University of Novi Sad
Faculty of Technical Sciences
Department of Traffic Engineering

REPUBLIC OF SERBIA
AUTONOMOUS PROVINCE OF VOJVODINA
PROVINCIAL SECRETARIAT FOR ENERGY, CONSTRUCTION AND TRANSPORT

Association
Humane City

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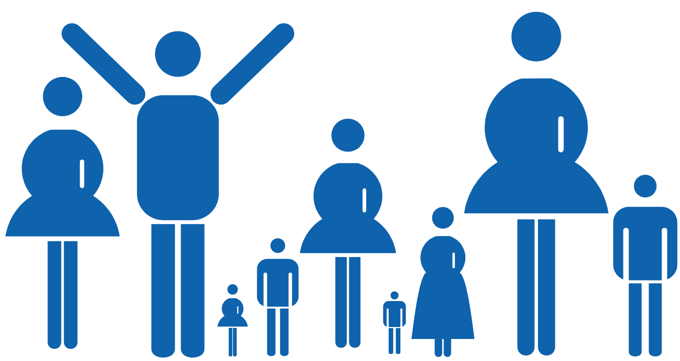

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"Towards a Humane City"
New Mobility Challenges

Novi Sad, 11th and 12th November 2021

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LOW CARBON URBAN TRAFFIC DEVELOPMENT IN FUNCTION OF ENERGY AND CLIMATE SUSTAINABLE DEVELOPMENT

Key Words

Sustainable development

Traffic

Decarbonization

Abstract

The ambitious goal of decarbonization of Europe by 2050 is also reflected in Southeast Europe, including Bosnia and Herzegovina. As a Contracting Party of the Energy Community, Bosnia and Herzegovina has made a number of commitments in the energy and climate sector. However, the biggest challenge is to preserve a pleasant living environment, which in the future will imply the need for a series of activities aimed at increasing energy efficiency and share of renewable energy sources, as well as decarbonising the transport sector. The Sustainable Energy and Climate Action Plan (SECAP) and the Sustainable Urban Mobility Plan (SUMP) are just some of the instruments that cities and municipalities are developing to achieve their goals.

1. INTRODUCTION

The ambitious goal of decarbonization of Europe by 2050 is also reflected in Southeast Europe, including Bosnia and Herzegovina. As a Contracting Party (CP) of the Energy Community, Bosnia and Herzegovina has made a number of commitments in the energy and climate sector. The obligation to integrate energy and climate planning is being transferred from the State to the entity level, and local governments, as the ultimate implementers of policies and strategies adopted at various levels of government. However, the biggest challenge is to preserve a pleasant living environment, which in the future will imply the need for a series of activities aimed at increasing energy efficiency and share of renewable energy sources, decarbonising the transport sector. The Sustainable Energy and Climate Action Plan (SECAP) and the Sustainable Urban Mobility Plan (SUMP) are just some of the instruments that cities and municipalities are developing to achieve their goals. In its 2019, the European Commission presented the European Green Deal for the European Union. The European Green Deal specifically accepts the acceleration of the transition to sustainable and smart mobility, as transport accounts for a quarter of EU greenhouse gas emissions (GHG). In order to achieve climate neutrality, it is necessary to reduce emissions in transport by 90% by 2050. An integral part of the European Green Deal is a strategy for sustainable and smart mobility, which, among other things, envisages that about 75% of the land freight transported by road today should be shifted to rail and inland waterways. The transition to low-emission mobility also requires the deployment and market acceptance of alternative fuel-powered vehicles. This depends on the wide availability of the corresponding charging infrastructure. Journeys across Europe in electric vehicles should be straightforward: this means electric charging must be as easy as filling the tank. The Commission is actively encouraging electric mobility through legislation (e.g. EU-wide technical specifications) and investments. By 2020, over 1200 alternative fuelling points, notably e-mobility charging points, was have received EU financial support under the Connecting Europe Facility alone [1].

2. SUSTAINABLE & SMART MOBILITY STRATEGY OF EU

The new EU Transport Strategy (Sustainable & Smart Mobility Strategy) [2] is fundamental and will, if successful, change the European transport sector completely with impacts on many other aspects of life such as the economy, environment, and health. The objectives new EU Transport Strategy are (Figure 1):

- ✓ Sustainable mobility.
- ✓ Smart mobility.
- ✓ Resilient mobility.

Figure 1. Objectives the New Transport strategy EU, (2020)

Main topics on the new transport strategy are:

- ✓ electric mobility,
- ✓ digitalization,
- ✓ aviation,
- ✓ SUMP,
- ✓ automated driving,
- ✓ road safety, and
- ✓ infrastructure.

The first objective of the new EU Transport Strategy is Sustainable Mobility, which defines the following sub-goals:

- ✓ **Reducing dependence of transport on fossil fuels** (By 2030, there will be at least 30 million zero-emission cars and 80 thousand zero-emission lorries in operation; By 2030, there will be at least 100 climate-neutral cities in Europe; Scheduled collective travels under 500 km should be carbon neutral by 2030 within the EU; Zero-emission large aircraft will become ready for market by 2035.)
- ✓ **Making alternative choices available** (All large and medium-sized cities put in place their own sustainable urban mobility plans by 2030; Traffic on high-speed rail will double by 2030; By 2050 rail freight traffic will double; Transport by inland waterways and short sea shipping will increase by 25% by 2030.).
- ✓ **Pricing to reflect environmental impact** (The internalisation of external costs of transport at the latest by 2050 will ensure that those who use transport will bear the full costs rather than leaving others in our society to meet them).

The second objective of new EU Transport Strategy is Smart Mobility, which defines the following sub-goals:

- ✓ Unleash full potential of data.
- ✓ By 2030, integrated electronic ticketing facilitates seamless multimodal passenger transport.
- ✓ Freight transport will be paperless.
- ✓ By 2030, automated mobility will be deployed on large scale.

The third objective of the new EU Transport Strategy is Resilient Mobility, that defines the following sub-goals:

- ✓ **Building a strong and resilient Single Market** (Investment in transport infrastructure across the EU Member States; By 2050, a fully operational, multimodal Trans-European Transport Network for sustainable and smart transport with high speed connectivity.).
- ✓ **Creating a mobility system that is fair and just for all** (Make mobility affordable and accessible in all regions and for all passengers; Improve the conditions for transport workers.);
- ✓ **Ensuring the highest standards of safety and security in European transport** (By 2050, the death toll for all modes of transport in the EU will be close to zero).

3. DETERMINANTS OF THE ENERGY COMMUNITY SECRETARIAT

In its first Report [5], the Energy Community Secretariat (ECS) presented data of CO2 emissions per sector for the Western Balkan 6 (WB6) countries (Figure 2).

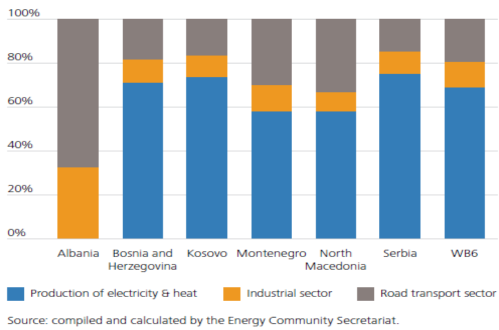

Figure 2. CO2 emissions per sector, 2018, WB6

The CPs have committed to the share of renewable energy sources in transport by 2020 (biodiesel, batteries, etc.) to 10%, which is not achieved until mid-2021. (Figure 3).

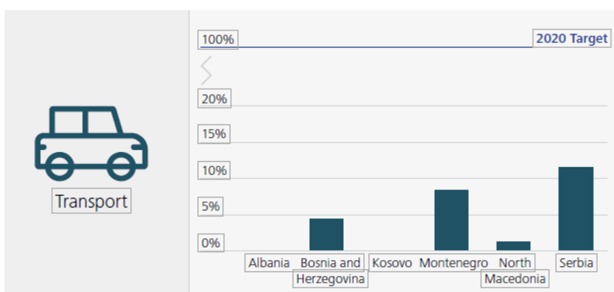

Figure 3. WB6 implementation of renewable energy 2020 targets

As of January 2020, Bosnia and Herzegovina has been sanctioned by ECS due to non-compliance with the Second Energy Package in the gas sector, the Sulfur and Fuels Directive, as well as the Third Energy Package for electricity and gas. The sanctions were adopted at a session of the Ministerial Council on December 17th, and before that, BIH was warned several times that this could happen. In a report published on November 30th, ECS stated that eight proceedings had been initiated against BIH for violating obligations and laws in almost all spheres covered by the Energy Community Treaty. Also, ECS has initiated misdemeanor proceedings due to the fact that the authorities in BIH still allow a larger amount of sulfur in petroleum products, in order to protect the production in the Brod Oil Refinery. Misdemeanor proceedings have also been initiated for non-transposition of the Energy Efficiency Directive (EED). ECS has warned Bosnia and Herzegovina that it does not have a gas law, nor does it have a state regulator for gas, which could control, among other things, the issue of monopolies.

4. SUMP IN THE FUNCTION OF LOW CARBON AND ENERGY EFFICIENT URBAN TRANSPORT

In the EU, transport is currently responsible for a quarter of total CO2 emissions related to energy and reaches a share of 30% in Luxembourg, France and Spain, where in Slovenia it was around 21%. According to the Renewable Energy Directive 2009/28/EC, the share of renewable energy sources in the gross final consumption (GFC) in the European Union must be 20% by 2020. In the long run, the goals of the share of RES in GFC by 2040 in the EU shall reach over 50% (electricity 52%, heating 32%, transport 13%). (Source: IEA - World Energy Outlook 2016). Sustainable Urban Mobility Plans (SUMPs) have been designed to tackle transport-related problems in urban areas more efficiently. SUMPs are a structured process whereby visions are created, objectives and targets are set, policies and measures are selected and active communication, monitoring and evaluation all take place.

SUMPs contribute to reaching the European climate and energy targets set by EU leaders. SUMPs have been promoted by the Commission as a planning concept that is able to address transport-related challenges of urban areas in a more sustainable and integrative way.

The Sustainable Urban Mobility Plan (SUMP) is a strategic plan designed to meet the mobility needs of people and businesses and its surroundings for a better quality of life. New approaches to urban mobility planning include developing a strategy that can encourage a shift to cleaner and more sustainable modes of transport, such as walking, cycling, public transport, new patterns of car use and ownership, the use of new technologies, and the adoption of new concepts of sustainable city logistics.

The SUMP measures focus on strategic directions towards building a system that will provide the citizens with the expected mobility and accessibility and a successful dynamic environment that promotes sustainable development and environmental protection. The measures include actions in sustainable urban mobility that should result in a healthier and safer environment for all the residents and the participants in the system of traffic and transport, emphasizing non-motorized movement and transport, pedestrians, cyclists, and people with reduced mobility [6] (Figure 4).

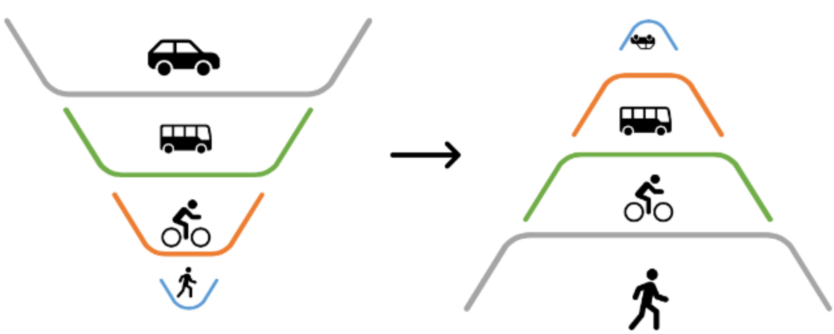

Figure 4. Integrated spatial and urban mobility planning

Strategic pillars and measures of SUMP, include Zero- And Low-emission transport system (Ensure affordable, available, and accessible transport with low-carbon emissions, low noise, and low vibrations; Ensure a simple and quality access to all modes of transport and non-motorized movement; Ensure the quality networking of transport systems into an integrated urban mobility system; Raise awareness of alternative ways of transport and movement.) [8].

The implementation of sustainable mobility from the aspect of low-carbon development of urban areas contributes to [9]:

- ✓ Expanding the offer of transport options that provide all residents and visitors with access to key destinations and services,
- ✓ Encouraging the development of entrepreneurship and the economy,
- ✓ Stimulating clean and sustainable modes of transport (walking, cycling, public transport, electromobility and innovative forms of vehicle use and ownership),
- ✓ Increasing security and protection,
- ✓ Reduction of air and noise pollution, greenhouse gas emissions, and energy consumption,
- ✓ Improving the quality of life and public health,
- ✓ Improving the efficiency and economy of transport of persons and goods,
- ✓ Improving the concept of city logistics, and
- ✓ Increasing the attractiveness and quality of the urban environment and urban design.

5. SUSTAINABLE ENERGY AND CLIMATE ACTION PLANS

The Covenant of Mayors is the world's largest movement for local climate and energy actions. By joining this initiative, cities that have signed the Covenant of Mayors' Charter commit to reducing their greenhouse gas emissions by 40% by 2030. In order to achieve the goals set (or at least get closer to them), they are committed to developing the SECAP, a strategic document in which transport is one of the key sectors.

Sustainable Energy And Climate Action Plan (SECAP) defines measures for reducing energy consumption and CO_2 emissions through the sectors of construction, transport (public transport) and public lighting.

Globally achievable targets and guidelines for reducing carbon emissions from transport can be achieved by:

- ✓ Increasing the number of publicly available means for non-motorized movement.
- ✓ Increasing the share of low-carbon vehicles in public transport.
- ✓ Providing accessible and affordable transportation with low carbon emissions, low noise, and vibration.
- ✓ Increasing the number of charging stations for electric vehicles.
- ✓ Support technologies with zero emissions in transport (e-vehicles, e-bus, e-bike, e-scooters, etc.).
- ✓ Increasing space free from motor vehicle movements.
- ✓ Increasing the degree of acceptability of the price of a public transport tickets.

- ✓ Decreasing the average annual growth rate of the degree of motorization of vehicles with SUS engines.
- ✓ Encouraging innovative acceptable solutions in planning, sustainable development and low and zero emission urban mobility.

In addition to the stated achievable goals for low carbon traffic and transport, the following activities need to be carried out:

- ✓ Informing consumers about fuel economy and CO_2 emissions of new passenger vehicles,
- ✓ Training of motor vehicle drivers for eco driving,
- ✓ Obligation to use biofuels in traffic,
- ✓ Introduction of special environmental charge for motor vehicles,
- ✓ Introduction of special tax on motor vehicles,
- ✓ Financial incentives for the purchase of hybrid and electric vehicles,
- ✓ Development of infrastructure for alternative fuels,
- ✓ Promotion of integrated both ITS and alternative fuels in urban areas,
- ✓ Monitoring, verification, and reporting of greenhouse gas emissions in urban areas.

6. CONCLUSION

The EU is on the path to creating the sustainable, smart and resilient mobility system of the future and bringing about the fundamental changes needed to achieve the objectives of the European Green Deal. The application of modern technologies provides significant potential for cost-effective improvement of motor vehicle performance and reduction of CO_2 emissions. With new technologies, cost-effective reduction of CO_2 emissions from motor vehicles of at least 20% can be achieved.

Efficient and effective urban mobility planning in Bosnia and Herzegovina can significantly contribute to achieving the targets. The policies that yet need to be fully transposed from the EU level to the legal and regulatory framework of Bosnia and Herzegovina are efficiency of the EU transport system, socio-economic objectives, energy dependency, and climate change, partly depends on actions taken by national, entity and local authorities. However, the development of mobility plans by local authorities is highly influenced by national and entity governance frameworks.

Furthermore, The EU Covenant of Mayors for Climate & Energy brings together thousands of local governments voluntarily committed to implementing EU climate and energy objectives. Cities and Municipalities in Bosnia and Herzegovina have pledged by signing the Covenant, where apart from energy planning, climate planning will be made by conducting baseline emission Inventories to track mitigation actions and a climate risks and vulnerability assessments. SECAPs and SUMPs can be considered as tools for low carbon urban traffic development in function of energy and climate sustainable development.

REFERENCES

[1] Europe on the Move, Action Plan, EC, 2019.

[2] Sustainable and Smart Mobility Strategy - putting European transport on track for the future, EC, Brussels, 9.12.2020.
[3] Lindov, O; Mehinović, H; Mujezin H., Green and Smart Mobility Transport Industry Innovation and Promotion, 7th International conference ''Towards a Humane City‘‘, Environmentally Friendly Mobility, Novi Sad 6th and 7th December 2019.
[4] Lyons, Glenn. "Getting smart about urban mobility–aligning the paradigms of smart and sustainable." (2018).
[5] WB6, Energy Transition Tracker, Energy Community Secretariat, July 2020.
[6] Sustainable Urban Mobility Plan for Sarajevo Canton and City of Sarajevo, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Sarajevo, 2020.

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AUTONOMOUS VEHICLES CHARACTERISTICS AND THEIR POTENTIAL USAGE IN THE TRANSPORT SYSTEM

Key Words

Autonomous vehicles

Advantages

Disadvantages

Application

Abstract

In the given traffic conditions, autonomous vehicles move without human involvement, detecting the environment with sensors and making decisions for their safe management. The vehicle system interprets the information and selects the appropriate trajectory, speed and analyzes the obstacles it may encounter. The paper presents the expected advantages of autonomous vehicles, but also their negative features. The way in which autonomous vehicles understand information and create an image of the environment is also explained. Some of the current achievements in the field of autonomous vehicles are presented with their characteristics as significant visions for the future of urban mobility and application in the transport system. With all the problems and challenges (legal and ethical) that these vehicles carry, it is necessary to improve them to perfection, what will be done in the future.

1. INTRODUCTION

Autonomous vehicles are vehicles capable of sensing the environment and the complete process of directing and decision making is left to the onboard computer. Thanks to the built in sensors autonomous vehicles can make a perception of the environment on a certain but limited level. After perception, the vehicle uses complex algorithms that manage and control the behavior, so the vehicle is able to perform tasks. That is, autonomous vehicles are vehicles that can move independently and all real-time driving functions are transferred to the Vehicle Automation System [1].

The Society of Automotive Engineers (SAE) currently defines 6 levels of driving automation ranging from Level 0 to Level 5. Level 0 are full manual vehicles, no automation, where the human performs all driving tasks (steering, braking, etc.). At the next level are vehicles equipped with driving assistance. These vehicles are featured with a single automated system (e.g. monitors speed through cruise control). Level 2 are partial automation vehicles, the vehicle can perform steering and acceleration. The human still monitors all tasks and can take control at any time. At Level 3 are conditional automation vehicles. At this level vehicle can perform most driving tasks, but human override is required. Level 4 are highly automation vehicles, these vehicles are similar to full automation but they still have elements inside the car that allows human to take over the control. At the last level, Level 5, are full automation vehicles. Zero human attention or interaction is required [2, 3]. According to SAE, just vehicles from Level 3 to Level 5 are considered as autonomous vehicles.

Fully autonomous vehicles have the ability to:

- Collect data about the surrounding environment in order to create a maps;
- Detection of objects that can be of interest (people, vehicles, traffic signals etc.);
- Getting distance between two points without navigation by ground objects;
- Work for a long time without human intervention;
- Avoid situations that are harmful to a person, property or the vehicle itself;
- Self repair without external help.

As noted, all the autonomous vehicles are based on sensors and software. There is no standardized architecture for such vehicles, but there are some main sensor that allows the vehicle to operate. Those sensors are: optical (video) camera, high-frequency radar, LIDAR, ultrasonic sensors, compass, inclinometer, odometer, Global Navigation System and Inertial navigation system [4].

Video cameras are designed to recognize traffic lights, traffic signs and moving objects. Video cameras are designed not only for moving cars, but also for people and cyclists. Ordinary HD cameras are used in such vehicles and they are mounted on the windshield and on the back of the vehicle [5].

Autonomous vehicles are equipped with RADAR (Radio Detection and Ranging), designed to determine the objects height, distance, speed and direction of movement in the front and back of the vehicle. Typically, these radars are mounted in the front and rear bumpers. They work on the basis of a Doppler effect, that it sends signals and detects the characteristics of the object according to the changed frequency [6].

LIDAR (Light Detection and Ranging) is the most important part of autonomous vehicles. The main role is to provide mutual interaction between vehicle and all objects in its environment [7]. The principle of operation is similar to the operation of traditional radar, just in the case of LIDAR the receiver is a light sensitive semiconductor device. It emits over a million laser signals per second that reflect from the target and return to the vehicle creating a very accurate 3D image of the environment. The onboard computer compares the image obtained through the LIDAR and the database, and thus the vehicle can determines what kind of vehicle (e. g. car, bike, pedestrian, ect.) is around them. Ultrasonic sensors are used as short - range measuring devices and they emit periodic short-term high-frequency sound pulses. As these are small distance devices, they usually perform the functions of parking systems and to determinate vehicle position in so called "dead spots". Ultrasonic sensors measure distance from 20mm to 10m.

Global navigation systems help to determine the position of the vehicle: latitude, longitude and altitude. The inertial navigation system (INS) is a navigational device that uses a computer, motion sensors and rotational sensors to continuously calculate the position, orientation and speed of a moving object without external reference. The INS measures angular velocity and linear acceleration so it can determinate its position relative to the starting point. INS is integrated into the vehicle navigation system in autonomous vehicles [8].

Inclinometer is a device used to measure the angle of inclination with respect to the Earth's gravity. The inclinometer can be used for both vertical and horizontal measurement of angles. Inclinometer is built-in with the compass on autonomous vehicles. They have a connector with an onboard computer, so data can be displayed not only visually, but also computer-processed. The compass as a navigation instrument is used for orientation, while the odometer is used to measure the distance traveled based on the wheel speed sensor.

Advanced control systems interpret the collected sensory information to identify appropriate navigation paths, as well as obstacles and relevant signals. Camera, RADAR and LIDAR are the main sensors of an autonomous vehicle, but all of the mentioned sensors provide the vehicle a clear image of the surrounding, but the vehicle has to know its position in some kind of map so it can plan the route of operation. For that purpose vehicle uses Global navigation system and Inertial navigation system [4].

This paper presents the positive and negative characteristics of autonomous vehicles and examples of their potential usage in the transportation system. It also shows how autonomous vehicles understand information and create an image of the environment.

2. ADVANTAGES AND DISADVANTAGES

Autonomous vehicles can be used for passenger traffic (e.g. car, taxi, bus) as well as cargo transportation. Table 1. shows the advantages and disadvantages of autonomous vehicles compared to conventional vehicles.

The sufficiently frequent accidents or at least emergency situations occur due to driver distraction, which is not a case with autonomous vehicles. This distortion can be caused by many factors, like: billboards, radio, self-phone, passenger presents, noises, etc. The advantage of autonomous vehicle is reflected in the elimination of driver errors in the decision-making process while driving, which results in fewer traffic accidents. Onboard computer is programmed to adhere to strict traffic rules, so potentially dangerous situations can be avoided (e.g. drunk driving, self-phone usage, irregularly parking, exceed speed limit, etc.) [9]. Mostly autonomous vehicles are electrically powered, so they are more convenient for the environment [10].

In particular, autonomous vehicles can work under unfavorable weather conditions and at daytime. Such vehicles do not suffer from fatigue. Long sitting at the car's wheel provokes physical and psychological fatigue. Even in the most ideal road and weather conditions, even in the most comfortable cars, a person experiences fatigue over a long time running through the steering wheel. Also, such vehicles can reduce a parking space near to destination, especially in city centers. Vehicles can bring the passengers to the destination and leave to find parking spot in a different place. Passengers can easily call the vehicle back, when it is needed, by self-phone [11]. One of the main advantages of launching the autonomous vehicles is the ability to remove a person from potentially dangerous locations, such as work in areas of radioactive or chemical pollution, work with explosives, etc. [12].

Table 1. Advantages and disadvantages of autonomous vehicles

ADVANTAGES	DISADVANTAGES
The vehicle cannot be distract	Job losses
Can work under any weather conditions	Human dependency and lack of intelligence
Comfortable driving	Software abuse
Better road safety	Non-acceptance in humans
Easy maneuvering and parking	Legal issues
Ecological benefits	Ethical issues
Easy traffic control	High cost
Ability to remove a person from potentially dangerous locations.	Power and energy dependence and battery life

Usage of autonomous vehicles will come with a lot of job losses and retraining of certain qualification. Also these vehicles may be susceptible to cyber-attacks, just like home computers. If that happens it will be necessary to change certain components on all vehicles of the same series, which can be a very demanding and expensive job. Despite the fact that autonomous vehicles have a number of sensors that can identify various obstacles, that the speeds of such vehicles are not high, but the crashes happen with them. There is, also, a problem with perspective in such vehicles. For the onboard computer it is difficult to recognize and understand the pedestrian behavior (e.g. facial expression, hand signs, etc.) [9]. Sensors on autonomous vehicle can fail due to situations that could not be overviewed in the laboratory. Such failures are mostly fatal for passengers. While many of our power and energy sources have increasingly greater capacity, autonomous vehicle cannot last infinitely and are still plagued by the need to be recharged. These vehicles will cost much more than conventional vehicles, so the price can be classified as disadvantage [12]. In addition to above disadvantages, usage of autonomous vehicles face some legal, ethical and social responsibilities.

