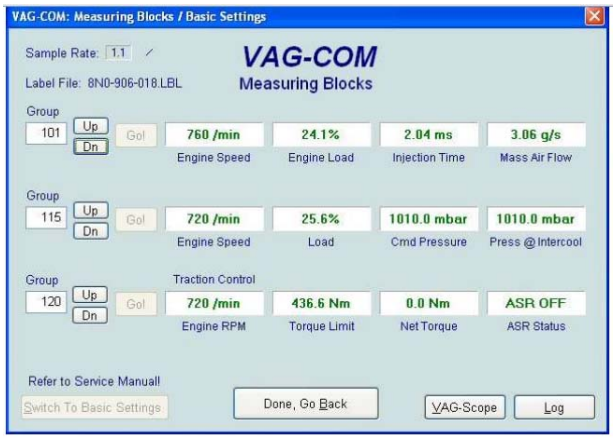


**Figure 4.** Work environment of program VAG V.C.D.S.

The program's output VAG V.C.D.S shows the fuel consumption in l.h-1 which is needed to be recalculated into l.100 km-1. Since the program's frequency of data writing is approximately 3times per second, the calculations were carried out via Microsoft Excel. In the first step it was necessary to recalculate the fuel consumption from l/h into l/s according to the equation:

$$Q_s = \frac{Q_h}{3600} \tag{4}$$

*Qs – fuel consumption per second [l.s-1]*
*Qh – fuel consumption per hour [l.h-1]*

The second step included the calculation to determine the amount of fuel consumed per period of time during which the fuel consumption was measured:

$$Q_c = Q_s \,.t \tag{5}$$

*$Q_c$ – amount of fuel consumed per period of measuring [l]*
*$Q_s$ – fuel consumption per second [l.s$^{-1}$]*
*t – time period of measuring [s]*

$Q_{l100} = \frac{Q_c}{s} .100\ 000$The time period of measuring is equal to the frequency of data writing, and thus it is approximately 0.33s. The fuel consumption was subsequently calculated in l.100 km-1 according to the equation:

(6)

*Ql100 – fuel consumption [l.100 km-1]*
*s – trajectory of measuring [m]*

The given calculation was carried out for each writing during the measurement, and the result of all the measurements was averaged.

### 2.3. Measuring the impact of using the trailer on fuel consumption during driving at constant speeds

The measurement procedure to ascertain the impact of using the trailer on fuel consumption during driving at constant speed was as follows:

1. Vehicle acceleration,
2. achieving constant speed,
3. start of recording the values,
4. driving at constant speed,
5. end of value recording and saving them.

The measurements were carried out three times at speed 50 km·h$^{-1}$ and three times at speed 90 km·h$^{-1}$. Subsequently, the frame of the trailer, (indicated by number 1 in Figure 1) was removed and measurements were repeated three times separately for speed 50 km·h$^{-1}$ and 90 km·h$^{-1}$. After complete removal of the plastic cover of the trailer (indicated by number 2 in Figure 1, the measurements were repeated again. In the end, the trailer was disconnected, cargo was loaded into the vehicle luggage compartment and the measurements were repeated again. During each measuring the vehicle speed was recorded. If there was a speed change by more than ± 2 km.h$^{-1}$ from the speed at which the measurement should have been done, the measuring was annulled. To record the value went around 3 times per second.