3. POTENTIAL USAGE IN TRANSPORT SYSTEM

Autonomous vehicles require a base map to successfully drive on some territory. Those maps should contain basic information of the streets position as well as traffic signs position. Based on characteristics of autonomous vehicles the best application would be in the urban passenger transport system, because all the vehicles in urban passenger transport use the same transportation route so it would be easy to make a base map for autonomous vehicles [13]. However, these vehicles can transport passengers to and from work during the day, deliver goods and collect waste during the night [14]. Nowadays, a number of companies are working on the development of autonomous vehicles like: Google, Scania, Tesla Motors, Amazon, Nissan, Toyota, Volkswagen/Audi, Mercedes-Benz, Delphi Automotive and Bosch [10].

Application of autonomous vehicles leads to several challenges. One of the biggest is who is responsible when it comes to accidents. There is also an ethical character question, if we want to create an ethical robotic system, it is unclear what ethical theory to use as a model, as ethical principles depend on every individual differently [15]. Table 2. shows the current situation of autonomous vehicles and their characteristics.

Table 2.Autonomous vehicles and their characteristics

Scania AXL autonomous truck [16,17]

- no cabine
- bio-dizel
- usage in the large closed construction sites and mines
- tested in 2021 on the E4 motorway between Södertälje and Jönköping
- 4th degree of automation (a person can take control in a critical situation)

Scania NXT autonomous bus [18]

- carrying passengers (during the day), and waste (during the night)
- intended for 2030
- 8m long,162 kWh battery pack, range of 245 km
- 55 passengers, 20 seats, weight of 8 tonne
- for extra power use solar panels at the rooftop.
- infrared heating system
- small turning radius (10,5 m)
- easy mounting stand

<u>Amazon Zoox autonomous taxi vehicle [19,20]</u>

- carry ut to 4 passengers
- all the sensors are inbuilt
- same speed in both direction
- 3,63m long, electric vehicle, 133kw battery pack
- 16 hours of continuous driving
- two motors (front and back) for energy efficient
- tested in cities: San Francisco and Las Vegasa
- speed around 130 km/h and view field around 270 degree

The main problem of autonomous vehicles are errors. Errors can be physical (sensor or actuator error, control, power and communication systems, etc.) and human made (programing and design). Actuators fail most often due to mud getting into the gears. A common error is a failure of the onboard computer and control unit. As a result, the vehicle does not respond to commands and in some situations a sudden increase in speed.The loss of communication is due to the wrong choice of communication system. The problem with the sensors occurs due to inadequate placement of sensors, less often there is a malfunction on them. There are the least problems with the power supply, since they are electric vehicles [13].

4. CONCLUSION

Autonomous vehicles, called robotic vehicles, are those vehicles that move independently and where all real-time driving functions are transferred to the Vehicle Automation System. Autonomous vehicles use sensors to create an image of the environment at a certain but limited level. After perception, the vehicle uses control algorithms to perform certain tasks: chooses routes and appropriate speeds, avoids obstacles, etc.

There are divided opinions regarding the acceptance and non-acceptance of autonomous vehicles. The public claims that autonomous vehicles provide greater autonomy to people with disabilities, improve safety and reduce emissions, while opponents of this technology believe it is less safe and insufficiently tested in a real traffic environment [3]. The use of these vehicles in everyday life can lead to the loss of a significant number of jobs. Traffic safety can not be an excuse for autonomous vehicle application, because application of such vehicles require huge amounts of money that can be transferred to more efficient measures in traffic safety, like driver education.

Significant development of autonomous vehicles started twenty years ago as a result of numerous projects. However, it is necessary to improve the system of autonomous vehicles to perfection, their constant testing and especially in real driving conditions where there is human influence and compliance with legal and ethical issues.

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REFERENCES

[1] http://driverlessworld.com/2011/06/a-brief-history-of-driverless-vehicles/

[2] https://www.rt-rk.uns.ac.rs/?q=novosti/autonomna-budu%C4%87nost-u-automobilskoj-industriji

[3] https://www.synopsys.com/automotive/autonomous-driving-levels.html

[4] Japertas, S., “Lecture 2.3: Sensorse used in unmanned ground vehicle systems”, Unmanned Ground Vehicle Systems; KTU, Kaunas, 2018.

[5] National Research Council, “Technology development for army Unmanned Ground Vehicles”, Washington, DC, 2002.

[6] Varshney, L,. “Human Machine interface for Radar Systems”, Syracuse Research Corporation, North Syracuse, 2002.

[7] Univerzitet Union, Računarski fakultet, “Autonomna vozila: početak i primena robotizovanih vozila u saobraćaju”, https://www.raf.edu.rs/docs/Diplomski_radovi/Autonomna_vozila_Kajtez.pdf.

[8] http://www.geoservis.ftn.uns.ac.rs/downloads/ISP/ZbornikStudRadova/15/Pozicioniranje%20inarcijalnom%20sistemom%20i%20GPS-om.pdf

[9] https://www.rt-rk.uns.ac.rs/?q=novosti/autonomna-budu%C4%87nost-u-automobilskoj-industriji

[10] Mester, G, “Samovozeći automobili 2018”, Yu Info Conference, Kopaonik, Serbia, 2018.

[11] Kajtez, M., “Autonomna vozila: početak i primena robotizovanih vozila u saobraćaju”, Računarski fakultet, Univerzitet ’’Union’’, https://raf.edu.rs/docs/Diplomski_radovi/Autonomna_vozila_Kajtez.pdf

[12] Japertas, S., “Lecture 1.1: History”, Unmanned Ground Vehicle Systems, KTU, Kaunas, 2018.

[13] https://www.scania.com/uk/en/home/experience-scania/features/nxt concept-vehicle-represents-a-vision-of-the-future.html

[14] https://www.carscoops.com/2019/06/scania-nxt-autonomous-vehicle-concept-can-transport-people-goods-and-garbage/

[15] Japertas, S., “Lecture 3.5: Ethical and legal unmanned ground vehicle systems use aspects”, Unmanned Ground Vehicle Systems, KTU, Kaunas, 2018.

[16] https://www.autoblog.com/2019/09/25/scanias-axl-concept-is-an-autonomous-cab-less-sci-fi-semi/
[17] https://www.scania.com/uk/en/home/experience-scania/features/axl.html
[18] https://insideevs.com/news/354248/electric-autonomous-modular-scania-nxt/
[19] https://zoox.com/
[20] https://www.tech-lifestyle.com/lifestyle/zoox-predstavlja-samovozeci-automobil/

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EFFECTIVE MEASURES IN SUSTAINABLE URBAN MOBILITY PLANS (SUMPS): ANALYSIS OF 10 (SUCCESSFUL) EUROPEAN CITIES

Key Words

Effective measures

SUMP

Modal shift

Road space transformation

Abstract

The paper presents results of an analysis of measures implemented in various European cities that have been effective in reducing the share of trips by car and increasing the shares of active mobility and public transportation.

Ten cities with a significant modal shift from cars to public transportation and/or active mobility in a period of several years were analysed. For each city, an interview was conducted with a local expert. The questions focused on the reasons for successful changes in travel habits and the existence and relevance of the SUMP in bringing about these changes.

The results show that all cities analysed have some form of SUMP, and many have additional, more specific documents. Also, most cities have been developing these documents and implementing the measures in them for many years. The modal shift has not been the result of a single measure but was always due to the combination of several push and pull measures. Cities implemented restrictive measures for cars as well as improved conditions for alternative modes of mobility and often focused on road space transformation.

1. INTRODUCTION

A Sustainable Urban Mobility Plan (SUMP) is a strategic plan that can be implemented by cities (or municipalities, regions, etc.) with the aim of satisfying the mobility needs of people and businesses for a better quality of life [1]. The SUMP concept is widely supported by European commission, and it was first introduced in 2009 which was followed by the first SUMP guidelines in 2013. SUMPs take into account social, environmental and economic objectives, and mark a departure from the more traditional transport engineering based approaches to developing urban transport systems, which have historically been based on the principle of "predict and provide" and been infrastructure-led [2], [3].The process of developing a SUMP follows a participatory approach, focusing on people's needs. At the same time, it's effectively tackling the challenges of climate, energy, and environment, caused by transport. Cities with SUMP are achieving different success stories, many of them improving health of the residents – 8 out of 10 healthiest cities have a SUMP [4].

More than 80 municipalities in Slovenia, in which three quarters of the country's population live, have adopted the SUMP, which laid the foundations for Sustainable urban mobility planning at the local level. The analysis of the experience with SUMPs in Slovenia carried out by the Urban Planning Institute of the Republic of Slovenia showed that SUMPs of Slovenian municipalities are at the initial stage of development and their measures have little impact on changing travel habits [5]. The study also showed that no major shift in residents travel habits was achieved with this first generation of SUMPs. Additional information was needed to show that the right selection of measures could not only provide economic benefits to the local communities [6], but also change the residents travel habits visibly in short to mid term time frame. Therefore, a study was started to analyse the European cities, which have achieved major changes in travel habits in a short time. It focused on the key measures that contributed most to the modal shift. The paper presents the key results of this study.

2. METHODS

The analysis included European cities, which have managed to achieve a major change in travel habits with sustainable modes of travel at the expense of car transport in the recent years. We gathered information on cities' modal split from various sources on the internet, mostly from the cities' websites and strategic documents, including SUMPs. The range of the cities researched is diverse, from capitals to smaller European cities (in alphabetical order): Edinburgh, Freiburg, Ghent, Leuven, Lund, Malmö, Pontevedra, Trondheim, Vienna, and Vitoria Gasteiz. The cities involved reduced the share of car use on average from just under 50% to around 35% in a period of several years. It means that on average the cities lowered the share of cars for around 29 %.

Table 1. Table with all the included cities and their collected data.

Cities (alphabetical order)	Car use (before)	Year (before)	Care use (after)	Year (after)	Period before-after	% Of change
Edinburg	54 %	2001	48 %	2011	10 years	11,1 %
Freiburg	39 %	1982	21 %	2016	34 years	46,2 %
Gent	63 %	2008	38 %	2018	10 years	39,7 %
Leuven	62 %	2016	49 %	2019	3 years	21,0 %
Lund	42 %	2007	34 %	2018	11 years	19,0 %
Malmö	53 %	2003	34 %	2018	15 years	35,8 %
Pontevedra	42 %	1999	28 %	2016	17 years	33,3 %
Trondheim	57 %	2009	50 %	2014	5 years	12,3 %
Vienna	40 %	1993	27 %	2016	23 years	32,5 %
Vitoria Gasteiz	36 %	2006	24 %	2014	8 years	33,3 %
AVERAGE	49 %		35 %			29 %

An interview was conducted in each city with a local expert who monitored these changes or was involved in these changes. The questions focused on the reasons for successful changes in travel habits in their city, and the measures that shifted their citizens from using a car to public passenger transportation, cycling or walking. The role of the SUMPs in these changes was also examined.

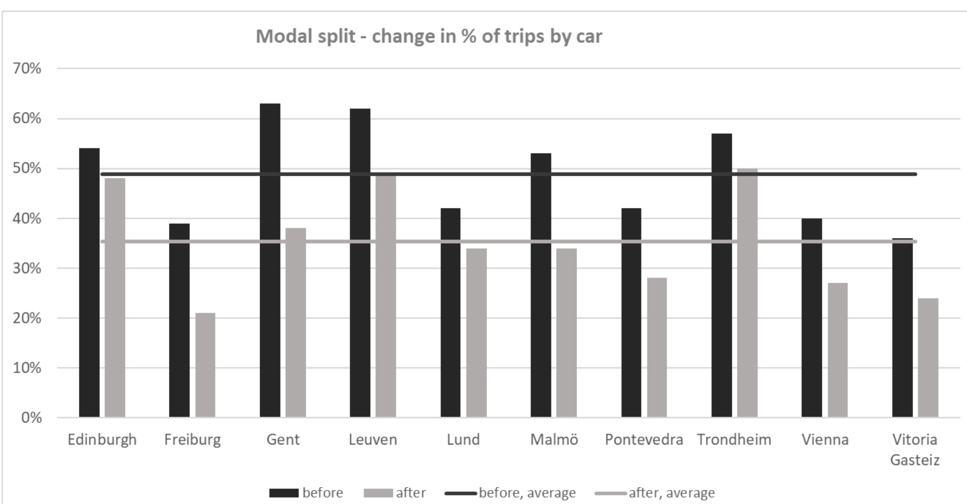

Figure 1. Modal split – change in shares of trips by car for each city

3. RESULTS

The results show that all the cities in the analysis have a SUMP or a similar document Many cities have also additional, more specific documents that strategically address individual travel modes, e.g., cycling strategy or parking policy. Their responses show that most cities have been developing their SUMP (or similar) for a long time and use it as a starting point for implementing ambitious and effective measures. It helps setting modal split goals and reaching those goals.

Not just one individual measure has brought about change, but combinations of measures are always important for change. As a rule, they apply the ”push and pull” principle. When implementing unpopular or restrictive measures and, they at the same time as fundamentally improving measures, thoroughly improve the conditions for alternative modes of mobility.

For example, the case from Freiburg states that as push factor they implemented the measures: higher parking fees, reduction of parking space and partly decreasing the capacity of the motorway network. On the other hand, they took care for pull factors: improving public transportation (especially tram tracks), improving cycle network, improving sharing services (car sharing, bike sharing). While improving the conditions for using the alternative modes they also did some marketing for environmentally friendly traffic modes to let people know that improvements have been made.

All the successful cities have the same principle in common – restraining car traffic and improving all the alternative modes, many of them focusing on public transportation, and also on improving conditions for cycling and walking.

The approach that encapsulates the majority of implemented measures in the cities researched is the road space transformation which can be a push and pull approach itself. It usually takes up space from cars, reduces their speed, and at the same time provides the infrastructure for sustainable alternatives in this space. These are comprehensive measures, such as integrated traffic calming, parking management, establishment of friendly traffic areas, thorough reorganization of public transport, dense cycling network, fast cycling connections, etc.

4. DISCUSSION AND CONCLUSION

The results from all the cities point in the same direction. The cities need to implement SUMP (or similar) to set up the foundation for successful modal shift. Other, more specific documents can also be beneficial when trying to improve conditions for a specific travel model. Unpopular or restrictive measures need to be implemented together with providing the infrastructure for sustainable modes of mobility to ensure that people will change their travel habits.

One important thing that has been highlighted in the interviews and could be further explored is the importance of political support since it can be a decisive condition for making progress.

There have been some measures implemented in several Slovenian cities, but not as a comprehensive approach with all sufficient push and pull measures that would make a significant shift from car use to other modes. For example, some restrictions for cars have been implemented, but no sufficient improvements has been made to provide better experience of public transport or cycling as competitive modes to car use.

In our opinion any city or town, regardless of the mentality of its citizens, can be successful in modal shift if there is a comprehensive approach of both, push and pull measures. Experience shows, that when people are given a realistic and efficient alternative to car use, they will use it, especially if car use is restrained. To succeed this, the key element is also the political will since without it, SUMP (or similar) document cannot be prepared and implemented. The same applies for the measures that should be implemented to achieve the actual modal shift.

The results of the research can be used as a recommendation for cities with large share of car use which are starting or struggling with changing their modal split in favour of public transportation and active mobility. The experience from successful European cities have been included in new Guidelines for the preparation of municipal SUMP in Slovenia. It is expected that the new generation of SUMPs in Slovenian municipalities will be set much more ambitiously and will contribute more quickly to improving the quality of life.

REFERENCES

[1] Rupprecht Consult, Ed., ‘Guidelines for Developing and Implementing a Sustainable Urban Mobility Plan, Second Edition’. European Commission, Brussels, 2019. [Online]. Available: www.eltis.org/mobility-plans/sump-online-guidelines

[2] E. Arsenio, K. Martens, and F. Di Ciommo, ‘Sustainable urban mobility plans: Bridging climate change and equity targets?’, Research in Transportation Economics, vol. 55, pp. 30–39, Jun. 2016, doi: 10.1016/j.retrec.2016.04.008.

[3] A. May, ‘Encouraging good practice in the development of Sustainable Urban Mobility Plans’, Case Studies on Transport Policy, vol. 3, no. 1, pp. 3–11, Mar. 2015, doi: 10.1016/j.cstp.2014.09.001.

[4] ‘Healthiest Cities in the World 2018 by Spotahome’. https://www.spotahome.com/healthiest-cities (accessed Aug. 30, 2021).

[5] A. Plevnik, L. Mladenovič, M. Balant, and A. Hudoklin, ‘Analiza stanja Celostnega prometnega načrtovanja na lokalni ravni’, presented at the Ministry of Infrastructure of the Republic of Slovenia, Ministry of Infrastructure of the Republic of Slovenia, 2020.

[6] C. Bartle et al., ‘The Economic Benefits of Sustainable Urban Mobility Measures - Independent Review of Evidence: Reviews’. European Platform on Sustainable Urban Mobility Plans, 2016.

8th INTERNATIONAL CONFERENCE
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ROLE OF TRAFFIC SAFETY IN REGIONAL SUMP

Key Words
SUMP
Traffic safety
Assessment
Regional planning
Status analysis

Abstract

Traffic safety is an important part of traffic planning. It is a complex field that is traditionally dealt with by traffic safety experts. In recent years there has been several calls for change of paradigm, which would put more focus on a wider look at the safety challenges and securing generally better conditions for pedestrians and cyclists. As such it should be considered in the process of SUMP preparation to specify a baseline situation and to identify potential problematic areas that needs to be addressed in future. The paper presents assessment of traffic safety in Slovenian Koroška region as a part of a regional SUMP development process. Within the analysis we were using actual, non-aggregated data of traffic accidents including location. Within the paper we are presenting a proposal for a statistical data processing approach that is relevant from the point of view of a SUMP status analysis and target setting. The objective was to evaluate the variables related to traffic safety that can be influenced by a SUMP. The approach is showing an interesting insight into conditions of traffic safety on a regional scale, but also potential for further research if collected data would be merged with additional data, such as actual passenger data for different transport modes.

1. INTRODUCTION

Road traffic is causing negative externalities on society. Research shows, that in partly urban/rural routes traffic accidents contributed largest share of external costs, [1]. Traffic safety increased dramatically in last decades, thanks to improvements in vehicles safety, road design, traffic safety campaigns and other measures to reduce accidents. Accidents rate per vehicle/km has been significantly reduced, however increase in kilometers traveled is slowing down the progress in reducing total number of road accidents.

Traditional traffic safety paradigm is targeting reduction of special risk factors for traffic accidents. These programs usually impose significant costs but provide only limited additional benefits. Therefore Littman proposes a new paradigm [2–4] which addresses the safety issues much wider, by supporting integrated planning, bringing significant co-benefits other than traffic safety: congestion reduction, infrastructure cost savings, lower emissions and energy consumption and better basic accessibility.

One of the emerging areas in transport planning are Sustainable urban mobility plans (SUMP-s) which are expanding the focus from local to regional level. Traffic safety is one of the objectives within the SUMP preparation. However general guidelines don't provide enough details about relevant traffic safety indicators [5, 6]. In order to evaluate progress, we first need a solid baseline measure.

Relevant statistics on a regional level are often lacking. Results from a regional analysis should be compared with data on national and international level. General statistics are often not sufficient, because they lack precise location. The most accurate measure of exposure would be if we would measure accidents by distance travelled. Unfortunately, travel data is not readily available.

The objective of this paper is to assess traffic safety for Koroška region, as a part of regional SUMP preparation. Koroška lies in the northern part of Slovenia. It is mostly rural with 70,755 inhabitants in year 2020 and three larger urban centres: Slovenj Gradec, Dravograd and Ravne na Koroškem. We analyzed traffic accidents data and displayed key statistics relevant for traffic safety assessment. Besides general analysis, we focused more closely on Štrekna bike path, as an example of a well-designed bike path.

2. METHODOLOGY

Database with traffic accidents data was retrieved from Ministry of the Interior website [7]. It includes all accidents where police were called to examine the accident. In practice, this means that minor accidents are not included, but those are not as relevant for our analysis. Data is split into yearly reports and consists of two tables, one with traffic accidents and the other with persons involved in these accidents, with unique identifier connecting two tables with one-to-many relationship. Raw data for period 2005–2019 was imported to Microsoft Access where we joined, filtered and statistically analyzed data. Spatial analysis was performed in QGIS 3.16.

Location of accidents is included in two fields – one with administrative unit and other with coordinates, that are retrieved from position on a state road, or from the closest house address on municipal roads. We first filtered data based on administrative units from Koroška region (Dravograd, Radlje ob Dravi, Ravne na koroškem and Slovenj Gradec). Out of 9,410 traffic accidents 715 had wrong coordinates or coordinates were missing. Those were included in statistical analysis but were not displayed on a map.

3. RESULTS

In Koroška region 9,410 traffic accidents with 17,801 persons involved occurred in the period 2005–2019. This numbers have been rapidly declining till 2009 and then fluctuated a bit, but in average stayed below 2009 level – see figure 1.

To get a better representation of progress in Koroška region, we calculated average no. of persons by severity of accidents in periods 2005–2009 and 2015–2019 and calculated index for Koroška and Slovenia.

Table 1. Decline in persons involved in traffic accidents by type of injury for period 2015–2019 compared to 2005–2009 for Koroška and Slovenia

no injury	minor injury	severe injury	death	all	period	area
1.011,8	457,2	36,6	7,4	1.513,0	2005-2009	
678,2	242,6	33,0	4,6	958,4	2015-2019	Koroška
33%	47%	10%	38%	37%	decline	
38.626,0	13.020,0	1.169,8	239,6	53.208,8	2005-2009	
24.812,8	7.253,4	861,0	108,8	33.137,6	2015-2019	Slovenia
36%	44%	26%	55%	38%	decline	

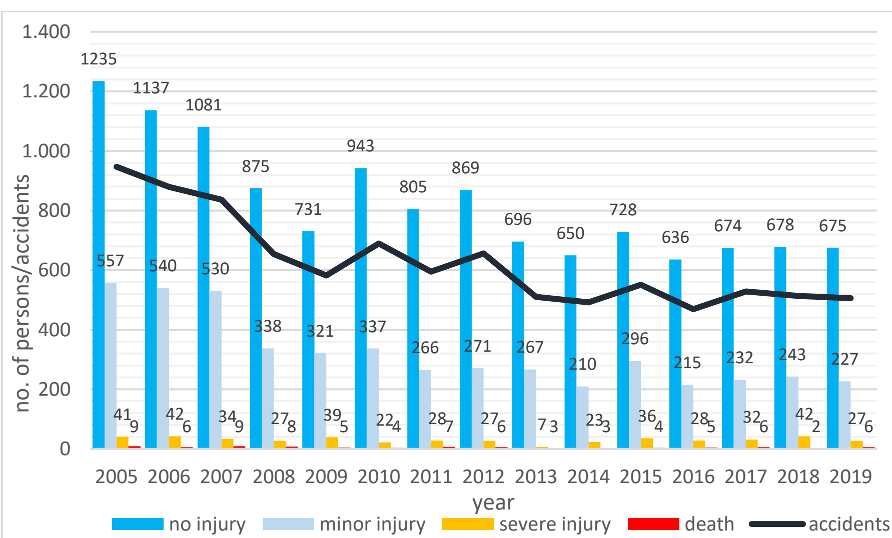

Figure 1. Persons involved in traffic accidents in Koroška region by severity of consequences

Traffic accidents can also be analyzed by travel modes. We wanted to analyze if vulnerable road users are disproportionally involved in traffic accidents. Table 1 shows number and percentage of total traffic accidents for pedestrians, cyclists and moped users by severity of injury in Koroška region in period 2005–2019.

Table 2. Involvement of vulnerable road users in traffic accidents in Koroška for period 2005–2019

	minor injury		severe injury		death	
	No.	% of total	No.	% of total	No.	% of total
pedestrian	251	5%	64	14%	10	12%
cyclist	295	6%	63	14%	3	4%
moped	141	3%	24	5%	3	4%

In Koroška region Štrekna bike path is very popular long distance separated bicycle path. We wanted to test the hypothesis, if a good infrastructure for cyclists means less traffic accidents, especially those ending with severe injury or death. For stakeholders and general public, traffic accidents around Štrekna bike path were displayed on an interactive map [8]. Data shows, that there are no spots with high concentration of accidents. Also, there were no fatal accidents.

Spatial component is one of the most important aspects with analyzing traffic accidents. For a better representation of space-time relation, an animation with weekly aggregated data was prepared [9]. Animation shows weekly aggregates of accidents by severity, with underlaying heatmap, that shows concentration of accidents that ended with death or severe injury.

4. DISCUSSION

From analyzed data for Koroška, we can see that total number of accidents and number of persons involved in them is declining. The decline has been rapid in the years 2005–2009. After that, the progress in traffic safety has been slow. If we compare averages for periods 2005–2009 and 2015–2019 (table 1), we can see that the biggest improvement has been in accidents with minor injury, which decreased by 47 %. What is worrying, is the fact, that there has been only a 10 % decline in number of persons with severe injuries. Compared to national average, Koroška has had a larger decline only in number of persons with minor injury. We can conclude that progress in traffic safety in Koroška has been slower than the national average. Unfortunately, we can’t compare exposure per person kilometer travelled since we lack travel information. Comparisons are only possible for fatalities per 100.000 population. Slovenia with 5,2 and Koroška with 5,9 average fatalities per 100.000 inhabitants in period 2015–2019 are safer compared to world average, and in fact also from European average [10].

We can argue that existing traffic safety programs exhausted it's potential. Now measures implemented in SUMP can help to improve traffic safety. According to Litman [2], mobility management strategies have large benefits also on traffic safety.

Table 3. Mobility management strategies and their safety benefits (Source [2])

Strategies	Safety benefits
Traffic calming and speed control	Large benefits
Active transport improvements	Benefits if programs increase walking & cycling safety
Public transit improvements	Large benefits
Transport pricing reforms	Large benefits
Mobility management marketing	Moderate benefits
Smart growth development policies	Large benefits

All mobility management strategies from table 3 will be included in SUMP action plan. One of the goals of SUMP is to increase walking and cycling. The increase will have to be supported by infrastructure improvements in walking and cycling network. From the example of Štrekna bike path, we can see that a good infrastructure can provide safe conditions for cyclists. There will also be improvements in road infrastructure with a new expressway. New road infrastructure is controversial in terms of sustainable mobility, however this will open an opportunity for traffic calming on existing state roads, where majority of severe accidents happened – see heatmap [9].

5. CONCLUSION

Koroška region in Slovenia was selected as one of the pilot regions to develop a regional level SUMP. Regional level of planning is beneficial terms of integration of spatial and traffic planning. Public transport and regional cycling network can't be planned by single municipality. With the new infrastructural improvements and upgrades of road (new fast road to connect the region to existing motorway network) and cycling network (extension of separated bike connection Štrekna to city of Velenje) major changes in accessibility, but also traffic safety is expected.

The development of regional SUMP opened several challenges already in the initial phases, such as status analysis. Even though traffic safety data is one of the more systematically collected, the analysis on the regional level as well as the interpretation of the collected data offered a different insight into this topic. The main objective of regional analysis of traffic accidents was to establish a baseline and to recognize specific problematic areas where traffic safety can be improved by measures included in SUMP.

If today most traffic accidents are concentrated on the regional road, we can expect this to change once the new road connection is in place. With better road a reduction of accidents is expected on the main road, as well on the regional road because of less traffic. The second group of accidents is taking place in urban areas. Considering the wider approach to improvements of traffic safety, which is supported by a number of actions in regional but also local SUMPs, such as traffic calming and improvements of cycling and pedestrian networks, additional improvements in number of accidents and their severity could be expected.

Unfortunately, comparisons of traffic safety in different regions is only possible by a more general indicator of fatalities per 100.000 inhabitants. Additional data would be needed to measure exposure by distance travelled, which would give us more precise measurement.

The collected data presented in this paper will serve as the baseline data and will be used in target settings. The presented method will support the monitoring and evaluation of the SUMP and will be repeated to observe the changes of the transport system in the region in future.

REFERENCES

[1] P. Fernandes *et al.*, 'Integrating road traffic externalities through a sustainability indicator', *Science of The Total Environment*, vol. 691, pp. 483–498, Nov. 2019, doi: 10.1016/j.scitotenv.2019.07.124.

[2] T. Litman, 'Evaluating Transportation Demand Management Traffic Safety Impacts', p. 74, 2021.

[3] B. Welle *et al.*, *Sustainable and Safe: A Vision and Guidance for Zero Road Deaths*. 2018. Accessed: Aug. 29, 2021. [Online]. Available: https://www.wri.org/research/sustainable-and-safe-vision-and-guidance-zero-road-deaths

[4] T. Litman, 'A New Traffic Safety Paradigm', *Research in Transportation Business & Management*, vol. 29, pp. 127–135, 2021, doi: 10.1016/j.rtbm.2019.01.003.

[5] Rupreht Consult, Ed., *Guidelines for Developing and Implementing a Sustainable Urban Mobility Plan, second edition*. 2019. Accessed: Aug. 29, 2021. [Online]. Available: https://www.eltis.org/sites/default/files/sump_guidelines_2019_interactive_document_1.pdf

[6] A. Plevnik, L. Mladenovič, T. Rye, M. Balant, and A. Hudoklin, *Potovali bomo udobneje, živeli bomo bolje : nacionalne smernice za pripravo Občinske celostne prometne strategije*. Ljubljana: Ministrstvo za infrastrukturo, 2021.

[7] 'Traffic safety statistical data'. Republic of Slovenia, Ministry of interior, Police, 2021. [Online]. Available: https://www.policija.si/o-slovenski-policiji/statistika/prometna-varnost

[8] S. Koblar, ‘Štrekna - infastructure and traffic accidents’, 2020. http://koroska.uirs.si/Portals/koroska/karte/strekna/strekna.html#12/46.5013/15.1117 (accessed Jul. 01, 2021).

[9] S. Koblar, ‘Animation of trafifc accidents in Koroška’, 2020. http://koroska.uirs.si/animacija (accessed Jul. 01, 2021).

[10] World Health Organization, *Global status report on road safety 2018*. Geneva: World Health Organization, 2018. Accessed: Aug. 31, 2021. [Online]. Available: https://apps.who.int/iris/handle/10665/276462

8th INTERNATIONAL CONFERENCE
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EFFECT OF DECREASED MOBILITY ON TRAFFIC SAFETY DURING THE COVID-19 PANDEMIC

Key Words

Mobility

Traffic

Safety

Travel

Abstract

Mobility analysis is used to determine how people change travel behavior, and safety analysis focuses on how traffic safety can change. The integration of mobility, safety and behavioral data related to COVID-19 is expected to provide valuable insights to decision makers. Today, the wide availability of mobile sensors has given us the opportunity to be able to assess changes in the performance and mobility of transport systems in near real time. The researchers also measured the impact of COVID-19 on human mobility using public mobile location data available from many companies such as Google and Apple, which is very useful for changing human mobility. The platforms produce aggregated metrics of daily mobility, including the purpose of travel, the mode of travel, and imputations of social demographics. Based on a comprehensive data set of people who participated in the collected accident data and mobile device data, we record the impact of COVID-19 on traffic safety. The paper systematically and statistically approaches the assessment of road safety during the COVID-19 pandemic. To sustain the spread of COVID-19, a natural experiment is being conducted that dramatically reduces traffic and provides unprecedented data. While such measures cannot be replicated, understanding their impact can help us devise more effective policies and interventions on road safety.

1. INTRODUCTION

Recently, on March 11, 2020, the World Health Organization declared a new infectious coronavirus, also known as COVID-19, a global pandemic. All countries were affected by the coronavirus epidemic. In response, national governments have implemented suppression measures focused on reducing people’s mobility and social interactions. Strict restrictions and policies have been introduced in various countries to limit the spread of COVID-19, including quarantines, job restrictions, education, shopping, physical activities, and ban social gatherings. All the measures adopted to protect human health were actually aimed at preventing the movement of people and their contact. To limit the occurrence of the virus and the likely casualties, most governments around the world have conducted quarantines. Due to the relatively limited space, public transport stations and cars are considered to be the area with the highest risk of COVID-19 spread [1].

Reduced mobility also indirectly affected the reduction in traffic volume. Prohibitions on leaving the place of residence, less burden on public transport and the like, have led to a smaller number of personal vehicles and public transport vehicles on the roads. Following the available data and traffic analyzes, the question arises whether all this together led to a reduction in the number of traffic accidents and injuries in traffic in the past 2020. This article analyzes in detail the traffic safety situation during the COVID-19 pandemic in the Republic of Croatia. This study looks at traffic safety according to the records of traffic accidents with injured and fatalities in the time before and during the COVID-19 pandemic. This is a preparatory study and when more data becomes available the report will be updated with better estimates.

2. METHODOLOGY AND RESOURCES

Google released community mobility reports that show movement trends by region, across different categories of places. For each category in a region, reports show the changes in two different ways. Compares mobility for the report date to the baseline day. Calculated for the report date and reported as a positive or negative percentage. Using anonymous data provided by apps like Google Map, the company has created a regularly updated dataset that shows how people’s movements changed during a pandemic. Since road transport and air transport were two key dimensions for the spread of COVID-19, one of the restrictions imposed was the restriction of personal mobility [2].

This Google data set measures the number of visitors to certain categories of places on a daily basis and compares this change to the starting day before the outbreak. Baseline days represent the normal value for that day of the week, which is given as the average over five weeks from January 3 to February 6, 2020.

Apple released a series of mobility data related to the COVID-19 pandemic. Data are collected from requests for instructions in Apple Maps and are provided nationwide, as well as for the selection of major cities around the world. Apple has released time series data for countries and cities for each of the two modes of movement: driving and walking.

2.1. Mobility Trends in Croatia

The chart shows the relative volume of requests for driving and walking in Republic of Croatia, compared to the base volume of January 13, 2020. In a part of the country, on March 14, 2020, preventive measures will be introduced and on March 19, 2020, the implementation of measures to close most stores and cancelling public events across the country began. On March 21, 2020, the National Headquarters issued a decision to strictly limit detention on the streets, squares and other public places, as well as a decision to suspend public transport in order to prevent an increase in the number of infected people. Intercity lines for trains and buses are also being cut off.

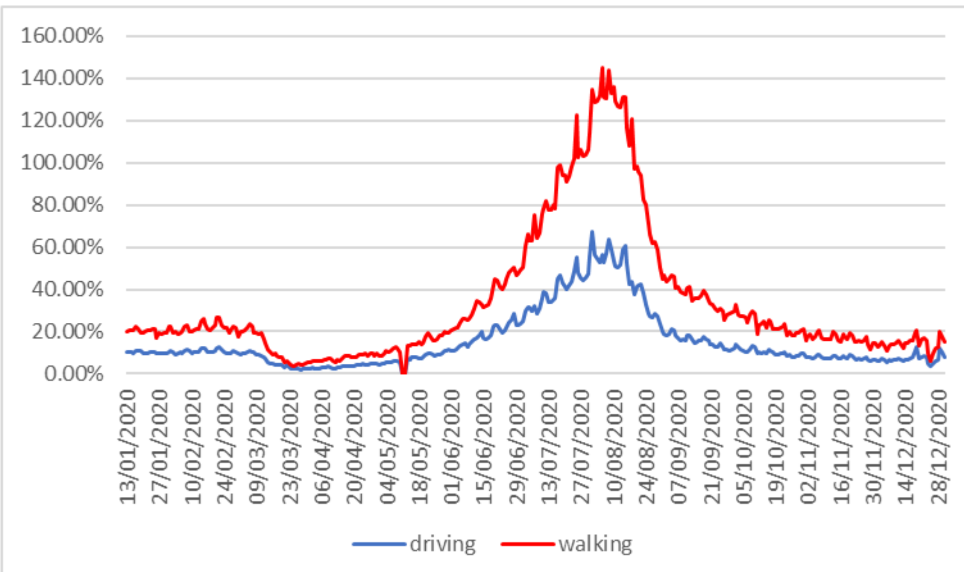


Figure 1. Mobility Trends Report from Croatia [3]

The graph shows the largest decline in mobility on March 23, 2020, and the reason is the ban on leaving the place of residence or permanent residence. By the decision of the National Headquarters on April 27, 2020, the first phase of easing pandemic protection measures in order to partially start the economy came into force. This enables the work of all business entities that perform the activity of trade, except those that perform trade activities, except for those who operate shopping centers. The third phase of easing epidemiological measures began on May 11, 2020, so schools were opened for some students, and after almost two months, shopping malls, cafes and restaurants began to operate. This establishes a long-distance road, rail and domestic air transport of passengers, as well as open bus and train stations for long-distance traffic.

2.2. Analysis of traffic safety

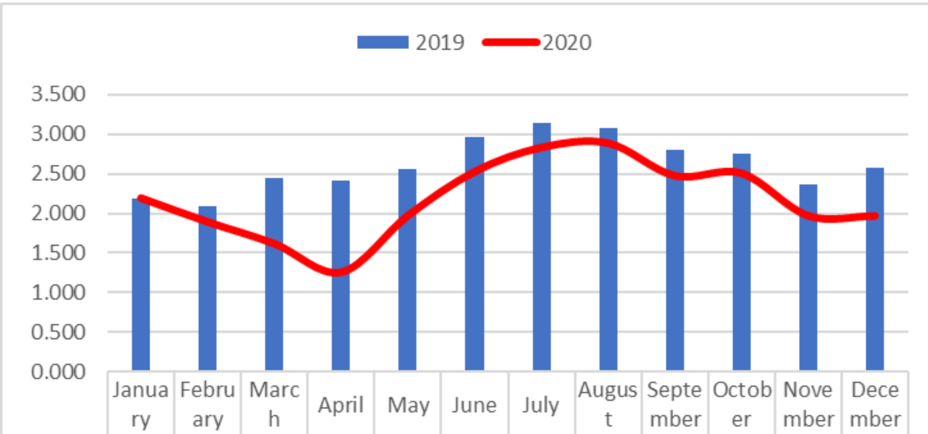
The Ministry of the Interior takes care of the state of road traffic safety. In order to make this part of the work as successful as possible, the condition and changes in road safety are systematically monitored. The results of this work are statistical information that provides a more detailed and complete picture of the state of road safety in the Republic of Croatia and all risk factors that threaten it. Following the available data and traffic analyzes, the question arises whether all this together led to a reduction in the number of traffic accidents and injuries in traffic, the past 2020. We compared the number of traffic accidents before and during the COVID-19 pandemic.

Table 1. Traffic accidents by months with fatalities and injured persons [4]

Month	Traffic accidents					
	Total		With fatalities		With injured persons	
	2019.	2020.	2019.	2020.	2019.	2020.
January	2.180	2.191	20	21	536	636
February	2.092	1.893	14	18	556	521
March	2.437	1.621	12	11	720	402
April	2.417	1.265	22	16	723	349
May	2.553	1.972	24	16	753	585
June	2.966	2.522	28	24	976	773
July	3.146	2.824	24	33	997	939
August	3.080	2.878	26	19	1.042	918
September	2.807	2.470	27	18	903	775
October	2.746	2.501	31	13	870	639
November	2.371	1.969	16	13	667	490
December	2.572	1.968	35	12	673	469
Total	31.367	26.074	279	214	9.416	7.496

Our findings show that the lockout set by the Croatian government on March 21, 2020, as a measure to drastically reduce the spread of COVID-19 disease, has led to a significant reduction in traffic accidents. Although the number of accidents can vary from year to year and even from season to season, the huge difference in the number that occurred during 2020 and the equivalent period in 2019, as well as between the periods before and during isolation, can mainly be attributed locking. The probability of a traffic accident is higher if there are more vehicles on the roads.

In the year in which it will be remembered for the covida-19 pandemic, the number of deaths decreased by 65 people, i.e. from 279 in 2019 to 214 in 2020, which is a 23.30 percent lower number of deaths. It was recorded and reduce the number of road accidents, and with 31,367 in 2019 to around 26,074 in 2020, which is 5,293 fewer traffic accidents or 16.87 percent lower number of traffic accidents. Last year, there were about 20.39 percent fewer injured, or 9,416 compared to 7,496 during 2019, which is 1,920 fewer accidents with injured people, according to police statistics.



	January	February	March	April	May	June	July	August	September	October	November	December
2019	2.180	2.092	2.437	2.417	2.553	2.966	3.146	3.080	2.807	2.746	2.371	2.572
2020	2.191	1.893	1.621	1.265	1.972	2.522	2.824	2.878	2.470	2.501	1.969	1.968

Figure 2. Comparison of the number of traffic accidents in 2019 and 2020

The results suggest that during April when the strictest measures were in place for the entire month, traffic accidents dropped approximately by 47.66 percent, deaths declined by 43 percent and injuries declined by 64 percent compared to April of last year.

The total number of registered road vehicles in the Republic of Croatia amounted to 2.312.280 in 2020, which was 1.6% more than in 2019. The total number of registered passenger cars amounted to 1.746.285 in 2020, which was an increase of 1.2% compared to 2019. The number of first registrations of road vehicles amounted to 132.572, which was a significant decrease of 31.8% compared to 2019. The decrease in first registrations was recorded for all types of vehicles. The circumstances brought about by the spread of the COVID-19 disease have directly influenced the decrease in the number of first registrations of road vehicles. The number of first registrations of passenger cars amounted to 95.577 in 2020, which was a decrease of 35.9% compared to 2019. The decrease was caused by the reduction in the number of first registrations of used cars (27.6%) and new vehicles (49.9%) [5].

3. CONCLUSION

In order to raise the state of road safety to a higher level, society must invest significantly more efforts in improving transport infrastructure and developing a transport culture. A large part of this effort belongs to the Ministry of the Interior, ie the traffic police, whose activities influence the increase of traffic discipline of all participants. The development of traffic accidents after a period of isolation should be studied.

The unexpected benefits of the crisis caused by the COVID-19 pandemic are likely to persist only if mobility restrictions are maintained or if new public policies are designed and implemented to allow for a gradual change in mobility patterns. The rapid growth in the share of bicycles and e-scooter-free documents has created new challenges for policy makers and regulators and exacerbated some pre-existing fears. Areas of concern include safety, not just the consequence of potential conflict with other means, consumer protection and external influences, especially the overcrowding of public spaces with an excessive number of sometimes neglected bicycles or scooters.

Although traffic has increased in recent months with some return to work and to school, reluctance to use public transport and parking, and a large number of delivery vehicles, many of the risk behaviors continue. The problem is further exacerbated by a significant increase in the number of pedestrians and cyclists on the roads. It has become clearer than ever that roads do not belong only to vehicles, but are common areas for cars, pedestrians, cyclists, scooters and other modes of transport.

Due to the limited data and information available, no more advanced methods have been used in this study, but they will be included in future research. If sufficient quality data is available, a more detailed picture of the impact of COVID-19 and quarantine on road and transport system safety could be produced, but this could be explored in future studies.

REFERENCES

[1] Musselwhit C, Avineri E, Susilo Y. Editorial JTH 16—the Coronavirus Disease COVID-19 and implications for transport and health. J Transport Health. 2020;16:100853.

[2] Wu JT, Leung K, Leung GM. Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study. The Lancet. 2020;395(10225):689–97.

[3] Apple reports on trends of mobility. [Online]. Available at: https://covid19.apple.com/mobility [Accessed June 27, 2021].

[4] Bulletin about road safety 2019, 2020, Republic of Croatia, Ministry of the Interior

[5] *Central Bureau of Statistics of the Republic of Croatia. Registered road vehicles and road traffic accidents in 2018*.

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KATINKA – GATHERING A REFERENCE DATA SET OF BICYCLE TRAFFIC FOR TRANSPORT MODELS

Key Words

Public space
Transmodal
Active mobility
Transportation model

Abstract

Active transport modes play an important role in the decarbonization of urban transportation. Transport models and data are important decision supporting tools for infrastructure investments. For active mobility modes only a minimum data quantity and quality is available, an unleveled playing field in decision making processes is predestined.

This paper presents a mixed-method approach to generate a reference dataset for cycling in a certain study area. The approach combines short-term, long-term and permanent bicycle counts together with interviews. The resulting outcome provides a better reference for decision making processes. This enables city- and transport-planners to better assess the effects of actions in the public space for all transport modalities.

By implementing the generated reference data in transportation models that include active modes, it is possible to determine in an objective manner, whether proposed actions in the public space contribute to the aims as posed in traffic strategy and policy documents. This will enable evidence-based improvements for active mobility modes.

1. INTRODUCTION

Mobility surveys, traffic research and transport models are important decision supporting tools for infrastructure investments at all scales. As for active mobility modes only a minimum data quantity and quality is available, an unleveled playing field in decision making processes is predestined.

A true integration of active mobility modes in the strategically important transport models is not present at the moment. Especially as active transport modes play an important role in the decarbonization of urban transportation, improvements of active mode data collection and modelling methods are essential.

The aim of the „KAtinka"-project is to contribute to active mode data collection and modelling methods by the exploration of new data sources and experimentation with implementation of active modes in a transport model.

The main challenge in any modelling application is the availability of knowledge about the "ground-truth" or reference data. Conventional mobility data, such as those gathered in travel diaries, can only be used for macroscopic bicycle models to a certain extent: often the sample is too small and the resolution too low.

It is also known that there is a strong interaction between the different modes of transport. These transmodal effects are often very complex and difficult to survey. Multimodal traffic models are usually just "multiple unimodal" traffic models, that can't depict these strong effects of multimodal trips where bicycle and public transport complement each other (bicycle traffic as a feeder to public transport or taking bicycles on the train).

This paper presents a mixed-method approach to generate a reference dataset for cycling in a certain study area. The mixed-method approach was applied to the city of Graz in Austria.

2. METHODS

In order to extract a reference dataset for cycling in our study area three surveys were conducted:

[1] A traffic (=bicycle) count on a qualifying date

The count was conducted on a working day (April 12th 2021) over a period of 3 hours from 7 to 10 a.m on 37 different locations in the urban area of Graz and along the main bicycle routes.

At each location the number of bicycles, e-bikes and other vehicles (scooter, e-scooter, cargo bike, segway, etc.) were counted for both directions separately and in 15-minute intervals. Within this short period of time more than 10.000 bicycles were counted.

[2] Simultaneous automatic traffic counters

To validate the manual surveys traffic counters were installed on 6 different locations throughout the city of Graz in coordination with the 4 existing permanent bicycle counting points of the city [1] for 2 whole weeks (April 5th 2021 – April 18th 2021) simultaneously to the other two surveys.

The devices used radar detection to measure the traffic, which also allowed bi-directional counting.

Figure1 shows the locations of the different surveys and the main bicycle routes of the city of Graz.

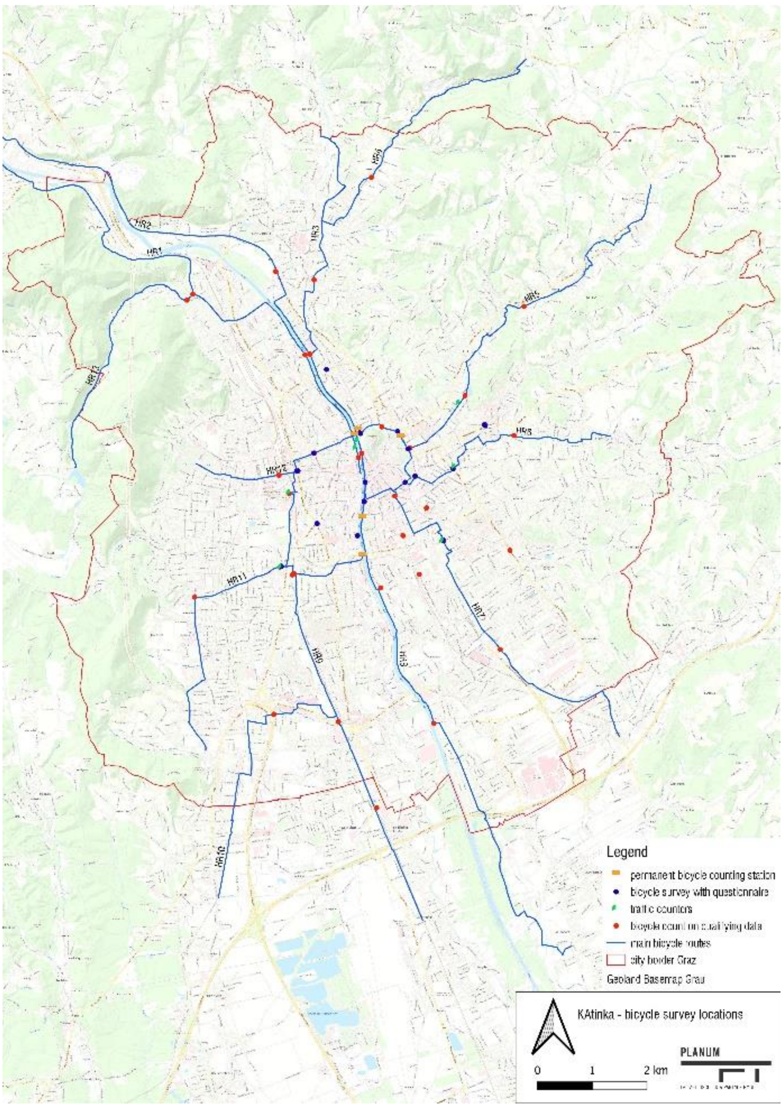

Figure 1. Map of all survey locations

[3] Survey of cyclists at cross-sections in Graz during a 2-week-time-period with questionnaire

The survey was conducted on 16 different locations all over the inner urban area of Graz on 6 working days (Tue, Wed, Thu) within a period of 2 weeks in April of 2021. The survey time was from 6 to 10 a.m. and from 2 to 6 p.m. The questionnaire was designed in digital form, so the survey was conducted with tablets.