### 2.4. Measuring the impact of using the trailer on fuel consumption during vehicle acceleration

The measurement procedure to determine the impact of using the trailer on fuel consumption during vehicle acceleration was as follows:

1. stopping the vehicle on a flat road
2. start of recording the values
3. vehicle acceleration to the desired speed
4. recording the values after achieving the desired speed

The measurements with the trailer were carried out three times for vehicle acceleration to the speed of 50 km·h-1 and three times to the speed of 90 km·h-1. Subsequently, the trailer was disconnected, cargo was loaded into the vehicle luggage compartment and the measurements for vehicle acceleration were repeated again three times separately for speed 50 km·h-1 and 90 km·h-1. During vehicle acceleration to the speed of 50 km·h-1, gears from 1 to 4 were employed and gears from 1 to 5 were employed to achieve 90 km·h-1. Only those measurements were taken into the results, of which the mutual correlation was lesser than 0.97. The mutual correlation of the engine and vehicle speed was taken into consideration. The application of acceleration pedal was compared only in the case of measuring under the same conditions, that means there were mutually compared only those measurements with trailer or the measurements without trailer. The repetition of accelerations with such accuracy was very difficult and only about half of the measurements conducted met this condition. For better display, the Figure 5 shows the example of comparison of how the curves of the engine speed are changing during two accelerations.

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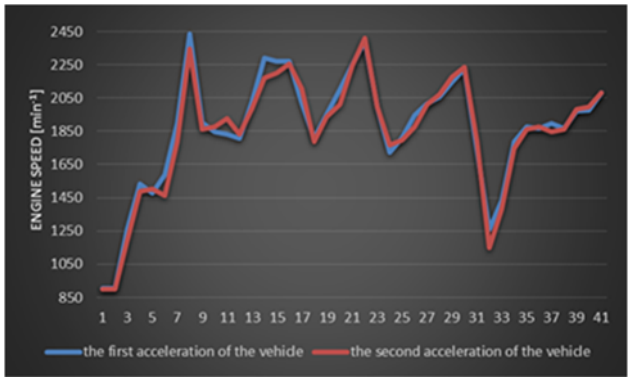


**Figure 5.** Comparison of the engine speed during two vehicle accelerations.

# 3. Results

The fuel consumption values during driving at constant speed are given in Table 3.

**Table 3** Fuel consumption measured during driving at constant speed

| Version | 50 km·h$^{-1}$ | 90 km·h$^{-1}$ |
|---|---|---|
| Fuel consumption with the trailer in complete assembly [l·100km$^{-1}$] | 4.2 | 6.1 |
| Fuel consumption in the case of the dismantled frame [l·100km$^{-1}$] | 4.2 | 5.8 |
| Fuel consumption in the case of the removed trailer plastic cover [l·100km$^{-1}$] | 4.2 | 6.3 |
| Fuel consumption in the case of cargo loaded in the trunk (without using the trailer) [l·100km$^{-1}$] | 3.7 | 4.7 |

For greater clarity, the results are also depicted in the graph in Figure 6.

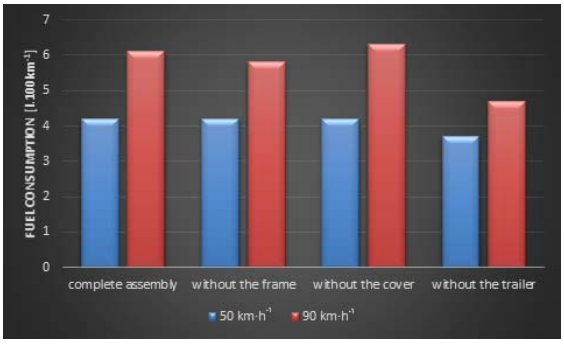


**Figure 6.** The values measured during driving at constant speed

As it can be seen from Table 3 and Figure 6, the removal of the frame or the plastic cover of the trailer did not affect the amount of fuel consumed in the case of driving at speed 50 km·h$^{-1}$. By disconnecting the trailer and loading the cargo into the luggage compartment, fuel consumption decreased by 0.5 l·100km$^{-1}$ which represents $CO_2$ reduction by 1.4 kg·100 km$^{-1}$.

When driving without the trailer frame at speed 90 km·h$^{-1}$, fuel consumption decreased by 0.3 l·100 km$^{-1}$ which resulted in $CO_2$ reduction by 0.84 kg·100 km$^{-1}$. This decrease was apparently caused by reducing the air resistance of the trailer [17]. The frame mounted on the plastic cover of the trailer disrupts the air flow around surface of the cover and this results in increasing the aerodynamic drag coefficient [18].