The survey had the focus on determining path length distributions according to the purpose of the journey. Above all, the results provide different path length distributions for bikes and e-bikes. The survey was designed to attain a high number of cases. In order to be able to cover all trip purposes, cross-sections have been selected along the main cycle routes of Graz. In addition, the surveys were carried out at intersections with traffic lights, since communication between the interviewer and the person being interviewed is facilitated when stopping and waiting is mandatory.

Only survey sites with sufficient space were selected so as not to hinder the flow of traffic. Ideally, an interview was to be carried out within a traffic light phase. Therefore, only essential questions were asked. These were:

- Origin of the trip (as accurately as possible) and purpose (home, work, shopping, etc.)
- Destination of the trip and purpose

If the interviewee had enough time, additional questions were asked, such as:

- Is there a safe bicycle parking at your source? (you can lock up your bike to something firmly anchored)
- Is there a safe bicycle parking at your destination?
- if e-bike: Is there a charging option for your bike at your source?
- if e-bike: Is there a charging option for your bike at your destination?

At the end of each interview the interviewer stepped aside to finish their report as well as to document the estimated gender (binary) and age (given age groups) of the interviewee.

In this survey 2.437 cyclists were interviewed.

3. RESULTS

The resulting data shows, that about 98 % of the trips had their origin as well as their destination within the urban area of Graz. About 55 % of the trips originated from one specific postal code (8010 = inner city). About 54 % of the trips have their destination within one specific postal code (8010).

It has to be noted, that only 85 % of the interviewees stated the street name of their origin respectively only 39 % of the interviewees the street name AND the exact house number. For the destination, also 85 % of the interviewees stated the street name, but 48 % the street name as well as the exact house number.

Only 2 % of the bicycles being interviewed were e-bikes; about 0,5 % e-scooters as well as cargo bikes. During the bicycle count on the qualifying date the percentage of e-bikes however was at around 7 % (at all counting locations throughout the city). The low percentage of e-bikes during the questionnaire survey might be ascribable to the fact, that the survey was conducted during the COVID-pandemic and regulations were stricter than usual: therefore, it was advised for the interviewer to minimize the interaction with the interview by reducing the questions asked and by keeping the most possible distance. Some interviewers reported, that the motor of e-bikes is very often very small and hidden, so that they couldn't recognize whether the vehicle was an e-bike or a normal bicycle.

Figure 2 shows the flow map on zip-code level and indicates a very strong inner-city traffic.

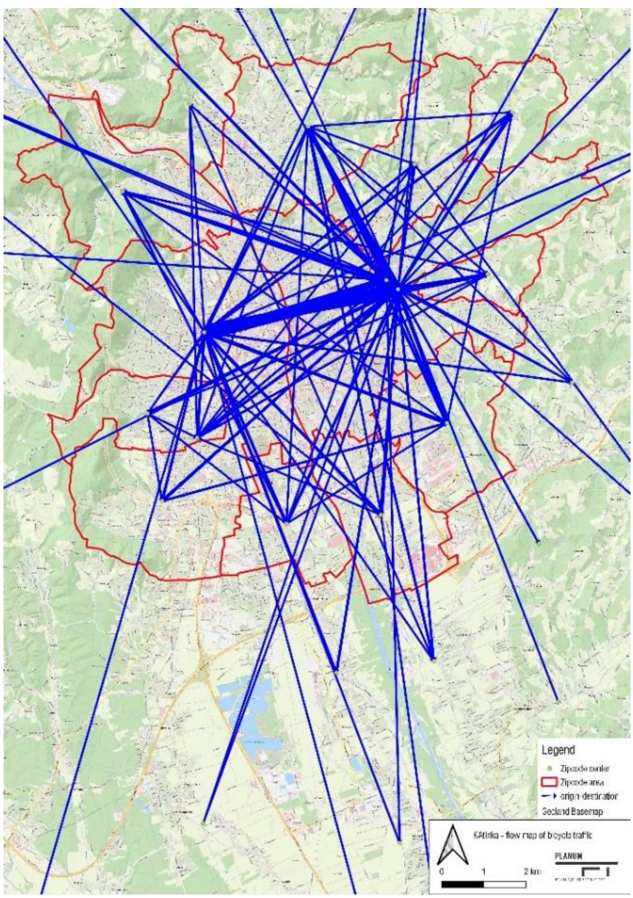

Figure 2. Desire lines – origins and destination on zip-code level

4. CONCLUSION AND OUTLOOK

As identified in the introduction, the main challenge in any modelling application is the availability of knowledge about the “ground-truth” or reference data. This paper presented a mixed-method approach to generate a reference dataset for cycling in a certain study area.

In the next steps, the individual survey results will be combined with data of the permanent bicycle counting stations in order to create trendlines for all 43 temporary counting locations. Through combining counting data with weather observations we might be able to extrapolate bicycle volumes for all 43 temporary counting locations for any given time and weather situation.

ACKNOWLEGDEMENT

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REFERENCES

[1] Permanent bicycle counting stations of the city of Graz, see: https://www.graz.at/cms/beitrag/10116349/8032890/Rad_Zaehlstellen.html#

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THE IMPACT OF TRAINING YOUNG DRIVERS IN DRIVING SCHOOLS ON ROAD SAFETY

Key Words
Young drivers
Road safety
Driving school
Traffic accidents

Abstract

Road traffic accidents are the leading cause of death for young people worldwide. In the Republic of Croatia, young drivers cause a total of 9.6% of all road traffic accidents and 12.5% of road traffic accidents resulting in fatalities. Such unfavourable statistics point to the need to conduct research into the causes of road traffic accidents attributable to young drivers, including the possibilities of reducing these accidents and the loss of young lives. For this purpose, a survey was conducted on a sample of 740 young drivers from all over Croatia. The respondents were asked about their habits and behaviour after starting independent driving, about the consequences of reckless behaviour on the roads, the use of alcohol and narcotic drugs, and the use of mobile phones while driving. In addition, young drivers were asked to assess the quality of the three training courses they completed at the driving school and their opinion on the need for changes and improvements in training. The results of the research led to conclusions regarding the measures required to increase the quality of training of young drivers, as well as regarding optimal and viable solutions for raising awareness among young drivers, greater preparedness to drive alone, the development of traffic culture among young people, and consequently greater road safety.

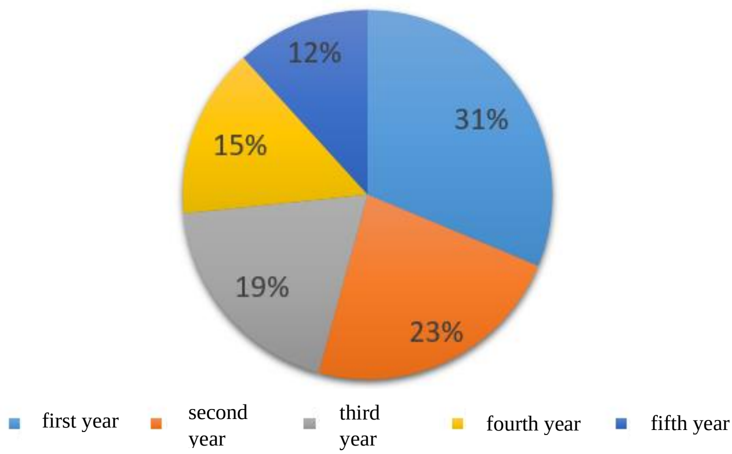
1. INTRODUCTION

With almost 1.3 million people dying in road traffic every year, the incidence rate in Croatia is 10.4 per 100,000 inhabitants. It is estimated that by 2030, road traffic accidents will have become the fifth leading cause of death globally. Young drivers make up about 8% of the driving population and account for an excessive percentage in all statistics related to road traffic accidents. In fact, young drivers are twice or three times as likely as more experienced drivers to cause a road traffic accident. For each young driver killed in a road traffic accident, averagely 1.3 people (passengers and other road users) also die in the same road traffic accident. Novice drivers thus present a great challenge in improving road safety considering that the mistakes they make when driving a vehicle result in as many as about 15% of the total number of road deaths. Often without thinking about the consequences, young people take lightly the risks of irresponsible behaviour behind the wheel. Inexperience, overconfidence, speeding, and the use of narcotic drugs and alcohol are just some of the factors contributing to the excessive number of road traffic accidents of young drivers. The level of education of young drivers on road safety, the amount of effort put into raising their awareness of the risks of driving and the necessary culture of driving behaviour, including the level of knowledge they actually have at the time of obtaining a driver's license, is of the greatest concern. Therefore, it is necessary to examine the quality of training provided by driving schools and try to improve it as much as possible as this will prevent accidents of young drivers and increase road safety in general.

2. ROAD SAFETY FOR YOUNG DRIVERS IN CROATIA

In terms of acquiring driving skills, young people have an advantage over older people because of their high level of psychophysical abilities enabling them to master the driving technique much faster, have better reflexes, and gain understanding of traffic rules and regulations more easily compared to older people. However, as a result of their lack of experience and their underestimation of the potential risks involved, younger and inexperienced drivers are slower in terms of assessing potentially risky situations in road traffic, perceiving road traffic in general, and detecting possible hazards in time. Furthermore, the problems that occur with young drivers in road traffic include their poor assessment of their own present psychophysical abilities to drive. The use of alcohol, narcotic drugs, and psychoactive substances, including fatigue, leads to lower self-control of behaviour in young people. The urge to take more risks to impress another person is also a major factor leading to accidents. For the majority of young people, this urge is stronger than the need to comply with traffic regulations, often compelling young drivers to press the accelerator pedal too much and exceed the speed limits without considering the risks involved. If a young driver in a vehicle is carrying multiple passengers who are the driver’s peers, the driver focuses more on laughter, conversation, loud music, and all in-vehicle entertainment than on the monitoring of traffic in front of and around the vehicle.

Consequently, the young driver fails to notice the hazardous situation, either in time or at all, and thus is not able to react promptly and properly. Nowadays, young drivers' attention is mostly diverted by modern technology: talking on mobile phones, texting, posting content on social networks while driving, selecting and changing music on the radio, etc. Research shows that using a mobile phone while driving is equivalent to drink-driving, or even worse. The reaction time while using a mobile phone is longer than the reaction time of a person with blood alcohol level of 0.8%. According to statistics, the majority of accidents caused by young drivers occurred on Saturdays and the majority of people died on Sundays. In terms of the time of the day, the majority of accidents occurred between 12:00 pm and 04:00 pm, and the majority of people died between 08:00 pm and 12:00 am. The most common type of road traffic accidents caused by young drivers refers to the vehicle skidding off the road (26.64%), as a result of which 221 people have died in the last 10 years in Croatia.



Graph 1. Accidents of young drivers by years after taking the driving test

The most common cause of accidents among young drivers is speed unsuitable for road conditions which, compared to other causes, accounts for as many as 42.38% of accidents that resulted in as many as 284 fatalities in the period from 2010 to 2019.

In 2020, a total of 5925 young drivers were involved in some type of road traffic accident. Graph 1 shows the percentage of accidents by years after taking the driving test.

3. RESEARCH INTO THE HABITS AND BEHAVIOR OF YOUNG DRIVERS AFTER THEY START INDEPENDENT DRIVING

A survey was conducted on a sample of 740 young drivers from across Croatia who were asked about their opinion on the training process in driving schools, about driving techniques and habits, the consequences of irresponsible behaviour and about their understanding of legal provisions related to young drivers.

3.1. The impact of training young drivers in road safety in driving schools

In the process of training provided by driving schools, young drivers gain knowledge about traffic rules and regulations, including the provision of first aid to people injured in road traffic accidents. They also acquire driving skills, learn about traffic culture and importance of showing consideration for other road users, as well as about safe and cautious driving. However, house manners, instilled behaviour, qualities and traits largely determine driving patterns and responsibilities in road traffic after a young driver passes the driving test and starts driving independently. It is thus important to explore methods on how to affect awareness among young people, improve training and ensure that young people, when they get their driving license, continue following the rules and behaviours taught in driving schools.

When asked about the quality of the training course on traffic regulations and safety rules, 45.9% of the respondents said they were not satisfied with the method of teaching because the candidates were taught only through examples of situations that were usually presented in the tests. Instead of wasting time on dull and unnecessary definitions, the instructors should focus on showing the candidates real everyday situations and using practical examples. The respondents said that there should be more videos with real cases, simulations and more modern presentations, including more interaction with the candidates in the lectures. The course on the provision of first aid was given the highest quality rating by only 35.2% of the candidates. The survey indicated inadequate lecturers and insufficient practical work as the most common shortcomings of that training course. The young drivers stated that the training course lacked interaction in lectures, and videos showing real-life situations. They said that future drivers should be taught and prepared psychologically how to stay calm in case of a road traffic accident. They stated that the training in the provision of first aid to the people injured should be done every few years. As the main reasons for dissatisfaction with the course on driving a vehicle, the respondents (47.7%) cited various flaws of driving instructors (bad behaviour, shouting, insults, lack of interest, etc.) and exceedingly long waiting time for the practical driving test after the completion of driving lessons (one month to take the driving test for the first time, and often up to two months to re-take the driving test).

3.2. Reckless behaviour on the roads

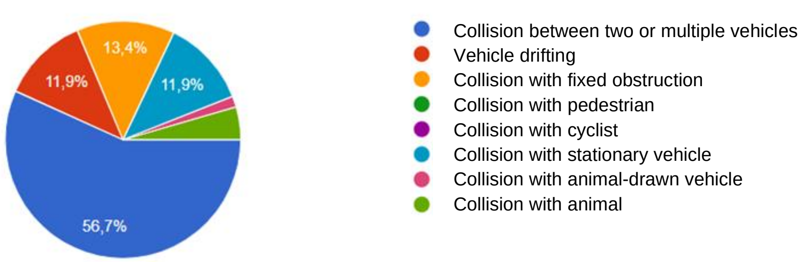
When asked about the use of narcotic drugs before driving, 6.9% of the respondents in the survey answered in the affirmative. As regards the use of alcohol, 36.4% of the respondents answered in the affirmative. This is a really high percentage, considering the draconian penalties for alcohol use and the fact that young drivers are forbidden to use even the smallest amounts of alcohol, i.e. they are required to have blood alcohol concentration of 0.00 g/kg. When asked whether they were aware of this statutory provision, 97.1% of the respondents in the survey answered in the affirmative. Using a mobile phone while driving is very popular among young drivers since as many as 58.2% confirmed they were using their mobile phones while driving. Given that mobile phone use while driving is considered the fourth cause of fatal road accidents, the number of young drivers who answered in the affirmative is quite discouraging and troubling. Seat belt is used by 97.7% of young drivers, which is commendable, but this high percentage can also be attributed to newer vehicles that sound signals to warn of the mandatory fastening of seat belts.

The survey revealed that 50% of young drivers who caused a road traffic accident drank alcohol before driving, 15% used narcotic drugs, and as many as 74% of the respondents used a mobile phone while driving. These percentages are much higher than the percentages relevant to the same irresponsible behaviour of the respondents who did not cause a road traffic accident, which leads to the conclusion that the foregoing factors greatly contribute to causing road traffic accidents. Devastatingly, 29.6% of the respondents stated that the fine they received for causing a road traffic accident and violating traffic regulations did not prevent them from repeating the same mistakes or compel them to be more careful when driving. As many as 89% of the respondents answered in the affirmative to the question of whether they considered themselves safe drivers. Hence, even the accidents they caused did not dent their high self-confidence or motivate them not to overestimate their own driving skills.

When asked if they have ever hit a fixed obstacle or another parked vehicle without leaving their details or notifying the police (including the time before obtaining a driver's license), 14.8% of the respondents answered in the affirmative. This indicates the need for systematic education and training in moral values, consideration for others and increase in general knowledge and common courtesy.

3.3. Causes and types of road traffic accidents

With respect to the types of road traffic accidents caused by young drivers that took part in the survey, as many as 56.7% relate to the collision of two or more vehicles. Of all types of collisions, the most common one was a side collision with a vehicle (35.7%), followed by a rear-end collision (26.2%), a collision occurring when driving side by side (14.3%), a head-on collision and a back-up collision (each 11.9%).



Graph 2. Types of road traffic accidents caused by young drivers

The most common cause of road traffic accidents is tailgating (23.4%), followed by violation of the right of way and speed inappropriate for road conditions (17.2%).

4. RECOMMENDATIONS FOR INCREASING ROAD SAFETY FOR YOUNG DRIVERS

Research conducted among young drivers has led to the conclusion that certain changes are critical in the process of training. This fact is demonstrated by the number of accidents caused by young drivers on Croatian roads. In addition to training provided by driving schools, grim statistics are also an outcome of young people's attitudes and behaviours resulting from house manners. With the current training programme, it is impossible to effect substantial changes in young people's behaviour, given the lack of teaching content that would bring about changes in unacceptable behaviour in traffic such as the need for young people to impress their peers by taking more risks in the company of their peers and reckless behaviour behind the wheel (alcohol, drugs, mobile phone use).

The results of the conducted surveys clearly indicate that changes are essential in delivering teaching content of the course on traffic regulations and safety rules and on the provision of first aid. The proposal of measures to improve teaching refers to the modernisation of lectures, simulations of real-life traffic situations, interactive participation in addressing demonstrated situations that can occur while driving, learning with understanding and not just by examples from the test. In that case, the lecturers would be more motivated without having to constantly repeat the same definitions and analyse the same situations shown on the pictures. The discussion and exchange of views would result in the transfer of greater knowledge to future young drivers. Considering that the research among young drivers showed that the course on driving is faced with a grave problem with the behaviour of certain instructors who lack patience or knowledge, the proposed solution is that the final exam for driving instructors is administered by an authorised professional organisation instead of private colleges currently administering the exams. This would avert the issuance of licenses without testing the acquired knowledge and driving skills of future instructors.

Great emphasis is placed on the need to introduce lectures on traffic culture in driving schools in order to try to influence young people's behaviour and attitudes with the aim of raising awareness of the consequences of their irresponsible behaviour on the roads. To this end, psychologists trained to work with young people should be included in the training process. Competent authorities (Ministry of the Interior), whose representatives would present statistics of road traffic accidents of young drivers, including their causes and consequences, should be engaged in the training process as well. Additionally, showing videos of road traffic accidents with severe consequences would be a good way to influence the behaviour and the minds of young drivers.

The survey conducted to investigate the extent to which young drivers are ready to drive independently shows the importance of young people's opinion about the methods and quality of training. Therefore, one of the proposed solutions is the introduction of questionnaires and various surveys on satisfaction with training, and preparedness to drive independently after training as such measure would take into account the need for changes, criticism and suggestions of the majority of service users, which would undoubtedly lead to improved training of young drivers.

5. CONCLUSION

Surveys for the purpose of this research which were conducted on a sample of 740 young drivers from across Croatia point to the need for changes in the method of training provided by driving schools. In addition to the problem of insufficient number of driving lessons and other shortcomings of the training process itself, surveys also show the problem of irresponsible behaviour among young drivers; 58.3% of them stated that they used a mobile phone while driving, and as many as 36.4% drank alcohol before driving. These survey results demonstrate the risk that young drivers pose to road safety and indicate the need for constant efforts to find solutions to this problem.

The process of training young drivers in driving schools may have a number of shortcomings, but the entire blame for the grim statistics relevant to young drivers on the roads cannot be placed solely on driving schools and driving instructors. The problem also lies in the individual's own identity, personality traits, character, attitudes, temperament, upbringing and other characteristics. It is, therefore, very important to consider engaging psychologists in the training process. Part of the responsibility for the lack of training, and thus the bleak statistics relevant to young drivers, rests with the government. Plenty of challenges facing driving schools and young drivers require government assistance to streamline the whole training process, both financially and psychologically. If the government initiated any prevention programmes, as well as surveys of candidates for drivers and driving instructors, and carried through the necessary reforms on the basis of the received feedback, many shortcomings related to training would be minimised, resulting in increased road safety and reduced number of young people killed on the roads.

REFERENCES

[1] Road Traffic Safety Act (Official Gazette 108/17)

[2] Proposal for an Act on Amendments to the Road Traffic Safety Act (108/17)

[3] The 2019 Road Safety Bulletin, Ministry of the Interior, Zagreb 2020

[4] Regulations on the Training of Driving Candidates (Official Gazette 132/2017-3037)

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CHILD PEDESTRIAN SAFETY EDUCATION: A CASE STUDY IN SERBIA

Key Words
Safety
School children
Pedestrian
Education

Abstract

The primary goal of the presented research are inception, implementation and evaluation of a pedestrian safety education program for school-age children (7 and 8 years old) without formal traffic safety knowledge and skills. The sample was taken among students from selected classes from four elementary schools located in various regions of the Republic of Serbia. In order to measure and evaluate the knowledge and behaviour, the students were put through testing before and after the pedestrian safety education program. Data were analysed using repeated multivariate analysis of variance test (MANOVA). The presented research provides evidence that education programs might be effective in improving pedestrian-related knowledge and behaviour among children.

1. INTRODUCTION

Walking or cycling to school or going to other activities for children has many benefits that affect the improvement of children's physical and mental health and socialization. Keeping children healthy, mobile and safe requires a balance between encouraging and allowing movement on the one hand and ensuring their safety in a complex traffic environment on the other. Young children have physical and cognitive limitations that make them more vulnerable in road traffic than others participants [1]. They lack experience and they are less visible to other road users due to their small stature. Children are also often unaware of the risks they take unintentionally, and more easily become innocent victims in collisions. Children under 12 years lack the perceptual judgement and skills to interact with a complex traffic environment. In the European Union in 2016, died 630 children in traffic accidents, half (48%) were vehicle occupants, 30% were pedestrians and 13% cyclists [2]. On the territory of the Republic of Serbia, in the past ten years (2010-2019), there were a total of 53 child pedestrian fatalities, up to 14 years of age, which is about 36% of total child fatalities [3].

Child road safety education is important at all levels from pre-school on for preparing children properly for traffic participation. The literature that considered the child pedestrian safety points out that there is a need to develop the skills and improve the behaviour of children in traffic condition [4-6]. The authors point out that crossing the road has been identified as a key child safety problem [7]. Therefore, it is necessary for decision makers to initiate programs to educate children about safe behaviour when they are walking, in order to develop the abilities and skills necessary for safer participation in traffic.

According to the school curriculum in Serbia, there are no individual subjects dedicated to traffic education. One of the key aspects of program implementation is the evaluation of its effectiveness. This evaluation is conducted by tests of knowledge and behaviour and real controlled conditions.

The training program lasted for three months. The children's behaviour test is designed in accordance with the guidelines of the most important literature dealing with the assessment of children's skills and behaviour of pedestrians in traffic [8-11] and in accordance with the program that is planned to be implemented by teachers with children in class. In order to measure and evaluate the knowledge and skills, the students were put through testing before and after the pedestrian safety education program.

The main goal of the presented research is evaluation of effects of implemented traffic safety education program on children's pedestrian knowledge and behaviour without formal traffic safety education.

2. METHODOLOGY

The sample was taken among students from selected classes from four elementary schools located in various regions of the Republic of Serbia. In order to measure and evaluate the knowledge and skills, the students were put through testing before and after the safety education program. Data were analysed using repeated multivariate analysis of variance test (MANOVA).

2.1. Participants

The sample consisted of 217 students from second grade of elementary schools. Within this sample 97 (44.7%) children were from the control group, while 120 (55.3%) students were from intervention group. The sample consisted of 105 male students (48.4%), and 112 female students (51.6%).

2.2. Procedure

The training program lasted for three months. Theoretical training was done by trained teachers with their students in school classrooms, while the practice was done on specially prepared training grounds within school yards. All procedures performed in this study were in accordance with the ethical standards and all participants completed informed written consent. Evaluation of students' knowledge pre-training and post-training was done through a test at first session and final session. The knowledge test consisted of a series of 15 multiple choice questions. The duration of the test was 30 minutes. The test items referred to 5 learning models (where pedestrian can walk, how pedestrian can cross the street safety, risky situations, behaviour in car, behaviour near the bus stops).

The procedure for testing the behaviour of children as pedestrian is carried out in real but controlled traffic conditions, where the behaviour of children can be tested safely. The first condition, in terms of child safety, is provided by the presence of researchers at all places where children should cross the road. Each researcher is trained to evaluate child's behaviour in a valid and reliable way, using evaluation sheets. The children think that they are participating in a certain game. The game is called "Traffic Light". Between the starting and ending positions, there are researchers who record children's behaviour. At the beginning, children are given instructions on the path they should take, in such a way that it does not affect their behaviour. These behaviours are systematized into 11 activities.

3. RESULTS

Data analysis was performed using IBM’s SPSS Statistical Package (Version 22). Descriptive statistics were used to examine the basic features of the sample. Furthermore, data were analysed using repeated multivariate analysis of variance test (MANOVA).

3.1. Analysis of child pedestrians' knowledge

Table 1 displays results of the two-way repeated multivariate analysis of variance (MANOVA) test for each cluster of knowledge individually and in total. Overall, there was a statistically significant improvement in the level of knowledge before and after the implementation of the program in the control and intervention group. The children from the control group had a statistically significantly higher knowledge by 4.9% after the implementation of the program (t = -3.02; p <0.01). In the intervention group, a statistically significant total increase in knowledge by 9.4% after the implementation of pedestrian education program (t = -4.93; p <0.01). If individual behaviours are observed in the intervention group, an increase in behavioral levels can be observed in terms of identification places where pedestrians can walk by 12.8% (t = -4.01; p <0.01) and road crossing ways by 23.9% (t = -8.95; p <0.01.

Table 1. Changing the knowledge of child pedestrians
before and after the implementation of the program

Knowledge	Group	Pre-intervention		Post-intervention		% change	t-value
		M	SD	M	SD		
Where pedestrian can walk	Control	57,0	22,6	68,1	23,2	11,1	-4,117
	Intervention	61,7	22,8	74,5	24,1	12,8	-4,013
How pedestrian crossing the street safety	Control	53,5	24,0	67,9	24,4	14,4	-4,103
	Intervention	59,4	23,5	83,3	20,2	23,9	-8,945
Risky situations	Control	74,7	30,7	61,7	33,8	-13,0	2,965
	Intervention	67,5	33,8	67,0	26,6	-0,5	0,134
Behaviour in car	Control	61,3	31,4	57,2	32,6	-4,1	0,897
	Intervention	61,6	32,1	64,5	31,0	2,8	-0,853
Behaviour near the bus stop	Control	82,1	27,7	82,7	26,4	0,6	-0,168
	Intervention	75,9	33,3	74,1	35,3	-1,9	0,435
Total	Control	65,3	16,9	70,3	15,8	4,9	-3,021
	Intervention	66,9	17,2	76,3	16,1	9,4	-4,933

3.2. Pedestrian behaviour analysis

Table 2 displays results of t-test with repeated measurements for eleven groups of observed behaviours of children pedestrians. Overall, a statistically significant difference was identified between students' behaviours before and after the implementation of the training by teachers. Behavioral improvement was achieved in both the control and intervention group. Students from intervention group showed a 48.1% more positive overall behaviour after the end of the three-month implementation period of education program (t = -31.78; p <0.01). Regarding individual behaviours, a better result was achieved for each observed behaviour, and the difference for the intervention group ranged from 7.9% to 124.5%. In terms of identification the place for walking, children pedestrians in the interventional group showed significantly more favorable behaviour by 7.9% ($t = -6.58$; $p < 0.01$). Furthermore, in terms of the way of moving on the sidewalk, the program influenced the improvement of behaviour by 34.4% ($t = -10.51$; $p < 0.01$). In situations of walking around obstacles on the sidewalk, children also achieved more favorable results by 37.0% after the implementation of the program in the intervention group ($t = -10.23$; $p < 0.01$). Furthermore, children from the intervention group after performing the education program had higher abilities to identify places for crossing the road by 38% ($t = -15.62$; $p < 0.01$).

Table 2. Changing the behaviour of child pedestrians
before and after the implementation of the education program

Behaviour	Group	Pre-intervention		Post-intervention		% change	t-value
		M	SD	M	SD		
Identification the place for walking	Control	4,39	0,74	5,00	0,00	13,8	-7,287
	Intervention	4,63	0,56	5,00	0,00	7,9	-6,579
Moving on the sidewalk	Control	3,77	0,88	4,52	0,64	19,8	-7,403
	Intervention	3,53	1,05	4,74	0,5	34,4	-10,514
Walking around an obstacle on the sidewalk	Control	4,42	1,06	4,90	0,34	10,9	-4,337
	Intervention	3,58	1,31	4,91	0,29	37,0	-10,228
Identification of crossing points	Control	3,52	0,96	4,73	0,52	34,5	-10,633
	Intervention	3,54	0,83	4,89	0,40	38,0	-15,621
Stopping and waiting on the sidewalk	Control	3,13	0,77	4,38	0,72	40,1	-11,668
	Intervention	3,26	0,68	4,88	0,41	49,8	-21,606
Observation left – right -left	Control	2,65	0,73	3,91	0,74	47,8	-11,511
	Intervention	3,26	0,68	4,88	0,41	49,8	-22,675
Observation of traffic during the street crossing	Control	2,34	0,92	3,22	0,76	37,3	-6,782
	Intervention	2,21	0,83	4,42	0,59	99,5	-24,222
Road crossing speed	Control	3,27	0,98	4,15	0,74	27,1	-8,000
	Intervention	3,31	0,89	4,85	0,39	46,6	-16,127
Trajectory when crossing the street	Control	3,42	0,81	4,57	0,57	33,7	-10,812
	Intervention	3,49	0,82	4,94	0,28	41,5	-17,260
Respect of traffic light signals	Control	3,47	1,10	4,89	0,42	40,9	-11,867
	Intervention	3,56	1,02	4,95	0,33	39,0	-13,404
Crossing the access road	Control	2,22	1,22	3,94	1,12	77,7	-9,567
	Intervention	1,96	1,23	4,40	0,82	124,5	-15,746
Total	Control	3,32	0,49	4,38	0,29	31,8	-19,869
	Intervention	3,24	0,49	4,79	0,19	48,1	-31,784

4. DISCUSSION AND CONCLUSIONS

This retrospective research was demonstrated the impact of a safety educational course for elementary school–aged children without formal traffic safety education. Improvements were observed both in measured road safety knowledge and in observed behaviour change among children 7-8 years old.

This was in accordance with the previous studies [9,10,12] which concluded that education programs included in school curriculum resulted in improvement of knowledge on child safety.

Besides the results of the research show efficient of the implemented training program the study limitations should be highlighted. In addition to the fact that the number of students who participated in the research is satisfactory, a larger number of students should be included in future research.

Future efforts should be directed towards promotion and implementation of safety education programs in schools where there is no formal traffic safety training.

REFERENCES

[1] DaCoTA, "Children in road traffic: Deliverable 4.8c of the EC FP7", project DaCoTA,2012.http://www.dacotaproject.eu/Deliverables/Webtexts/Child%20Traffic%20Safety.pdf.

[2] ETSC, "Reducing child deaths on European roads. Pin Flesh Report 34", European Transport Safety Council, Brussels, 2018.

[3] RTSA, "Statistical report on the state of road safety in the Republic of Serbia for the year 2019", Road Traffic Safety Agency, Serbia, 2020.

[4] J. Percer, "Child pedestrian safety education: Applying learning and developmental theories to develop safe street-crossing behaviors", (No. DOT HS 811 190). United States, National Highway Traffic Safety Administration, 2009.

[5] C. M. McLaughlin, W. E. Barry, E. N. Barin, M. Mert, C. Lowery, J. S Upperman,., and H. Arbogast, "Interactive education is associated with lower incidence of pedestrian-related injury in children", *Journal of surgical research*, *244*, 57-62, 2019.

[6] DOT, "Pedestrian Safety Lesson Plans: Kindergarten through 3rd grade", Department of Transportation, Colorado, 2009.

[7] D. Cross, M. Stevenson, M. Hall, S. Burns, D. Laughlin, J. Officer and P. Howat, "Child pedestrian injury prevention project: student results", *Preventive medicine*, *30*(3), 179-187, 2000.

[8] W. H. Yeaton and J. S. Bailey, "Teaching pedestrian safety skills to young children: An analysis and one-year followup", Journal of applied behavior analysis, 11(3), 315-329, 1978.

[9] D. Cross, M.Hall and P. Howat, "Using theory to guide practice in children's pedestrian safety education", American Journal of Health Education, 34(sup5), S-42, 2003.

[10] G. A. Hotz, S. M. Cohn, J. Nelson, D. Mishkin, A. Castelblanco, "Pediatric pedestrian trauma study: a pilot project", Traffic injury prevention, 5(2), 132-136, 2004.

[11] M. C. Kenny and S. K. Wurtele, "Teaching preschoolers safety rules: a pilot study of injury prevention", Children's Health Care, 45(4), 428-440, 2016.

[12] G. A. Hotz, S. M. Cohn, A. Castelblanco, S.Colston, M. Thomas, A. Weiss and R. Duncan, "WalkSafe: a school-based pedestrian safety intervention program", Traffic injury prevention, 5(4), 382-389, 2004.

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SAFETY AND SUSTAINABILITY OF ACTIVE TRANSPORT MODES - OVERVIEW

Key Words

Active transport modes

Urban road safety

Safety

Sustainability

Abstract

When it comes to active transport modes special emphasis is placed on walking and cycling as transport modes. However, modern society is facing new forms of active transport modes where a human is the main or auxiliary trigger. What is common to all forms of active transport modes is to contribute to the improvement of urban road safety and thus the protection of the environment and psycho-physical health. Previous studies have shown a high percentage of walking in distributions (in Belgrade and Novi Sad), but the culture of cycling is still at a very low level (approximately 1% for the city of Belgrade (2020) and 9% for Novi Sad (2019)). However, these transport modes are recognized as very dangerous but the improvement of their safety is associated with the improvement of the overall level of road safety. In addition, these are economically acceptable transport modes with a high environmental contribution and health benefits to humans and urban life. However, active transport modes are still marginalized due to the very nature of road traffic development so far. The aim of this paper is to review the professional literature in order to contribute to the understanding of the importance of these transport modes in the formation of sustainable cities but also in achieving the goals of sustainable development.

1. INTRODUCTION

Active transport modes are recognized as an alternative to the use of passenger automobiles around the world, but also a means that can contribute to achieving the goals of sustainable development. Namely, the goals of sustainable development, which recognize the importance of urban road traffic safety, and thus active transport modes, are **good health** and **sustainable cities and communities**.

When we talk about active transport modes, we primarily mean cycling and walking. In addition, in practice, there are other forms that can be classified in the domain of micro-mobility vehicles, such as scooters, skates, and other vehicles that can be electric or human-powered [21, 6, 7]. However, cycling and walking stand out as the most common forms of active transport modes, accounting for 20-40% of all travel in the EU [7]. While, on the other hand, in the US 11% of travel is done by walking, and only 1% by cycling [17]. When it comes to the culture of choosing active transport modes in Belgrade, as the capital of the Republic of Serbia, 68% of citizens choose walking every day, while only 1.5% of citizens choose cycling [19].

Increasing the share of active transport modes can lead to a number of societal benefits, including health benefits, environmental protection, and improving the sustainability of cities [19, 20, 7]. Based on the above, it can be seen that the benefits of active transport modes alone exceed mobility targets [6], as increasing the share of active modes of transport leads to a reduction in road traffic congestion, noise, air pollution and travel costs. However, the use of active transport modes in certain parts of the world is not a choice but a necessary thing based on the economic, cultural and spatial characteristics of each country [6]. This has led to a significant share of active transport modes in low - income countries (around 30-45%; [6]).

However, vulnerable road users, i.e. users of active transport modes, are a particularly vulnerable category, especially in the EU. According to the ETSC report, approximately 9,500 people died in the EU in 2017 (i.e., approximately 26 people per million inhabitants), where 70% of them were involved in accidents as vulnerable road users (pedestrians, cyclists, drivers of small vehicles; [2]). In addition, the number of dead pedestrians and cyclists in the EU increased in 2018, compared to 2010 (pedestrians - an increase from 20% to 21%; cyclists - an increase from 7% to 8%) [3]. In addition, accidents with active road users very often go unreported to the police, where data on such accidents are often found from special sources, such as hospital reports [3].

The recognized reason for such data is the car-centric planning system established much earlier, which made the automobile recognized as a cheap and reliable means of transport. This is especially due to the lack of areas intended for vulnerable road users, the lack of good connectivity of existing areas and the subjective and objective sense of road traffic safety.

Recognizing the risks of active transport modes, but also the advantages of the same, the question arises whether the promotion of the same is safe from the point of view of human and at the same time sustainable from the point of view of the city. In this regard, the subject of this paper is the analysis of available literature dealing with the impact of active transport modes on safety and sustainability, all in order to define a starting point that will be important in favoring these modes of transport.

2. SAFETY OF ACTIVE TRANSPORT MODES

Research has shown a high level of safety of users of active modes of transport in countries where there is a culture of choice of such transport modes, i.e. in countries with a high proportion of cyclists and pedestrians [14, 1, 8]. In other words, the increase in active road users leads to a decrease in the accident rate and the consequences of accidents with this group of road users. However, in order to increase the number of road users who use active transport modes, and thus greater road traffic safety, it is necessary to work on infrastructure, policies and programs aimed at this group of road users [9].

However, the development of infrastructure for active transport modes can also contribute to increasing the overall level of road traffic safety. Namely, the design and construction of areas that are safer for users of active transport modes, leads to a reduction in the number of fatalities in road traffic accidents and better road traffic safety outcomes for all road users [11].

On the other hand, the emergence of an increasing number of users of active transport modes in urban areas, forces motorists to become aware of this group of road users [7]. It is for this reason that it is necessary to work on the development of strategic documents that will give a motive for a large percentage of motorists to change their daily way of traveling. However, the conducted research shows a low subjective feeling of road traffic safety of users of active transport modes [19, 21], in which additional efforts are needed.

3. THE IMPACT OF ACTIVE TRANSPORT MODES ON HUMAN HEALTH

Physical inactivity of children and adolescents is a significant health problem of modern times (the fourth leading cause of death in the world [18]). However, active travel offers immediate health benefits and forms future sustainability and healthier habits [10]. However, 8 out of 10 studies have shown that car-centric planning leads to the so-called dependence on the use of private automobiles, which is significantly associated with the risk of being overweight [13].

Physical activity, as a result of active transport modes, is associated with a reduced risk of premature death and a number of chronic diseases [16]. Physical activity has been estimated to reduce the likelihood of death by 30%, cardiovascular disease by 20-35%, type 2 diabetes by 30-40%, and by approximately 20% reduction in cancer cell development. Two related studies conducted in 2008 showed that the risk of developing cardiovascular disease is reduced by 16% if people walk approximately three hours a week [4], 11% if they choose active transport modes to perform their daily routines [5].

A study conducted in San Francisco in 2013 showed that changing the mode of transport from a private passenger automobile to active transport modes has significant health benefits in terms of reducing injuries and deaths in road traffic accidents [12]. In this way, it is estimated that it is possible to avoid more than one thousand five hundred deaths of users of active transport modes per year. In addition, just following the concept of a 15-minute walk a day can prevent more than a hundred thousand premature deaths a year [7].

4. THE IMPACT OF ACTIVE TRANSPORT MODES ON ENVIRONMENTAL PROTECTION

Active transport modes have zero emissions of pollutants and noise when moving in urban areas. In this regard, the transition from private passenger automobiles to active transport modes can lead to a reduction in CO_2 levels and the greenhouse effect at EU level by approximately 20% [7].

If air pollution were measured in deaths, it is estimated that approximately half a million EU residents die each year from air pollution, where health costs can be estimated at €67 billion [7]. Switching to active transport modes of transport can significantly reduce the number of premature deaths, but also lead to the improvement of the overall image of the city, reduction of exhaust gases and noise resulting from road traffic.

Road traffic congestion is a major part of the traffic situation in cities, where it is estimated that at the EU level they cause costs of 1% of GDP (approximately one hundred billion euros) [7]. Switching to active transport modes can lead to a reduction of road traffic congestion, but also to the formation of spaces that will be intended for users of active transport modes, if the parking space is removed.

5. DISCUSSION AND CONCLUSION

Active transport modes that literature and practice most often encounter are cycling and walking. Today, however, various forms of micro-vehicles are used around the world as an alternative to the use of private passenger automobiles. By using active transport modes, a number of social benefits can be achieved, such as health benefits, environmental protection and improving the sustainability of the city.

In order to work on the promotion of active transport modes as an alternative to private passenger automobiles, it is necessary to work on improving the infrastructure intended for this group of road users. In this way, a subjective sense of road traffic safety will be provided, which attracts a larger number of users of active transport modes. On the other hand, quality infrastructure intended for active transport modes can lead to an increase in the overall level of road traffic safety in cities, as drivers are aware of the presence of vulnerable road users; respect the implementation of new measures and strategies.

Active transport modes are of great importance in terms of health, as physical inactivity is recognized as the fourth leading cause of death in the world. Namely, the promotion of active transport modes leads to an increase in walking and cycling, which leads to a decrease in the likelihood of premature deaths and chronic diseases.

In terms of environmental protection, reduction of air pollution and noise resulting from road traffic, active transport modes have a significant advantage, since they are zero-emission vehicles, the so-called environmentally friendly vehicles. In addition, the transition to active transport modes can enable a significant reduction in private passenger automobiles, road traffic congestion and parking spaces that can be redesigned and intended for this group of road users.

This paper presents the basic advantages that the use of active transport modes has on living in cities. However, the culture of using active transport modes is very low and their advantages in practice are not sufficiently recognized. In this regard, future work must be based on promotional work that will show citizens through educational campaigns the importance of choosing active transport modes for everyday movements around the city. In addition, it is necessary to conduct more extensive research on the attitudes of citizens who already use and who do not use these means of transport (survey research), based on which the motives of use, subjective sense of road traffic safety will be seen, but also define future research and campaigns on this topic.

REFERENCES

[1] Elvik R. (2009), The non-linearity of risk and the promotion of environmentally sustainable transport

[2] ETSC (2019), Safer roads, safer cities: How to improve urban road safety in the EU

[3] ETSC (2020), How safe is walking and cycling in Europe?

[4] Hamer M., Chida Y. (2008a), Walking and primary prevention: a meta-analysis of prospective cohort studies

[5] Hamer M., Chida Y. (2008b), Active commuting and cardiovascular risk: A meta-analytic review

[6] Inter-American Development Bank (IDB) (2021), The role of active transport modes in enhancing the mobility of low-income people in Latin America and the Caribbean

[7] Interreg Europe (2019), Promoting Active Modes of Transport – A policy brief from the policy learning platform on low-carbon economy

[8] Jacobsen PL. (2003), Safety in numbers: more walkers and bicyclists, safer walking and bicycling

[9] Jacobsen PL., Ragland DR., Komanoff C. (2015), Safety in numbers for walkers and bicyclists: exploring the mechanisms

[10] Kaplan S., Alexander Sick Nielsen T., Giacomo Prato C. (2016), Walking, cycling and the urban form: A Heckman selection model of active travel mode and distance by young adolescents

[11] Marshall W.E., Ferenchak N.N. (2019), Why cities with high bicycle rates are safer for all road users

[12] Maizlish N. Woodcock J., Co S., Ostro B., Fanal A., Fairley D. (2013), Health cobenefits and transportation-related reductions in greenhouse gas emissions in the San Frabcisco Bay area

[13] McCormack GR., Virk JS. (2014), Driving towards obesity: A systematized literature review on the association between motor vehicle travel time and distance and weight status in adults

[14] Pucher J., Dill J., Handy S. (2010), Infrastructure, programs and policies to increase bicycling: an international review

[15] Smart City Study of Novi Sad (2019)

[16] U.S. Department of Health and Human Services (2008), Physical Activity Guidelines Advisory Committee Report

[17] U.S. Department of Transportation (2010), Federal Highway Administration, Our nation’s travel

[18] World Health Organization (2018), Global status report

[19] Živković F. (2021), Uran road safety – case study city of Belgrade, master thesis

[20] Živković F., Todorović O.P. (2021), Analysis of urban road safety of the city of Belgrade, 16th International Conference „Road Safety in Local Community“, Serbia, Kopaonik, Hotel Kraljevi Cardaci, June 16-19, 2021.

[21] Živković F., Velić I. (2021), Analysis of attitudes of road users on the use of electric scooters – comparative analysis on the example of Belgrade and Novi Sad, 16th International Conference „Road Safety in Local Community“, Serbia, Kopaonik, Hotel Kraljevi Cardaci, June 16-19, 2021.

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15-MINUTE CITY CONCEPT OVERVIEW AND TRANSFERABILITY

Key Words

15-minute city
City of short distances
Walkable city
Smart city
Humane city

Abstract

The 15-minute city is a concept that first emerged in response to dispersed urban development, where increasingly long car trips between daily activities such as living, working, recreation and shopping are considered acceptable. The concept builds on the idea that people who spend less time on daily journeys will live better and use less energy. Most elements of the concept have been present in the theory of urban planning for almost a century now and stem from the need for efficient organization of residents considering limited time and opportunities for daily travel.

The concept of 15-minute city returned in focus during the COVID-19 crisis and lockdowns, when countries and cities introduced measures to restrict movement of residents close to their homes. In this specific situation some cities recognized the need and opportunity of the situation to rethink the design of urban areas with a clear goal of ensuring better local accessibility.

The paper presents an analysis of key initiatives that emerged in last two years as a part of the concept. It compares the approaches, their key elements and implementation. Based on this, the paper proposes how elements of the concept could be transferred and integrated into current planning practice in Slovenia.

1. INTRODUCTION

The 15-minute city is a concept that is currently widely echoing in literature all around Europe. It emerged in response to the development of urban areas in recent decades, where the key daily programs such as living, working, recreation and shopping are separated 30 minutes or more by car, public transport is slow or non-existent and cycling and pedestrian networks are unconnected, low quality and quite often even dangerous.

Some elements of the concept have been present in the theory of spatial and urban planning for more than a century under different names and stem from the need for efficient organization of living, work, care of residents, considering limited opportunities for daily travel. The principles of ensuring the accessibility of various programs in pedestrian (and bicycle) accessibility are systematically and continuously present also in the context of the planning of residential neighbourhoods in the post-war years. However, in practice the importance of these concepts has been lost in recent decades due to the significantly improved accessibility of the population to the car, the development of the road network and the land use policies that allowed settlement dispersion and considered acceptable accessibility of work, school, and other programmes only by car.

The principles of cities of short distances were based as a response to ongoing dispersion of population and programs by development of the concepts sustainable city and sustainable mobility, as well as sustainable urban mobility planning [1–3]. Many national and city level policies have sought to reduce car dependence and encourage the development of vital urban areas and cities based on walking, cycling and public transport with various success.

A new push to the development of the concept around the world took place during the first waves of COVID-19 crisis, when many states and cities have introduced measures restricting the movement of the population in the vicinity of their residences. Some cities have recognized the need and potential to start renovating urban areas comprehensively with a clear goal of ensuring accessibility of daily activities within the walking distance. Namely, it turned out that the current accessibility of the population to key programs is very diverse between urban areas, and thus also the quality of their living can vary significantly between them.

2. METHODS

The paper presents an overview of the approaches to the concept. An overview of scientific and professional literature was prepared to search for examples of good practice. The search used keywords that are directly or indirectly related to the concept, namely: 15-minute city, 20-minute city, city of short distances, walkable city. Indirectly, the following keywords often appear in papers dealing with the topic: sustainable city, smart city, humane city, post-pandemic city, walkability, active mobility, accessibility and proximity.

Scientific articles were searched in the Web of Science, Scopus and Google Scholar databases.

The set of cities and examples represents the breadth of approaches and activities that take place under the auspices of the concept. A significantly larger number of cities appear in the literature, but they follow the selected concepts. It should also be noted that many of the presented cities have previously worked on similar concepts, but recently got a new push to continue the previous activities.

3. CASE STUDIES

3.1. Paris, 15-minute city

15-minute city is a concept developed by Carlos Moreno, a professor of urbanism at the Paris Sorbonne. It is based on the previous work of the author, who dealt with the topic of the so-called "chrono urbanism", i.e., urban planning based on the time availability of residents to key programs. In its work, he tries to improve the quality of living in cities and reduce the negative impact on the environment. Moreno's basic thinking [4] stems from the assumption that residents who spend less time on daily trips will also use less energy. Less travel demands would also free up space in cities, which could serve as a meeting place instead of traffic.

The concept is based on four key areas: optimal density, proximity, diversity, and digitization. Moreno defines a series of orientations for each of the four areas. The proximity of key programs and services, as the central area of the concept is, according to the author, understood spatially as well as temporally. Most programs for such accessibility cannot be evenly distributed throughout the space, but it is necessary to create local nodes, in the hinterland of which residents from the surrounding areas can quickly access the programs.

The so-called multimodal use of basic infrastructure also plays an important role in this, which the author explains in the case of the use of primary school playgrounds in the afternoon as recreational areas for all residents. This coincides with the concept of “crono urbanism”, which understands the city planning not only as a spatial, but also a temporal challenge.

3.2. Melbourne, 20-minute neighbourhood

The 20-minute neighbourhood is a concept within Melbourne's long-term development strategy called Melbourne 2017 - 2050 [5, 6]. The concept aims to provide more inclusive, vital, and healthy neighbourhoods in the city.

Within the concept, the characteristics that a 20-minute neighbourhood are defined in terms of safety, accessibility and connectivity for pedestrians and cyclists, offering quality public space, offering services that support local life, ensure access to public transport, ensuring housing and population densities that enable the operation of local services and transport, supporting vital local economies.

A key role in the concept is played by local centres, which are called neighbourhood activity centres. In traditional Australian cities local centres were established as main streets (high streets) or the village centres. The role was later taken over by local shopping malls with larger gravitational surrounding based on accessibility by private car. The plan is based on identifying and strengthening the centres that emerged from these predecessors and could take on the role of 20-minute neighbourhood centres in the future.