Removal of the plastic cover increased fuel consumption by 0.2 l·100 km$^{-1}$. This increase can be explained by the fact that after removing the cover the air flow entered into the space for transporting cargo and it acted the rear wall of the trailer. The inner side of the rear wall thus created another frontal area [19].

The difference in fuel consumption between driving without the trailer (with cargo loaded in the vehicle luggage compartment) and driving with the trailer in complete assembly represented 1.4 l·100 km$^{-1}$ which resulted in $CO_2$ reduction by 3.92 kg·100 km$^{-1}$.

The fuel consumption values during the vehicle acceleration are given in Table 4.

**Table 4** Fuel consumption measured during driving at constant speed

| | Acceleration to 50 km·h$^{-1}$ | Acceleration to 90 km·h$^{-1}$ |
|---|---|---|
| Acceleration without the trailer [l] | 0.021 | 0.059 |
| Acceleration with the trailer [l] | 0.021 | 0.079 |

The results are also depicted in the graph in Figure 7.

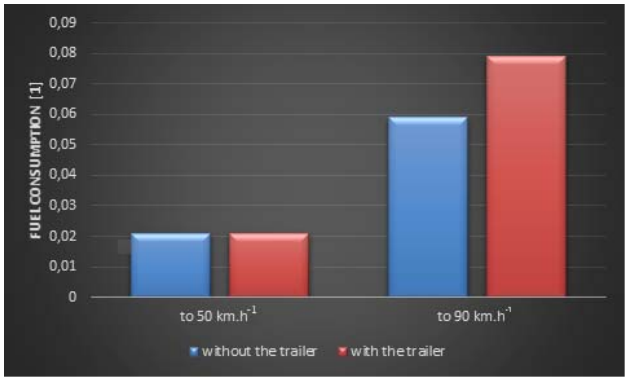


**Figure 7.** The values measured during the vehicle acceleration

Based on Table 4 and Figure 7, no difference can be observed in the amount of fuel consumption during the vehicle acceleration from zero speed to 50 km·h-1. This can be explained by the fact that there was achieved relatively low speed at which the air resistance reaches low or negligible values. Also, the difference in the vehicle mass represented only the trailer mass i.e. 136 kg. In the case of the vehicle acceleration to 90 km·h-1, the difference in fuel consumption was 0.02 l. The difference was probably caused by the change in the air resistance [20].

# 4. Conclusion

Based on the measurements, it can be concluded that the driving with the trailer increases fuel consumption, especially at higher speed (in this case 90 km·h-1). The obtained

results demonstrate that in terms of fuel consumed the passenger car trailers should be used only in cases when its use is a necessity. The results also show that fuel consumption when using trailers increases with increasing speed. Therefore, it is advisable to drive at lower speed when using a trailer. It is also necessary to take into account the fact that fuel consumption decreased by 0.3 l·100 km-1 at speed 90 km·h-1 after dismantling the trailer frame. The mentioned equipment is currently mounted by the manufacturer on each plastic cover of the trailer Agados. However, the practical use of this equipment is very rare in practice. In terms of fuel consumption, it would be appropriate for the frame to be included among the optional accessories. Thus, the trailer frame would only be suitable for the customer group that assumes its use or for the customers that do not expect to often drive at higher speed. The second alternative could represent such a frame design that would allow easy assembly and removal of the frame. At present, the dismantling of the trailer frame is rather complicated and it requires a cooperation of two persons.

The removal of the plastic cover resulted in fuel consumption increase by 0.2 l·100 km-1 at speed 90 km·h-1. Thus, the plastic cover of the trailer contributed to the reduced fuel consumption. The lowest fuel consumption was measured when driving without the trailer (with cargo transported in the luggage compartment) when no tensile resistance acted on the vehicle [21].

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