3.3. Barcelona, Superblock

The concept of superblocks has been introduced in Spain over the last decade in various forms and sizes [7, 8]. It has gained new momentum in conjunction with the 15-minute city concept, building on similar starting points and setting similar goals: restoring space for people, reducing motorized transport, promoting sustainable mobility and an active lifestyle, ensuring urban greening, and mitigating the effects of climate change. Superblock [7] represent the basic cell composed of city and provide a sustainable and healthy environment, compact and connected neighbourhoods with mixed land use and a high potential for social capital.

Superblocks are formed as larger urban areas, in the case of Barcelona about 400 x 400 meters or 3 x 3 building blocks, within which traffic within the area is calmed and limited to exclusively local access by residents. All transit traffic is directed to the edge of the superblock. Due to the reduction in the amount of traffic, it is possible to rearrange areas previously occupied by traffic into public space and within them there are greater possibilities for arranging green areas.

Since 2019, three pilot superblocks have been introduced in Barcelona, and the city plans to gradually introduce the concept in the entire city area, i.e. possibly 503. Mueller et al. [7] showed that the introduction of the concept significantly improved the situation in the city in the following areas: physical activities of residents associated with daily mobility, air quality, noise pollution, accessibility of residents to green areas and temperature (overheating) in the streets.

Due to specific urban design of Barcelona and its distinctive building blocks, the concept seems difficult to transfer to other cities with a less geometrically clean structure. However, the experience of other Spanish cities, where similar arrangements, such as Vitoria-Gasteiz, have been piloted, shows that transfer of the concept to other, more organically grown cities is also possible.

3.4. Milan, Post COVID city

For decades, the transport and urban development of Milan have been based on the traditional development of mobility. The city was aware that there was a need for more walking and cycling among the citizens, but investments in these transport modes were small [9].

With the COVID epidemic the city responded quickly to the onset of the epidemic and sought to take advantage of the changed situation not only for temporary but for deeper structural changes. Urban reorganization should not only provide a short-term operational response but should also provide the conditions for improving the city's preparedness and resilience to future critical situations that may arise. The city response included five main guiding principles: governance, economic development, public services, labour and sustainable development.

Overnight, the city redirected investment in the development of new bike paths and began redeveloping pedestrian streets. The planners tried to create areas that allow commercial, recreational, cultural and sports activities of the residents while respecting the appropriate physical distance and restrictions. It was therefore a matter of simultaneously strengthening local centres while restricting the movement of residents between different urban areas.

By reducing the use of passenger cars and more residents walking and cycling, the next step was to replace parking spaces with smaller public space arrangements, the so-called parquets. City officials were surprised to find that local shops and restaurants did not oppose the renovations, but based on the positive experiences of other streets, bar owners even began to take initiatives for such arrangements on their street as well.

3.5. Gothenburg, One-minute city

The minute city is named after one of the activities within the framework of urban experiments supported by the Swedish government under the auspices of the Street Moves project [10]. The purpose of the activity is to rearrange traffic areas, as the government intends to significantly reduce the importance of motorized vehicles in cities in the coming years.

Interventions vary according to local specifics and the needs of residents and users. In most cases, these are changes to parking spaces in a public space for residents by adding urban equipment such as benches or picnic accessories. In some cases, however, the space is being converted into parking spaces for bicycles, electric scooters or even mobility hubs for various forms of mobility.

The project is interesting because the approach arose from local initiatives such as Parking day and in the first attempts was mostly carried out by guerrilla, without official permits but based on the needs of the local environment. In recent years, however, it has been promoted and funded by city or even national authorities.

The authors point out that their interventions complement the offer of local programs, like what the 15-minute city concept envisages. However, they point out that small and undemanding spatial interventions, which can significantly improve the quality of living in the local environment in the immediate vicinity, i.e., a minute's walk from home or work, and thus reduce travel needs.

4. RESULTS

A review of the literature shows that several concepts are being developed following the ideas of the city of short distances. They differ in their starting points, as well as in the topics they address. What they have in common, however, is that practically all concepts try to combine elements of spatial and transport planning, and in addition, each of them addresses additional emphases from other areas.

Table 1. Comparison of approaches and addressed topics

	Paris	Melbourne	Barcelona	Milan	Gothenburg
Land use planning					
Density	X	X			
Mix of uses	X	X			X
Local centres	X	X	X	X	
Multiple space use	X		X		X
Public space	X	X	X	X	X
Service distribution	X	X		X	
Transport planning					
Street transformation	X		X	X	X
Active mobility	X	X	X	X	X
PT interchanges	X	X			
Effective PT		X	X		
Mobility nodes					X
Other					
Multiculturality	X				
Digitalization	X				
Citizen engagement	X		X	X	X
Local economy	X	X	X	X	X
Climate change			X		
City management				X	

5. DISCUSSION

As we can see from the overview, the starting points and focus of the approaches differ from city to city. Consequently, also the main considerations and actual implementations are very different. The foundation of the concept of a city of short distances is essentially an academic reflection that combines the values and knowledge of urban planning advocated by Camilo Sitte, Jane Jacobs, Jan Gehl, and other authors who advocated the focus on human in city planning. The concept is addressing poor integration of transport and land use planning and focus on private car in recent decades.

As such, many elements of the concept are already present in today's cities, also in our geographical area (central Europe) and scale (mostly medium and small sized cities). It’s elements were previously already researched [11], tested in practice and integrated in city plans in several residential neighbourhoods but then forgotten with change of values and priorities since the 1990ies.

The new push to the concept was given by the COVID pandemic, which shook the world and the cities and made the changes discussed for years finally possible. With this new situation, the topics of accessibility and local living finally got its inclusion in the political programmes of cities. The new circle can build on existing knowledge but also add the contemporary elements that shape the city life, such as increasingly present digitalization of work and services.

REFERENCES

[1] European Commission, ‘Urban Mobility Package’, *Mobility and Transport - European Commission*, 2013. https://ec.europa.eu/transport/themes/urban/urban-mobility/urban-mobility-package_en (accessed Feb. 01, 2021).

[2] European Comission, ‘Mobility and Transport, White paper’, *Mobility and Transport - European Commission*, 2011. https://ec.europa.eu/transport/themes/european-strategies/white-paper-2011_en (accessed Feb. 01, 2021).

[3] Rupprecht Consult, Ed., ‘Guidelines for Developing and Implementing a Sustainable Urban Mobility Plan, Second Edition’. European Commission, Brussels, 2019. [Online]. Available: www.eltis.org/mobility-plans/sump-online-guidelines

[4] C. Moreno, Z. Allam, D. Chabaud, C. Gall, and F. Pratlong, ‘Introducing the “15-Minute City”: Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities’, *Smart Cities*, vol. 4, no. 1, pp. 93–111, Jan. 2021, doi: 10.3390/smartcities4010006.

[5] Victoria State Goverment, ‘Plan Melbourne 2017 - 2050’, *Victoria State Goverment*, Mar. 24, 2020. https://www.planning.vic.gov.au/policy-and-strategy/planning-for-melbourne/plan-melbourne (accessed Jun. 21, 2021).

[6] e Department of Planning and Community Development, ‘Activity Centres Toolkit’. e Department of Planning and Community Development, Apr. 2010. [Online]. Available: https://www.planning.vic.gov.au/__data/assets/pdf_file/0032/97079/190_Activity_Centres_Toolkit_web.pdf

[7] N. Mueller *et al.*, ‘Changing the urban design of cities for health: The superblock model’, *Environment International*, vol. 134, p. 105132, Jan. 2020, doi: 10.1016/j.envint.2019.105132.

[8] E. Graells-Garrido, F. Serra-Burriel, F. Rowe, F. M. Cucchietti, and P. Reyes, ‘A city of cities: Measuring how 15-minutes urban accessibility shapes human mobility in Barcelona’, *PLoS ONE*, vol. 16, no. 5, p. e0250080, May 2021, doi: 10.1371/journal.pone.0250080.

[9] L. Barbarossa, ‘The Post Pandemic City: Challenges and Opportunities for a Non-Motorized Urban Environment. An Overview of Italian Cases’, *Sustainability*, vol. 12, no. 17, p. 7172, Sep. 2020, doi: 10.3390/su12177172.

[10] R. Orange, ‘How Sweden is taking back parking spaces to improve urban living’, *The Guardian*, p. 3.

[11] *Stanbena zajednica.* Ljubljana: Gospodarsko razstavišče, 1958.

8th INTERNATIONAL CONFERENCE
''TOWARDS A HUMANE CITY''
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Novi Sad 11th and 12th November 2021

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ANALYSIS OF THE ARRANGEMENT OF PUBLIC SPACE NEXT TO CULTURAL STATION FACILITIES IN NOVI SAD

Key Words

Public areas
Cultural stations
Planning
Informal city centres
Traffic

Abstract

For a time now, there has been a need in Novi Sad for the formation of new, secondary city centers with mixed content located within peripheral parts of the city, mostly for residential purposes. Obligatory within these centers are social centers and cultural facilities. The integration of new cultural facilities - cultural stations in the planned centers of existing residential settlements has opened the question of how to best design public spaces in their environment, so that these spaces become representative, functional and accessible. In order to achieve this, a number of urban principles, guidelines and rules needed to be implemented within the framework of the drafting and implementation of planning documents. The situation at the city given locations required different model variations for shaping public spaces and organizing traffic in the vicinity of cultural station facilities, as well as designing the facilities themselves.

1. INTRODUCTION

As part of the process of preparing Novi Sad for the status of the European Capitals of Culture, it was necessary to design new cultural infrastructure projects, programs and content. Through them, social and cultural life is enriched accompanied by modern movements and trends in the field of culture, as well as meeting the needs of the population in terms of cultural and social life. This turned out to be an opportunity for fragmented intervention in the public area of the city and the transformation of the same for the needs of the citizens. As Novi Sad has been developing for several decades, mainly through the growth of residential capacity, construction of new housing estates, but also the concentration of housing within existing ones, there is a need to arrange public spaces for movement and socialization, as well as for the introduction of cultural, entertainment and educational programs.

Novi Sad is a centrally organized city, in terms of the arrangement of non-residential programs and content in relation to its surface and the way it spreads through space. That is why most of the existing, especially cultural, entertainment and educational content intended for the functioning of the city and the life of its inhabitants, is focused in narrower and broader city center area. For this reason, an approach has been imposed, in terms of location, to place new facilities and programs along the perimeter and outskirts of the city. There is little public space, lack of programs and content, while public space is often inadequately landscaped.

In terms of forming a polycentric city, it is desirable to form secondary city centers in settlements further away from the city center. These would generate mixed urban content, activate space, make it more visited, accessible by foot, directing movement within the area, and forming focal points of assembly in parts of these settlements. Such interventions require landscaping, designing meeting places and living places, applying space design standards, arranging and organizing traffic areas, respecting ambient values, enabling accessibility, introducing modern design to the design of public spaces, functionality and familiarity of programs and content to public areas, as well as the use of frequent traffic routes to concentrate new programs and content.

In order to achieve this, during the construction of cultural facilities such as cultural stations, it was necessary to apply urban criteria and principles, harmonizing them with existing planning documentation.

The methodology in this paper includes an analysis of planning documentation on the basis of which the design, construction of cultural stations, and the transformation of space into informal city centers was carried out, and a comparative analysis of the original and as built state. A synthesis of this research is a concept for shaping public spaces in the vicinity of cultural facilities, as a contribution to the organization of public space, and changes to the traffic regimes within them, but also the successful integration of demanding public programs and content in mostly residential areas.

2. CHOICE OF LOCATIONS FOR CULTURAL STATIONS

Cultural stations are facilities. Their surface and stories are not necessarily large. In functional terms, they are characterized by the existence of halls and other areas for the collection of local residents and an attractive, accessible and functional, multifunctional public space in front of the buildings themselves. The function of the space in front of the facility is to attract people with cultural content and to impose it on the local community within the observation settlements, or parts of the settlement.

The situation in Novi Sad demanded the decentralization of cultural content as analysis showed that they were hyperconcentrated in the city center. All cultural institutions, whose founders are provincial, republic and city institutions, are concentrated within several blocks of the city, or Petrovaradin Fortress.

The first criterion for the selection of the location was that they be arranged in parts of the city that are either predominantly monofunctional (intended only for housing - "city dormitories") or are physically and functionally significantly separated from the city center. These are large settlements built on the principles of modernist urbanism such as Liman, Detelinara and Novo Naselje, then urban settlements, mostly with a residential purpose without accompanying facilities, such as Klisa, Petrovaradin, Sremska Kamenica, with the potential to attract a vast number of people. Another criterion was the approach to support local cultural initiatives that exist in these parts of the city. To determine, through dialog and research, what content the inhabitants of these localities needed. The first to be analyzed was the needs of the inhabitants in those parts of the city. Through this procedure, insight was made into the program tasks for the design of new, *i.e.*, the reconstruction of existing buildings, for the purpose of culture. The third criterion for choosing a location was that these sites had to be planned for some purpose which was commercial, general urban or culture. The fourth criterion was that these sites were owned by the city of Novi Sad in order for the realization to be efficient.

In Novo Naselje, a site was chosen in a city settlement of multi-residential homes, with more than 30,000 inhabitants, at the corner of Bate Brkića and Seljačkih buna, which has been foreseen as a general urban center. This is a location where cultural activities and social interactions have been taking place for years, making it recognizable to the residents. The next location is on Čenejska Street, in the settlement of Slana Bara/Klisa, exclusively residential housing on the northern outskirts of the city. Although very removed from the city center, it is a focal point. It is home to a semi-urban, socially and ethnically diverse population, which can be brought closer together through culture. One library is currently the only cultural institution for a settlement of about 25,000 inhabitants. The mentioned locality is located in the vicinity of a sports business center, a religious facility, a primary school and a health center. On the lot owned by the city of Novi Sad which already houses a temporary local community facility, what has been planned is a general urban center, and all processes required for the construction of a new facility have been completed. Within the multi-residential housing settlement of Liman, with more than 50,000 inhabitants, the location of an abandoned metal factory, so-called “Chinatown” was the most favorable location based on the defined criteria. Chinatown has been designed as a hybrid concept for the purpose of culture, specific business activities and youth activism. In the immediate vicinity are student dormitories, *i.e.*, the entire settlement of Liman, with a highly dense population that would gravitate to the stated purpose. This space, with 13 existing and 3 planned facilities, is undergoing a gradual reconstruction. The location of the cultural station for the Podbara settlement, namely Almaš area near the center of Novi Sad, is within a former silk factory.

There were ideas for this project of cultural stations to be on the Srem side of the city (the site of the former Sokolski dom in Petrovaradin and the castle smithy in Sremska Kamenica), *i.e.*, in other city settlements such as Detelinara, but those locations were not selected.

3. CURRENT STATE AT THE LOCATIONS AND TRAFFIC CONNECTIONS

At the location of the central part of Novo Naselje, there were three temporary facility - barracks dating back to the late 1970s when the settlement was being built. They needed to be brought to planned purpose, intended for a general urban center, i.e., commercial facility [1]. A cultural station lot would be located on part of the lot. The site is not located on the corner of Bate Brkića, ranked as a road [2], and Seljačkih buna, which are not busy streets, nor are they located on frequent pedestrian routes, but they are located near focal points such as: primary and secondary schools, a school for children with disabilities, an old age home. City public transport passes through Bate Brkića, with a bus stop. Bicycle paths intercept the sites. There are two larger parking areas located next to the lot. They are used by citizens who live in the surrounding residential buildings, and it is possible for other visitors to use them as well. This concept of cultural institution is more related to the local community, but still an underground garage is planned for visitors and the needs of the cultural station itself, and it is intended for the functioning of the facility (users), and not for residents of surrounding residential buildings.

The cultural station in Klisa, on Čenejska is also, as in Novi Sad, primarily of local character. It has been planned [3] for use by the local community (administration), with the possibility of an addition. In this respect, most citizens are expected to come by bike or foot. Bike paths do not exist near the facility itself but they do exist on busy streets in the immediate vicinity (Sentandrejski put). There is a system of public city transport lines in the immediate vicinity and there is a bus stop. A parking has not been foreseen within the Klisa cultural station. For the needs of the cultural station, visitors can park within the Slana Bara sports-commercial center located in the vicinity. Frequent pedestrian routes pass by the location, and there is a bicycle path along Sentandrejski put. In the immediate vicinity of this cultural station are focal points of the settlement Slana bara/Klisa, which is visited by a large number of people and are intended for service activities, sports (swimming pool and other facilities), banks, religious facilities and more. The introduction of cultural content would strengthen the function of the focal point and emphasize the character of the informal city center, primarily for the citizens of Klisa, but also for visitors to the cultural station from other parts of the city (who will come to visit the pool, etc.). The location for the cultural station in Liman is very attractive. It is located at the distinct focal point bearing an informal name of "Chinatown" located on Bulevaru despota Srefana, which is undergoing an extensive urban transformation, based on a new detailed regulation plan [4]. In this area, neglected facilities for crafts and production purposes will be replaced by facilities of the creative district planned for creative purposes, service activities and culture. There are other important focal points in the immediate vicinity, such as the Štrand beach and Limanski park. Dominant pedestrian routes pass by this location, which reach the riverfront through the settlement of Liman, continuing along it. These routes are: through Limanski park; from the settlement (Limanska pijaca) to the student dormitory complex of the University of Novi Sad; along Bulevar despota Stefana; and the route along the riverfront. At this location, several dozen new parking lots have been planned, for the entire creative district, in the immediate vicinity of the cultural station. The location is well connected by a bike path that stretches across the Liman settlement, as well as with a bike path that stretches along the riverbank. Nearby, the bus terminus is in the immediate vicinity.

The location in Almaš area (corner of Almaška and Đorđa Rajkovića) has been planned [5] within the facilities of the former silk factory which has in the recent past become, for the most part, part of the Academy of Arts in Novi Sad. The only part of the former factory that was without purpose and extremely derelict has been foreseen for the Svilara cultural station. Bus lines run along Kosovska in the immediate vicinity. The entire Almaška area, a zone of a protected spatial cultural and historical whole, where this cultural station is located, has low intensity traffic. The tendency is for this to become a pedestrian zone to continue from the pedestrian zone in the city center.

Common for all these cultural station sites is that they are in streets with low-intensity traffic, well connected by pedestrian and bicycle communications, and relatively well connected by public city bus lines and equipped with visitors parking.

4. AS BUILT STATE

The advantage of all these locations is that they are in public ownership, the city of Novi Sad, and that operational urban documents (general and detailed regulation plans) have been adopted for the subject locations, on the basis of which it was possible to initiate procedures for the construction of facilities, public and traffic areas. In addition to the construction of the facilities themselves, what has also been planned is to arrange the public areas next to each cultural station, its horticultural and landscaping, equipping it with street furniture, a water fountain, for it to be safe for use by all categories of residents, and for it to be suitable for hosting cultural programs.

This has been achieved at the Svilara Cultural Station locations. This cultural station was the first to be completed and opened on October 23, 2018. (Figure 1.). The city built a parking lot next to the cultural station. A part of Đorđe Rajkovića has been closed and is now a pedestrian zone, in the immediate vicinity of the pedestrian zone in the city center. The tendency is to form a single whole with it over time.

A facility is still being built at the cultural station in the settlement of Klisa/Slana bara. There are indications that part of Čenejska, between the school and the cultural station, will be closed to car traffic. A project for arranging the public area around the cultural station has been completed. The plan is to build a water fountain. This public space is intended for cultural events. The cultural station in the settlement of Klisa/Slana bara is in the completion phase (Figure 3.).

Within Chinatown in the settlement of Liman, a pedestrian zone has already been formed, closed to traffic. A representative public area has been set up in front of the cultural station, which will also be used for activities of the cultural station. This cultural station is intended for youth activism (Figure 2.). A large number of parking spaces intended for this location have already been built. This cultural station has the largest parking zone out of all four analyzed locations. In addition, many visitors to the Štrand City Beach, which is in close proximity, are potential users of this parking lot, which is free of charge. Bike lanes have been planned and executed so that visitors can, via the bike path, exit directly onto the Chinatown bike path from the riverbank bike path. By transforming Chinatown and building a cultural station, Bulevar despota Stefana was, for the first time, built in a complete cross-section in terms of complete utility infrastructure and all traffic areas.

The Novo Naselje cultural station has a large and landscaped green area in its vicinity. The station is designed to visually and functionally open up, the main hall, to that green surface. Landscaping, which will contain a small amphitheater, has yet to be completed. Construction of an underground parking is part of the project documentation that has been completed (Figure 4.).

Figure 1. Completed cultural station, Podbar

Figure 2. Completed cultural station, Liman

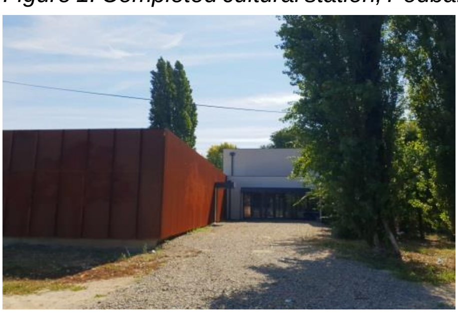

Figure 3. Cultural station under construction, Klisa

Figure 4. Cultural station under construction, Novo Naselje

All these cultural stations are primarily intended for their local environment, *i.e.*, urban settlements within which they are located. The Liman cultural station, unlike the others, was conceived as part of a creative block with a wealth of cultural content, so the introduction of a large parking area is due to a potential larger number of visitors coming from all over the city.

5. CONCLUSION

It has been shown that in the domain of urban planning, implementation and utility arrangement, the city of Novi Sad has implemented everything that has been foreseen and which is related to the cultural station project at the aforementioned locations.

City authorities reacted well to the introduction of a pedestrian traffic regime in the vicinity of the cultural stations. The implementation of that part of the plans was not a problem. In addition, the concept of pedestrian zones was well received by the users, with the provision that there was a need to get used to the new car regime. This applies to the area of Liman and Podbara (Almaška area), while the formation of a pedestrian zone is in progress in the region of Klisa.

A new general regulation plan has been prepared for the Svilara cultural station, which foresaw a square on that site. It turned out that the introduction of the cultural station, the formation of the plateau, the change to the traffic regime, and the formation of a pedestrian zone were the impetus for the further development of the Almaš area, and the connection of the pedestrian zone with the city center. A similar situation of forming an informal center within the pedestrian zone should happen in the vicinity of the cultural station in Klisa.

It can be concluded that the planning and design of cultural stations at the level of Novi Sad has established an urban practice that expands the zone of pedestrian use of space in the vicinity of cultural stations. The new quality of public life in public urban spaces implies putting pedestrians in the foreground and restricting the movement of cars. This means that the introduction of cultural station programs is an effective approach to the decentralization of the city and the formation of informal urban centers in predominantly residential suburbs. In addition to restricting the movement of cars in favor of pedestrians, the quality of these interventions within a space, is in the introduction of larger parking areas, which can be used by users of all public facilities within the newly formed urban centers, but also public facilities in the wider vicinity. In addition, all cultural stations will receive adequate parking areas, for the needs of visitors who will come from more distant parts of the city. It can also be stated that all cultural station locations will have excellent accessibility by bus lines and bicycle paths.

This intervention involved major or minor changes to the urban plans for these settlements. In Podbara, the general regulation plan for the Almaš area, which was under public review in July 2021, was changed so that the public space would be arranged and completely adjusted to the movement of pedestrians. This plan expanded the pedestrian zone and foresaw its arrangement according to the needs of pedestrian movement. In Klisa, this will require a minor change to the plan, although certain changes are possible with temporary solutions by introducing a special traffic regime. In Novo Naselje, similar changes were not necessary because the concept of the cultural station fit into the existing state. A special detailed regulation plan for Chinatown in Liman was adopted, which initiated the process of spatial transformation, and which foresaw a special landscaping solution for the pedestrian zone in the vicinity of the cultural station. It can be concluded that urban plans establish a new practice of forming urban centers in the vicinity of cultural stations in Novi Sad, new networks of cultural facilities, understand it and help continue its development.

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REFERENCES

[1] Decision on changes and amendments to the General Regulation Plan for mixed use space between Hajduk Veljkova, Rumenačka and Subotički bulevar in Novi Sad, Official Journal of the City of Novi Sad, No. 42/18.

[2] General Plan for the City of Novi Sad until 2021 (consolidated text), Official Journal of the City of Novi Sad, No. 39/06.

[3] General Regulation Plan for residential housing along Temerinska and Sentandrejski put with the surrounding areas in Novi Sad, Official Journal of the City of Novi Sad, Nos. 30/14 and 75/16.

[4] Detailed Regulation Plan for Chinatown with the Czech Warehouse, Official Journal of the City of Novi Sad, No. 17/17.

[5] Detailed Regulation Plan for Podbara in Novi Sad, Official Journal of the City of Novi Sad, No. 12/11.

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SUGGESTIONS FOR UPDATING AND CHANGING THE REGULATIONS WITH THE GOAL OF IMPROVING TRAFFIC SAFETY AND EFFICIENCY

Key Words

Law

Rulebook

Traffic signalization

Traffic safety

Abstract

Road traffic stands as a dynamic branch of economy which is in constant development and change as well as main entities of that system, “user” and “technology”, thus a conclusion is imposed that regulations following road traffic should be periodically renewed and updated for it to be applicable in real situations. Paper covers the observations and suggestions for changing and updating the existing legislative documents with the focus on *Law on road traffic safety* (Law) (1) especially in areas covering the traffic signalization. Conclusion is that preceding updates of these acts did not address these areas sufficiently. Suggestions for update of regulations would contribute fixing some of traffic system problems, both formal and practical, with the goal of reaching a sustainable long-term advancing of traffic safety system. The basis of such set of suggested measures for improving the regulations would be introduction of legislative framework for adopting and creating the missing acts and rulebooks to further organize specific areas of road traffic. During the process, new terms should be defined (the old ones redefined if it is necessary) in area of traffic signalization, given the fact that it is one of main constructing elements of the road. Specific proposals for updating the regulations will be further explained in detail.

1. EXISTING REGULATIONS, UPDATING EXISTING RULEBOOKS AND INTRODUCING NEW RULEBOOKS

Managing the traffic system through legislative means is quite challenging and seeks great responsibility from system creators and establishers. Main problem in application of legislative documents which are not periodically updated is the fact that the area impacted by those documents is advancing in practice while the legislative framework does not provide adequate support for that advance. Practice shows that as a solution to that problem adequate rulebook is often introduced since the procedure for creating and introducing specific rulebooks is much quicker and less complex than the procedures of changing legal acts.

Changes and updates to existing Law on road traffic safety should introduce following rulebooks:

Rulebook on traffic lights, Rulebook on traffic signalization in school zones, Rulebook on traffic signalization on railway crossings, Rulebook on traffic signalization for bicycle and pedestrian tracks, Rulebook on road admission control, Rulebook on criteria for designing pedestrian tracks, Rulebook on traffic signalization in roundabouts.

Existing rulebooks that should be updated:

Rulebook on technical measures for traffic calming and Rulebook on traffic management in construction zones which should be updated with missing typical schemes for placing temporary traffic signalization on state and local roads.

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By introducing some of suggested rulebooks specific areas would be withdrawn from the actual *Rulebook on traffic signalization,* which would facilitate its further changes and follow-up.

Since the detailed explanations and specific details for introducing rulebooks represent a complex subject, too extensive for this paper, only the main observations and suggestions will be explained in further text.

2. SUGGESTED RULEBOOKS AND BRIEF OBSERVATIONS

2.1. Rulebook on traffic lights

Necessity for introduction of *Rulebook on traffic lights* is imposed for a long time, especially given the fact that several of leading world countries already introduced such rulebooks (*Guidelines for Traffic Signal, RILSA), (9).* It would organize in detail the criteria for introducing, designing, installing, and operating modes for traffic lights. Impact of traffic lights on traffic flow and traffic safety on one side and professionally insufficient approach on criteria for introducing, designing, and operating modes of traffic lights both solidify the need for introduction of the rulebook.

Updates made to *Rulebook on traffic signalization (2)* in 2017. defined more precisely operation and designing of traffic lights and gave the basic safety precautions necessary for safe operation of traffic lights. As a very specific and comprehensive engineering subject, traffic lights should be legally defined in detail. Suggested rulebook would normalize traffic-lights introduction criteria, level of technical documentation, technical conditions and characteristics and safety precautions for the installed equipment. Modern concepts in traffic management impose usage of ever complex technical solutions and approaches for traffic lights management and operating (from fixed program modes, coordinated sections and modes which include usage of vehicle and pedestrian detectors for more efficient functioning). In addition to the mentioned operating modes, *adaptable traffic lights operating* is more and more present in urban networks today, managing traffic lights signal plans and functioning through specific sections or parts of network by the means of real time traffic flow measuring and vehicle detecting.

Rulebook on traffic lights should organize and redact in detail this subject by introducing different procedures, protocols, legal and technical requirements for introducing, installing, managing and maintenance of traffic lights equipment. Special attention should be given to creating and adopting standards which further normalize operating of traffic light devices and equipment (such as operating mode shifts, shift to safe operating mode (*yellow blinker mode)* in the case of logical errors (multiple conflicting signal groups given green light as a worst-case scenario)). Certificates issued by accredited institutions should be requested by the *Rulebook* as mandatory for all works, equipment and its functioning after installation of traffic light systems.

It is inadmissible for a traffic signalization subject as important and complex as traffic lights not to be normalized with adequate legal acts, both as a part of permanent traffic signalization and temporary traffic signalization in construction zones. Such acts and rulebook should normalize the domains of traffic lights operating modes, safe procedures for shifts between operating modes, safe operating modes (*yellow blinker)* and operating modes dependent on real time traffic data (traffic flows, vehicle speed and type etc.) gathered on the network. It should also provide necessary steps and mandatory parts for the *Main traffic design* for each intersection managed with traffic lights.

2.2. Rulebook on traffic signalization in school zones

This rulebook should further define school zones on public roads and normalize the traffic signalization placement in such zones through typical schemes of traffic signalization depending on school type, size, and location (elementary schools, high schools, schools for children with special needs etc.). It should also consider road rang in school zones, safe paths for children (pedestrians), school yard and entrance placement relative to roads and intersections on site etc. Rulebook should suggest and normalize the use of safety guardrails, technical means for traffic calming, uniform marking of busy pedestrian crossings and typical schematic presentation of other traffic signalization necessary for adequately and clearly signifying the school zone.

2.3. Rulebook on traffic signalization on railway crossings

There are some existing rulebooks covering this important domain of traffic signalization, but all were issued by railway authorities and do not address traffic signalization thoroughly. Therefore, new *Rulebook* should address traffic signalization in detail, intersecting road and railroad categories and extent of sufficient traffic signalization to be placed on crossings to ensure safety for all traffic modes (vehicles, trains, pedestrians etc.). Rulebook should be in accordance with existing rulebooks and should normalize the responsibilities of road authority in the domain of designing, installing and maintenance of traffic signalization and equipment on railway crossings. That means that the relations, responsibilities and obligations between road and railroad authorities and third parties using that railroad should be also legally normalized. Special focus should be brought to normalizing jurisdiction and maintenance of traffic light signals on crossings.

2.4. Rulebook on traffic signalization for bicycle and pedestrian tracks

Prior to updates and changes made to respecting Law to enable introduction of such a rulebook, it is necessary to define which road category bicycle and pedestrian tracks should be a part of, and which road authority (state or local) has jurisdiction on them. That should legally normalize exact responsibilities and jurisdictions over conditions and criteria for traffic signalization (such as language on informative signs, colorization of traffic signs etc.) issuing construction permits and detailed designs, and specific criteria and demands if the bicycle route represents a part of EuroVelo routes. As a specific part of the rulebook should be also the domain of relations between pedestrians and bicyclists and criteria for incorporating mixed tracks on site, especially in the field of traffic safety since more than one death was noted in traffic accidents between pedestrians and bicyclists. One of the upcoming problems in this domain is incrementing number of e-bikes, e-scoters and other electrified means of transport which mainly use the existing pedestrian and bicycle infrastructure. Therefore, conditions, obligations and responsibilities of those categories of traffic contestants should be addressed in the new rulebook as well.

2.5. Rulebook on road admission control

Although as a domain admission control is very comprehensive and complex matter, and contrary to the fact that it is already a part of several legal documents (*Law on planning and construction (5), Law on roads (4) and Law on traffic safety (1)*), it is concluded that it is still insufficiently addressed and as a part of traffic management domain, wrongfully secluded comparing to its status abroad. According to simplified regulations in domains of urban development and construction specific terms which address the admission control are defined: access (every direct connection of the pavement of public road with private lots alongside that road), lot access (means of reaching the lot from pavement and sidewalks for vehicles and pedestrians), and yard access (means for accessing yards from public road space). Access paths could be reserved for vehicles, pedestrians or mixed. Conditions and methods to ensure lot access are normalized in *Law on planning and construction (5)* and its respecting legal acts. Access path is defined by the *Law on roads (4).* In contradiction with the two mentioned laws, *Law on traffic safety (1)* nor its respecting legal acts do not define terms such as *access path (both for vehicles and pedestrians)* nor the criteria for its adequate marking, which is a source to many problems (both legal and practical). *Rulebook on traffic signalization (2)* defines the marking for vehicle access path as "*spot on which stopping and parking on the sidewalk is forbidden, and which serves as access path*" (marking code: V-16), and "*spot on which stopping and parking on the pavement is forbidden, and which serves as access path*" (marking code: V-16.1). Inconsistency and uncertainty of term *vehicle access path* in existing legal acts imposes several important questions: is the term *vehicle access path* identified same as terms *access path* and *lot access?; for which road categories is the term applicable?; does the term differ respective to road category?; does the term differ respective to surroundings of the road (open section or urban road)?.* Besides existing regulations, existing practice recognizes access control only for highways and some sections of two-way state roads, which is insufficient from aspect of road safety considering the size of other roads network. Practice shows that service roads are insufficiently applied on site on one side, and that citizen requests for approving *vehicle access paths* along state and urban roads are granted without criteria. It is important to mention that road access (especially state road) through direct pats from lot imposes considerable negative effects on road's safety, service level, average speed, and capacity. Therefore, updates to respective laws and introduction of new *Rulebook on road access control* would legally normalize specific conditions for granting and controlling access to public roads and adequate measures to organize and normalize this domain.

2.6. Rulebook on criteria for designing pedestrian tracks

Suggestion for updates to respective law and introduction of new Rulebook mainly covers the criteria for using pedestrian crossings, methods for properly marking pedestrian paths, and methods for guiding pedestrian flows since the pedestrian crossings represent important and potentially "dangerous" spots in which different road user categories intersect (motorized vehicles and different categories of pedestrians). Those spots thus become places with great safety risks for all users of the road with the most severe consequences for pedestrians (pedestrians, children, elder people, people with special needs etc.). Additional attention should be brought to this subject when the crossings are regulated with traffic lights. During the recent updates and changes made to *Rulebook on traffic signalization (2)* and Serbian standard which defines in detail the "pedestrian crossing" marking (marking code> V-4), more than once an open discussion with a goal of changing and updating of that specific marking were unsuccessful, during which the party mostly opposed to the suggested updates was the Police authority. Thus, opinion is that this domain should be primarily legally normalized with law changes, and then with changes and updates to *Rulebook on traffic signalization (2)* which would allow a more thorough approach to definition of pedestrian crossing marking. By introducing the *Rulebook* *on criteria for designing pedestrian tracks* missing criteria should be added (which should take to account expected traffic flows and paths, attraction zones, surroundings, motorized traffic flow, traffic speed, road width, placement of the road (urban or open), number of traffic lanes etc.). Subsequently, Rulebook should normalize the criteria for designing and constructing pedestrian under-passes and over-passes (taking to account potential users with special needs, and signaling and physical measures preventing the possibility for pedestrians occur on the road surface in such areas).

2.7. Rulebook on traffic signalization in roundabouts

Legal acts and existing rulebooks do not address thoroughly the design and construction of roundabouts in the domain of traffic signalization and right of passage regulation, and therefore this domain should be legally normalized with adequate updates to existing laws and introduction of new rulebook. As the constant road network reconstructions and updates occur, incrementing number of roundabouts are constructed as an alternative and more efficient way of intersecting same (or in some cases different) road categories. Nevertheless, most of the recently constructed roundabouts do not meet requirements technically and in terms of road safety. Due to the lack of normalizing legal acts, a number of different design solutions are applied in practice ant therefore there is no uniformity of necessary traffic signalization (sometimes the solutions are too complex and sometimes insufficiently thorough in terms of proposed traffic signalization). Therefore, Rulebook main objective would be to introduce adequate and uniform criteria for designing, constructing and necessary (and sufficient) traffic signalization on new (and existing if possible) roundabouts. That would even facilitate introduction of so called “turbo rotors” which rely mostly on proper traffic signalization for its safe functioning. It is important to mention that changes made to existing *Rulebook on traffic signalization (2)* in year 2017. Introduced new road markings for roundabouts, which could be further improved if needed.

2.8. Rulebook on technical measures for traffic calming

By updating and changing the *Rulebook on technical measures for traffic calming (3)* it is necessary to define the conditions and criteria for installation of those technical measures, precisely define their technical specifications, materials for its construction, looks, colour and levels of required retroreflective capabilities of their markings (foils), etc. Necessity of these updates and changes is imposed because of the situations and bad practices in which the technical measures for traffic calming are applied to public roads without clear criteria and justified causes, causing therefore a fall in efficiency, level of service and traffic safety in those sections of the road. While creating the new rulebook, special focus should be drawn to the question of application of these traffic calming measures on the roads used by the means of public transportation (buses, trolleys, taxis etc.).

3. EXISTING REGULATIONS STATUS, INTRODUCTION OF MISSING ACTS, UPDATES AND CHANGES TO EXISTING LAWS AND TERMS

Terms that are missing and should be defined by updates and changes to the Law (1) are: *school zone, vehicle access path, vehicles of micro-mobility (e-bikes, e-scooters etc.), Main traffic signalization design* etc.

It is suggested to reassess the validity of the existing procedures and exchange the term "accordance" with precisely defined form and new term for legal act "Rescript" in every Law (1) article which addresses it.

Main traffic signalization design should be introduced as a term along with the desirable and normalized *level of technical documentation* which makes it for different road categories and situations. In articles 157. and 158. of the Law (1) levels of necessary level of technical documentation should be defined for different road categories (state, local and urban roads) since in practice it happens that level of technical documentation defined by existing *Rulebook on traffic signalization (2)* is not always met.

It is necessary to define which authority conducts *regulation of traffic in noncategorized roads* and other responsibilities and obligations on such roads.

It is necessary to define *responsibilities and obligations in management and regulation of traffic on bicycle tracks* in manner that enables the tracks to be different in appearance than bicycle lanes. Bicycle track should be represented as a separate road, with adequate categorization, and well-defined obligations and responsibilities of the road authority which has jurisdiction over it. If the bicycle track is constructed on the territory of different states, as a part of international bicycle route, it should be defined as a state road and logically be in jurisdiction of such an authority.

4. OTHER OBSERVATIONS, REMARKS AND SUGGESTIONS FOR LAW (1) CHANGES

General remark is that specific articles of the *Rulebook on traffic signalization (2)* should be transferred to the *Law (1)* and vice versa. The law should define general terms, in accordance with other relating laws, and rulebooks should further define in detail the terms from the law.

Some of the suggested articles to be changed in the *Law (1)* are: *introduction of orange colour for marking road construction zones* in order to lessen the unclarity for the drivers in urban areas since yellow markings are also used to define road surfaces indented to be used by public transport vehicles.

Rulebook on traffic signalization should be updated by adding traffic signalization intended to be used by motorcyclists and micro-mobility vehicles.

Obligation of use of traffic sign "mandatory stop" (II-1) and road mark "uninterrupted stop line" (V-1) should be defined.

Obligation of use of different languages and letters on traffic signs should be defined, taking to account languages of national minorities. This subject should be defined by the law, not by the rulebook.

Priority of regular and interchangeable traffic signs should be defined in situations in which they are placed at the same location along the road.

5. CONCLUSION

Some of the main and most important tasks of engineers working in road authorities is introducing, improving and innovating the existing legal acts and the follow up of its application in practice through cooperation with colleagues who implement them in practice, gathering information about new international legal acts and standards (in the same domain, road traffic), constant improvement through education courses, conferences, etc. This should be achieved with conceptual approach and attitude that the system creators are responsible for its “adaptation to users”. In the past period a number of regulations was introduced, with especially important regulations which are in accordance with European directives in domain of roads and road safety. It should be taken to account the fact that those are technically good practices since a lot of transit traffic passes through our country and a lot of foreign drivers and vehicles use our roads. Unfortunately, the number of road accidents is still too high on our road network. In accordance with everything said, the intention of authors of this paper was to encourage the engineers and the rest of professionals from the domain of road traffic to try to improve and innovate the domain and its parts. Since the domain of road traffic is too comprehensive and complex to be adequately represented and improved in a single paper, the idea of authors of the paper is for it to help the future attempts and workgroups in their work.

REFERENCES

[1] Law on road traffic safety ("Sl. Glasnik RS", бр. 41/2009, 53/2010, 101/2011, 32/2013 - odluka US, 55/2014, 96/2015 - dr. zakon, 9/2016 - одлука УС, 24/2018, 41/2018, 41/2018 - dr. zakon, 87/2018, 23/2019 i 128/20 - dr. zakon)

[2] Rulebook on traffic signalization („Službeni glasnik RS“, broj 86/17 i 14/2021)

[3] Rulebook on technical measures for traffic calming (“Sl. glasnik RS“, br. 9/2014)

[4] Law on roads („Službeni glasnik RS“, br. 41/2018 i 95/2018 - dr. zakon)

[5] Law on planning and construction („Sl. glasnik RS“, br. 72/2009, 81/2009 - ispr., 64/2010 – odluka US, 24/2011, 121/2012, 42/2013 – odluka US, 98/2013 - odluka US, 132/2014, 145/2014, 83/2018, 31/2019, 37/2019 - dr. zakon i 9/2020)

[6] Rulebook on general rules for lot creation, regulation and construction („Sl. glasnik RS“, broj 22/2015)

[7] Jelena Krtenić, Ana Trpković, Nikola Čelar, Jelena Milić-Lalović; "Izmene propisa u oblasti saobraćaja", TESi, XII international conference, Vrnjačka Banja 2018.

[8] Miroslav Osoba, Smiljan Vukanović, Branimir Stanić: "Upravljanje saobraćajem pomoću svetlosnih signala", Saobraćajni fakultet Univerziteta u Beogadu, 1997.

[9] Tihomir Đorđević; „Regulisanje saobraćajnih tokova svetlosnom signalizacijom", Institut za puteve, Beograd, 1997.

[10] Branimir Milosavljević, Saša Babić; „Regulisanje saobraćaja"; Akademija Šumadija, Visoka tehnička škola Trstenik, 2020.

[11] Marijo Vidas, „Uticaj kontrole pristupa na kapacitet i nivo usluge dvotračnih puteva", Doktorska disertacija, Saobraćajni fakultet, Univerzitet u Beogradu, 2017.

[12] Vladan Tubić, Marijo Vidas, Draženko Glavić, Marina Milenković, „Kontrola pristupa – politika upravljanja pristupima", Međunarodna konferencija, „Bezbjednost saobraćaja u lokalnoj zajednici", Banjaluka, 2016.

[13] Priručnik za sticanje licenci i stručno usavršavanje Revizora i Proveravača bezbednosti puta, Agencija za bezbednost saobraćaja, 2021.

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THE INFLUENCE OF MICROMOBILITY ON SUSTAINABLE URBAN TRANSPORT POLICIES

Key Words

Micromobility

Development policy

Urban mobility

Innovative mobility

Sustainable development

Abstract

Rapid economic development, urbanization and technological progress have conditioned significant global changes whose effects can be seen through increased population mobility, the use of modern technologies, the emergence of new modes of transport etc. Most of the mentioned characteristics are closely related and reflected on the functioning of urban traffic-transport systems, which is why today's cities face various challenges. Existing sustainable development policies are focused primarily on the traditional approach of traffic-spatial planning, which does not recognize the specifics of new transport options. With the advent of micromobility, there were significant changes that needed to be considered at the strategic level and define activities for their implementation within local transport policies. In that sense, it is necessary to harmonize and improve the existing policies of sustainable urban development, in order to respond to new requirements.

The main goal of this paper is to consider the representation of new transport options within the existing policies of sustainable development of urban transport systems. Also, it is necessary to point out the shortcomings and potentials for improving these documents from the aspect of micromobility. Accordingly, an analysis of best practices and experiences of selected cities and countries was performed. Additionally, the paper analyzes the general impact of micromobility on transport policy development, with the aim of increasing the resilience and flexibility of cities in the process of responding to new and unexpected situations.

1. INTRODUCTION

Although not yet universally defined, micromobility refers to a set of different modes of transport, the latest representatives of which are e-scooters and e-bicycles. In addition to the above, micromobility vehicles include bicycles, skateboards, unicycles, e-skateboards, e-rollers, hoverboards, segways and other similar light vehicles used to transport one person, usually during short trips, or for the first/last kilometer [1]. It can be noticed that the term micromobility encompasses a wide range of vehicles with different technical and operational characteristics, which can be grouped into: traditional light human powered vehicles, electric and hybrid vehicles. It is also important to note that, in addition to private use, micromobility vehicles are increasingly becoming part of the public service in cities. Accordingly, the notion of shared micromobility differs, which includes the shared and public use of e-scooters, e-bicycles and other light vehicles [2].

The need to regulate micromobility, as a new transport subsystem, has emerged in almost all cities of the world, requiring rapid response, precisely because of the fast increase in the number of new vehicles on the network. It is important to emphasize that the current transport policies did not recognize the newly offered mobility options, which further complicated the process of regulation and integration.

The situation that, to a certain extent, supported and accelerated the integration of micromobility into traffic systems is the emergence of the Covid-19 pandemic. This pandemic has forced cities to promptly rethink their transport networks, and micromobility has emerged as a crucial mode for moving people, while minimizing physical contact [3]. Some cities have made good use of the pandemic and its rare positive effects, such as reducing the number of vehicles on streets, and have included micromobility in existing sustainable urban strategies and policies. Through pilot projects, testing the use of micromobility vehicles were performed, legislation, infrastructure was improved and enforcement and management policy was formed, which provided users with an adequate and sustainable alternative to passenger cars over shorter distances. Although various shortcomings were noticed during the integration process, cities and countries that have overcome the transition period are already actively working on improving transport policies, so that micromobility remains and takes its place in the modal share even after the pandemic.

The main goal of this paper is to consider the representation of new transport options within the existing policies of sustainable development of urban transport systems. Accordingly, an example analysis of the best world practice and experiences of six cities: Vienna, Paris, Madrid, Los Angeles (LA), Chicago and Auckland, was performed, in order to define the role and function of micromobility, but also to notice the advantages and the shortcomings of current policies. The main emphasis will be placed on e-bikes and e-scooters as the most widespread modes of transport within the micromobility subsystem. The research results presented in this paper can be used as an adequate basis for improving existing and forming future transport policies, which will cover the area of micromobility and actively treat its impact and function in the sustainability of cities and its transport systems.

2. MICROMOBILITY POLICY REQUIREMENTS

Current urban policies are mainly focused on the existing transport offer, which forms the basis of urban transport systems. However, within these policies, cities are oriented towards traditional forms of movement, i.e. motorized and non-motorized users, striving for their sustainability, equal participation and equal accessibility for all users [4]. With the advent of micromobility, there was a need to improve and supplement existing documents, to ensure the active participation of new modes of transport in traffic. This section reviews the most common and important upgraded parts of the current (micromobility) policies at the municipal and city level, including: curb space management, equitable standards and equity, enforcement and data standards (Figure 1) [2, 5]. Each of the policies presented in this chapter will be briefly described further in the paper.

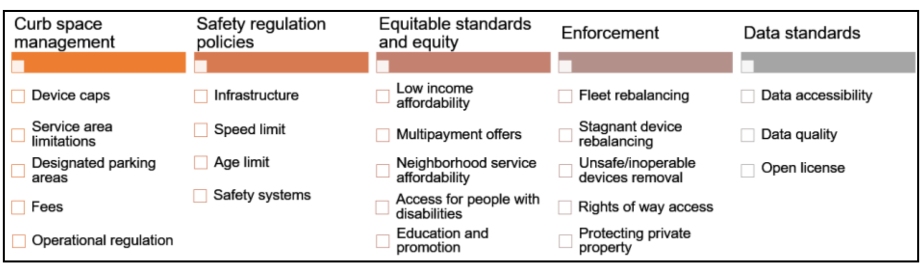

Figure 1. Most common micromobility policies, based on [2, 5]

2.1. Curb space management

This policy essentially relies on improving existing infrastructure capacities and defining measures to address infrastructure-related problems. According to the activities shown in Figure 1, Figure 2 illustrates examples of selected cities in which these measures have already been implemented.

As can be seen from Figure 1, device caps have been determined for each of the cities shown, except Madrid and Auckland, which do not have a defined limit on the number of e-bikes. For example, in the territory of Vienna fleet cap for bicycles is 1500, as well as for e-scooters. On the other hand, in Madrid regulatory fleet cap is 4800 for bicycles and 10.000 for e-scooters [6]. It is important to note that some cities define fleet cap per operator which is the case with Los Angeles (3.000 per applicant) [7].

Figure 2. Implemented measures in the analyzed cities as part of the curb space management policy

Another interesting strategy considering fleet cap is performance based cap represented mostly in American cities[1].

Service area limitation is, in the example of Vienna, controlled using geofencing. Geofencing is a technique that combines different geospatial data to delimitate real geographical zones through virtual boundaries or geofences. That way, it is possible to manage GPS-equipped vehicles when they cross a specific area boundary, and automatically reduce the speed or stop the vehicle [8]. This is especially useful for controlling the sidewalk movement, or movement on the other surfaces, where it is forbidden to use micromobility vehicles.

Because of the image of disorder, clutter, and pedestrian obstruction, every analyzed city provided designated parking areas (docking stations with corals, racks and other parking equipment). For example, the most interesting solutions are present in Los Angeles and Chicago which have designed red zones where it is forbidden to park or completely forbidden the usage of micromobility vehicles. These zones usually encompass high demand pedestrian zones and streets, parks or universities [9].

Equally important measures defined in micromobility policies are fees required from operators for participation and management of their fleet through the exploitation period. For example, in Los Angeles and Chicago, operators are required to pay the annual fee, as well as the annual per vehicle fee [7]. On the other hand, in Paris, operators are obliged to pay fees per device per year just to operate their fleet regularly [10]. In addition to the above, there are fees on a daily basis, per trip, station, etc., which are characteristic of American cities. In this way, competition is protected, and market equality between operators is enabled, while on the other hand, the required level of service and safety of vehicles is provided.

[1] Some cities have defined minimum or maximum number of trips per day (for example: Santa Monica defined 4 trips/day for e-scooter) which determine the decrease or increase of the fleet size based on the operator performance.

2.2. Safety regulation policies

The main activities within this policy are: defining the infrastructure, specifying the age limit, speed limit, and the use of safety systems (primarily helmets). European countries have mostly harmonized safety policies, so in Vienna, Paris and Madrid, for example, cycling infrastructure and carriageway are primarily used, the use of helmets is mandatory, while the age limit varies from 12 years (Paris) to 15 years [5], and speed limit is 25km/h. On the other hand, the federal states of America have quite different regulations, which are often determined at the regional level. For example, in Los Angeles, the use of sidewalks is allowed, while that is not the case with Chicago. The speed limit also varies from 25km/h to 42km/h, depending on the state.

What is important to note here is that, although a large number of cities still do not have a clearly defined safety policies, the countries that have updated these documents devote great importance to the safety aspect. Given that there are many differences in existing policies, it is extremely important to harmonize them locally and nationally, as well as internationally, in order to establish a unified control system and maintain the required level of traffic safety.

2.3. Equitable standards and equity

Given the different needs of people, especially people with reduced mobility, the elderly, children, but also people with lower incomes, it is necessary to provide policies so that all groups are treated equally and have an equal right to participate in traffic. Accordingly, many interesting approaches have emerged as a way of solving this problem. For example, the current micromobility policy in Vienna dictates that at least 1/3 of the fleet has to serve Vienna’s outerdistrics, while at most 1/3 of the fleet can serve the city center [6]. On the other hand, Chicago developed an integral policy which requires the operator to have at least 25% of the vehicles available every morning, in two zones that are less connected by public transport.

It is also standardized that help, given for micromobility vehicles use, should be in multiple languages, as well as with the enabled audio option. Also, when paying for the vehicle daily use, some operators offer a multi-payment option (cash, credit card, city pass etc.) [8]. In Austin, as a promotional measure, city proposed discount schemes for students, elderly and low income groups [11]. An interesting strategy in the same city includes special benefits and discounts for the working population in the central zones of the city.

Another important measure implies the provision of a needed service to people with reduced mobility. In American cities (LA, Chicago, Washington etc.) e-scooters with a seat, three wheels, as well as e-scooters with a larger wheel diameter are produced in order to increase stability. Additionally, the user is required to be informed about the use of the vehicle and to have sufficient knowledge of traffic regulations [12]. In this way, special attention is paid to vulnerable groups of participants who, through the adaptation of micromobility vehicles, are provided and enabled to use the daily services of the city's transport system.

2.4. Enforcement

Enforcement is important both to maintain compliance with traffic regulations by micromobility users, and to ensure a high level and quality of service by operators. For example, number of users often does not leave their vehicles in designated parking spaces, sometimes inoperable vehicles could be present in the fleet, or the number of vehicles is not evenly distributed in the city area etc. In this regard cities, through their urban policies, oblige operators to regularly control their fleet. For example, in Los Angeles e-scooter companies must respond to a customer complaint within 2 hours and fix the problem. In Paris, that deadline is 24 hours [13]. This policy includes different types of problems such as: inoperable devices, obstruction of pedestrian movement, stagnant devices, obstruction of private property etc. It is interesting to note that primarily in American cities (Los Angeles and Chicago in this analysis) as well as in Auckland, the operator is required to rebalance the number of vehicles on the network, in a certain period of time, in order to provide service equity [2].

What is important to emphasize at this point is that public education and inter-company cooperation can help and reduce the administrative burdens of enforcement. Furthermore, cities' obligation is to provide operators and the public clear and concise guidance on micromobility use expectations to achieve required quality and level of service [2].

2.5. Data standards

Public availability and transparency of data should be one of the main requirements of cities and public agencies, in the process of registering micromobility operators. Standardized and open data allows to understand micromobility impacts, to identify gaps in the transportation network, monitor service standards, and offer multimodal, real-time transportation information [2]. Los Angeles was the leading city in the development of the Mobility Data Specification (MDS), which greatly facilitates the sharing and availability of data. In 2018, ten cities in the United States accepted the data standard, which is why the operators are obliged to ensure the availability of data using MDS.

In spite of the rapid emergence of micromobility, publicly available data on vehicle type ridership, mode shift, and trip replacement is minimal, as is the case with the cities analyzed in this paper. These data are important for understanding how micromobility is meeting the needs of a particular city, and managing enforcement rules through different urban transport policies. This is exactly the main reason why, a clear strategy, should be developed that will be shared with operators prior to service provision [14].

3. CONCLUSION

Although micromobility is a relatively new concept, vehicles belonging to this group have quickly established themselves as an adequate and sustainable alternative to passenger cars over short distances. However, the development of micromobility largely depends on the willingness of cities to accept the changes it brings. This paper presents some of the basic strategies and policies that cities use to solve problems that arose during the integration of micromobility. Curb space management will remain one of the burning issues that needs to be addressed, both due to the growing demands for the use of micromobility vehicles, and due to the increasing number of services. The integration of micromobility with public transport into a unified public service is a very important part of urban policies. In addition, cities must pay special attention to improve existing strategies, and provide equal and publicly available ministrations for all users. On the other hand, enforcement as a crucial management measure must be present to ensure the functionality of the system as a whole.

It is clear that these innovative technologies will have a disruptive impact on traditional planning and design concepts, which will have to be tackled in the future policy documents. A precise understanding of how people use these services is an indicator and input for effective management, and a contribution to more sustainable transportation systems.

REFERENCES

[1] City of Hoboken, “Achieving Sustainable Micro-Mobility”, USA, New York, 2020.

[2] S. Shaheen and A. Cohen, “Shared Micromobility Policy Toolkit”, 2019.

[3] D. Yanocha and A. Mackenzie, “Maximizing Micromobility: Unlocking Opportunities to Integrate Micromobility and Public Transport”, 2021.

[4] S. Gössling, “Integrating e-scooters in urban transportation: Problems, policies, and the prospect of system change” Transp. Res. Part D Transp. Environ., vol. 79, p. 12, 2020.

[5] B. Şengül and H. Mostofi, “Impacts of e-micromobility on the sustainability of urban transportation—a systematic review,” Appl. Sci., vol. 11, no. 13, 2021.

[6] Flucto Mobility Intelligence, “European Shared Mobility Index”, France, Paris, 2021.

[7] R. Zack, I. Shapiro, and C. Bailey, “Micromobility Policy Survey”, 2018.

[8] H. Badia and E. Jenelius, “Shared e-scooter micromobility: A review of travel behavior, sustainability, infrastructure, safety and policies Shared e-scooter micromobility: A review of travel behavior, sustainability,” 2021.

[9] Polis, “Macro managing Micro mobility”, Belgium, Brussels, 2019.

[10] G. Bailey and T. Febvre, “European Policy Guidelines on Shared Micro-Mobility”, 2020.
[11] D. Lo, C. Mintrom, K. Robinson, and R. Thomas, “Shared micromobility: The influence of regulation on travel mode choice,” N. Z. Geog., vol. 76, no. 2, pp. 135–146, 2020.
[12] National Association of City Transportation Officials (NACTO), “Guidelines for Regulating Shared Micromobility”, USA, New York, 2019.
[13] Agora Verkehrswende, “Shared E-Scooters: Paving the Road Ahead Policy Recommendations for Local Government”, Germany, Berlin, 2019.
[14] Institute for Transportation & Development Policy (ITDP), “Leveraging E-bikes and E-scooters for more livable cities”, USA, New York, 2019.

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MICROMOBILITY RUSH IN THE REPUBLIC OF SERBIA – EXISTING TRENDS AND FUTURE CHALLENGES

Key Words
Micromobility
Urban design
Transport policy
Urban mobility

Abstract

The expansion of the use of micromobility vehicles has conditioned a number of changes that cities and countries around the world have faced. The lack and inconsistency of the existing regulations and limited infrastructure capacities have been singled out as two central problems that further complicate the process of adequate treatment of this area. On the other hand, the shift of users of traditional modes of transport to the use of new mobility options, at the same time changes their needs, habits and requirements. Some cities and countries have already gone through a period of testing and integration of micromobility into existing urban transport and traffic systems, while a large number of countries are currently in transition. This group of countries also includes the Republic of Serbia, which is actively working on improving the current legislation and examining the existing infrastructure options for the implementation of micromobility vehicles. Accordingly, the main goal of this paper is to present the current situation and the possibility of using micromobility vehicles in the Republic of Serbia. The results of the research presented in this paper are part of the Study "Micromobility vehicles" conducted for the Republic of Serbia, commissioned by the Road Traffic Safety Agency, which defines the basic technical and operational characteristics, classification of vehicles, how to use the existing infrastructure, as well as general conditions for their regulated and mass application.

1. INTRODUCTION

With the expansion and the development of micromobility during 2018 at the global level, there was a need for additional consideration of this group of vehicles and their inclusion in the existing traffic systems. Although micromobility seems to be an effective concept of efficient mobility for urban areas in the future, the reality indicates potential problems that these changes create, and which the Republic of Serbia faced, in the process of regulation [1]. First of all, micromobility vehicles are characterized by extensive development, which is not accompanied by appropriate legislation. The street profile has its spatial limitations and usually separates non-motorized and motorized users, which could be disrupted by new micromobility options [2]. In that sense, it is not possible to unambiguously take over some of the already implemented solutions in the countries that have regulated the usage of vehicles for micromobility, but it is necessary to give an optimal proposal for their use, taking into account local specifics design elements, users, vehicles, network and environment, as well as regulations on the territory of the Republic of Serbia.

The existing Traffic Regulation provides an adequate basis and legislative structure for regulating these vehicles, their management, defining the infrastructure, and other important aspects. However, certain shortcomings have forced actions and measures to be taken to improve the existing regulations. For example, *The Rulebook on the classification of motor vehicles and trailers* [3] provides a special type K (Other vehicles) which to some extent includes micromobility vehicles, but not in a sufficient way to include all existing (or future) types of electric or self-balancing vehicles. The existing legal acts do not define the infrastructure that can be used by these vehicles. *The Rulebook on Traffic Signalization* [4] includes a set of standard signs and markings that can be partially applied to micromobility vehicles. Certain situations, such as marking parking spaces, infrastructure for these vehicles, defining specific restrictions on movement, etc., require separate signalization, which must be defined by *The Rulebook*. On the other hand, the existing penal provisions defined by *The Road Traffic Safety Law* [5] do not fully cover all categories of micromobility vehicles, which is why this document cannot be used consistently without its amendment and improvement. Based on the above, it can be noticed that, unlike traditional vehicles, micromobility vehicles are not explicitly defined by the Law, nor is their use regulated by the existing Traffic Regulations. Prolonged use of micromobility vehicles without the necessary legal regulations reduces not only the level of road safety, but also the general level of service and efficiency [6].

The mentioned reasons conditioned the activities and measures on the improvement and regulation of this area on the territory of the Republic of Serbia. In that context, the Traffic Safety Agency decided to, through a systematic analysis and range of professional activities, develop and implement a study that aims to provide the answers to define the place and role of micromobility in the urban mobility system. Accordingly, this paper aims to present the current situation and possibilities of using micromobility vehicles in the Republic of Serbia, by presenting the methodological framework of the Study, and the most important research results that include: minimum structural and technical characteristics of vehicles, movement requirements, available infrastructure capacities for their use, and recommendations for the public use of micromobility vehicles.

2. METHODOLOGICAL FRAMEWORK OF THE STUDY

The general methodological procedure of the Study consists of five main phases: first, preparatory phase, second phase which includes presentation of micromobility vehicle characteristics, and literature review, third phase which represents the analysis of the current situation, fourth phase in which the legal framework and recommendations for implementation are defined, and fifth phase involves the dissemination of the results. The sequence and structure of phases within the Study are shown in Figure 1.

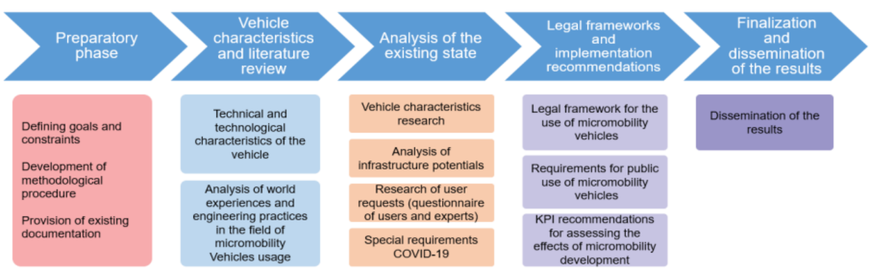

Figure 1. Study methodological framework

Further in the paper, the activities in the process of data collection will be explained in more detail, as well as:

- the analysis of the minimum requirements for structural and technical characteristics that must be met by micromobility vehicles, as well as general requirements for their use,
- the analysis of requirements and availability of existing infrastructure capacities,
- conditions for public use of micromobility vehicles on the territory of the Republic of Serbia.

3. CHARACTERISTICS REQUIREMENTS FOR MICROMOBILITY VEHICLES

Micromobility vehicles include a whole range of modes of transport that differ significantly in their technical and technological characteristics, the purpose of use, safety aspects, but also other elements. For this reason, it is necessary to standardize and define the minimum requirements that every vehicle for micromobility must meet, to enable its functional and safe use in traffic.

Although, there is still no universally defined classification of vehicles for micromobility, some countries and organizations have given their suggestions as to which vehicles should be classified in the group of micromobility. Figure 2 shows the classification and basic characteristics of a vehicle for micromobility, given by the Society of Automotive Engineers (SAE) [7].

	Powered Bicycle	Powered Standing Scooter	Powered Seated Scooter	Powered Self-Balancing Board	Powered Non-Self-Balancing Board	Powered Skates
Seat	Y	N	Y	N	N	N
Operable pedals	Y	N	N	N	N	N
Floorboard / foot pegs	Possible	Y	Y	Y	Y	Y
Self-balancing[2]	N	N	N	Y	N	Possible

Figure 2. SAE micromobility vehicles classification

The classification and guidelines of the EU Directive no. 168/2013 [8], served to form the proposal of the national classification of micromobility vehicles in the Republic of Serbia.

The results of the conducted expert survey, experiences of the best world practice, EU legislation and recommendations, i.e. standards, were used as a starting point for defining the proposals of minimum requirements related to vehicles for micromobility. Figure 3 summarizes the 11 most important structural and technical characteristics and the 11 most important requirements that have been considered from the aspect of micromobility vehicles usage.

Minimum technical characteristics requirements

- Maximum designed speed
- Maximum nominal power
- Maximum vehicle width
- Maximum vehicle length
- Minimum wheels dimension
- Maximum deceleration
- Minimum clearance
- Possession of devices for giving sound signals
- Possession of lighting system
- Pedestrian mode
- Possession of steering wheel

Vehicle use requirements

- Usage approval
- Vehicle registration
- Periodical vehicle check
- Driver licence
- User training
- Knowledge of regulations
- Insurance
- Usage of safety helmet
- Usage of retroreflective clothes
- Minimum age for vehicle use
- Speed limit

Figure 3. Technical and usage requirements analyzed in the Study

Structural and technical characteristics and requirements were analyzed concerning the following four general categories: e-bikes "pedelecs", "fast" e-bikes, e-scooters and other micromobility vehicles which include: segways, hoverboards, e-skateboards, e-rollers, unicycles, etc. The proposed constructive and technical characteristics for the micromobility vehicles are presented in Table 1.

Table 1. The proposed constructive-technical characteristics for the micromobility vehicles

Construction	Vehicle category			
	E-bike „pedelec"	„Fast" e-bike	E-scooter	Other micromobility vehicles
Maximum speed	25 km/h	45 km/h	25 km/h	25 km/h
Maximum nominal power	250 W	4000 W	600 W	500 W per wheel
Maximum vehicle width	1.00 m	1.00 m	0.70 m	1.00 m
Maximum vehicle deceleration	1.68 – 4.25 m/s²	✓	1.5 – 2 m/s²	1.5 – 2 m/s²
Sound signals	✓	✓	✓	✓
Lighting	✓	✓	✓	✓
Pedestrian mode	N/A	N/A	✓	✓

✓ - required; N/A – Not applicable

4. AVAILABILITY AND INFRASTRUCTURE REQUIREMENTS

Within this step of the Study, a comparative analysis of the attitudes of experts, users and potential users was performed based on the results of the survey, as well as the analysis of the experiences and best practices of five selected European countries: Italy, Austria, United Kingdom, Slovenia and Germany. The survey included 36 experts whose task was to propose the infrastructure for the use of micromobility vehicles. A special survey was conducted among both users and potential users. Users commented on the infrastructure they currently use for micromobility vehicles. On the other hand, the survey of potential users aimed to determine what type of infrastructure this group of respondents would use in case of the potential use of micromobility vehicles. The total sample collected for the needs of this phase of the research is 1002 respondents.

Existing infrastructural capacities were considered through six categories, shown in Figure 4. Having in mind that each city is arranged and functions in accordance with the planning documentation prepared for the needs of the specific subject area, it was noticed that there are significant differences in the road classification. Accordingly, for this Study, the available infrastructure is classified to cover all network capacities, bearing in mind the large differences in the network characteristics on the territory of the Republic of Serbia.

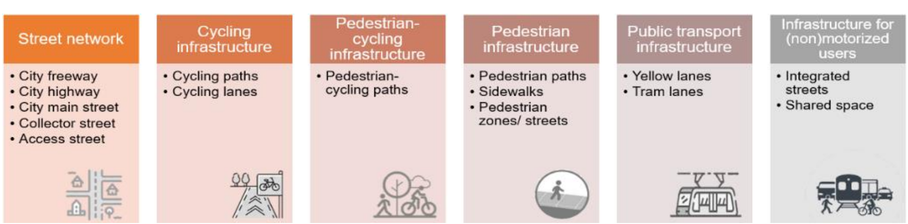

Figure 4. Analyzed infrastructure capacities defined for the Study

Based on the analysis of the current situation, expert recommendations and user attitudes, guidelines are given for the use of the presented infrastructure capacities by micromobility vehicles (Table 2). In general, it can be noticed that vehicles for micromobility can primarily be used on bicycle infrastructure, while e.g. secondary roads can be used by e-bikes, and conditionally (subject to legal restrictions) by e-scooters. It is recommended that shared spaces and integrated streets can be conditionally used by micromobility vehicles, as well as pedestrian infrastructure except for "fast" e-bikes. Infrastructure for public transport is generally not recommended for the use of these vehicles, while some areas are conditionally prohibited (city highways and yellow lanes). This leaves the possibility of changing mentioned recommendation, if the existing regulations are improved and supplemented.

Table 2. The proposed infrastructure capacities for the micromobility vehicles

Infrastructure	Vehicle category			
	E-bike „pedelec“	„Fast“ e-bike	E-scooter	Other micromobility vehicles
City highway	(✘)	(✘)	✘	✘
Main city street	✔	✔	✘	✘
Collector street	✔	✔	(✔)	✘
Access streets	✔	✔	(✔)	✘
Bicycle paths, bicycle lanes	✔	✔	✔	✔
Pedestrian-cycling infrastructure	(✔)	✘	(✔)	(✔)
Pedestrian paths	(✔)	✘	(✔)	(✔)
Sidewalks	(✔)	✘	(✔)	(✔)
Pedestrian zones/streets	(✔)	✘	(✔)	(✔)
Yellow lanes	✘	(✘)	✘	✘
Tram lanes	✘	✘	✘	✘
Integrated spaces, shared streets	(✔)	(✔)	(✔)	(✔)

✔ - allowed use; ✘ - prohibited use; (✔) - conditionally permitted use; (✘) - conditionally prohibited use;

5. PUBLIC USE OF MICROMOBILITY VEHICLES

The public micromobility system is a subsystem of flexible public transport available to users as a public service, in which the user realizes or supplements his transport needs using the micromobility vehicles, and thus optimizing the transport process. Accordingly, in this part of the Study, proposals and recommendations related to the implementation of the micromobility system as a public service are given. In this context, several important elements considering: vehicles, stations, system organization and management and data sharing are considered.

The basic characteristics considered within the “vehicle” element include: standard vehicle dimensions and comfort, durability, attractiveness, the practicality of vehicles, safety and security and "pedestrian mode" primarily for electric scooters.

When it comes to the general characteristics of public micromobility systems, they can be divided into two groups: 1) station systems, and 2) flexible systems, where there is no network of stations but users pick up and/or leave vehicles at the locations that suit them. Following the need to provide cellular infrastructure in the case of the implementation of the first group of public systems, the Study provides important recommendations for their installation and maintenance. Also, managing any system is unthinkable without reliable and timely information. For all actors in the system at all levels of management to have access to such information, it is necessary to clearly define the method of data management and exchange, following applicable national and international legal frameworks governing the protection of personal data.

6. CONCLUSION

The development and improvement of current regulations is a basic step in the process of integrating micromobility vehicles into urban traffic systems. It is important to note that the Republic of Serbia has a very detailed traffic-legal framework that refers to traditional modes of transport, which does not sufficiently cover and treat the area of micromobility. However, well-established legislative bases can be used as adequate support for its further improvements and additions. This step was recognized by the Traffic Safety Agency, which initiated the preparation of the Study "Micromobility Vehicles", whose methodological framework and the most important results, relating to the structural and technical characteristics of vehicles, infrastructure, and requirements for public use, are presented in this paper.

Although there are many similarities in terms of infrastructure use and regulation for micromobility vehicles in the world, each country has its local specifics in addressing this issue. The situation is further complicated because within each state, cities and local governments have the authority to adjust their regulation. For that reason, experts are facing a great challenge which is how to incorporate these vehicles into the existing transport and traffic system. The formation of precise and clear goals, harmonized with the postulates of sustainable development can greatly facilitate and guide all actors in this process, especially the decision-makers, in defining the place and role of these vehicles in traffic. The next steps include the final phase and the integration of micromobility vehicles, their management and control in the transport and traffic system of the Republic of Serbia.

REFERENCES

[1] D. Glavić, A. Trpković, M. Milenković, and S. Jevremović, “The E-Scooter Potential to Change Urban Mobility—Belgrade Case Study,” *Sustain.*, vol. 13, no. 11, p. 29, 2021.

[2] POLIS - Cities and Regions for Transport Innovation, “Macro managing Micro mobility,” 2019.

[3] “Službeni glasnik RS” br. 2/2020 ispr. 64/2021, *Pravilnik o podeli motornih i priključnih vozila i tehničkim uslovima za vozila u saobraćaju na putevima*. 2021, p. 142.

[4] “Službeni Glasnik RS” br. 85/2017, *Pravilnik o saobraćajnoj signalizaciji*. 2017, p. 114.

[5] "Službeni glasnik RS" br. 128/2020, *Zakon o bezbednosti saobraćaja na putevima*. 2020, p. 121.

[6] A. Trpković, B. Stanić, S. Tica, S. Jevremović, and P. Živanović, "Micromobility Revolution - Challenges and Potentials," *Towards a Humane City*, 2019, pp. 231–237.

[7] Society of Automotive Engineers (SAE), *Taxonomy and Classification of Powered Micromobility Vehicles J3194_201911*. 2019, p. 12.

[8] The European Parliament and The Council of the European Union, *Approval and market surveillance of two- or three-wheel vehicles and quadricycles*. 2013, p. 77.

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URBANIZATION OF THE COAST OF BACKA PALANKA

Key Words
Urbanization
Planning
Coastline
Regatta center

Abstract

The great potential of the Danube bank needs to be put in the function of a better quality of life for the inhabitants of Backa Palanka, better traffic connections and tourist offer. The introduction of attractive programs and contents, the functional expansion of the city in the context of the pan-European corridor, conditions the need for planned arrangement of the coast with an emphasis on the construction of a regatta center with accompanying facilities. The paper valorizes the potential of the Danube bank through spatial and urban plans and opportunities for further development of the city while preserving the natural environment and respecting environmental standards.

1. INTRODUCTION

The riverbank is the greatest potential of Bačka Palanka. It has great natural and historic value. The landscaping and exploitation of this potential has been a topic of discussion for decades, but there has been no initiative to urbanize this part of the settlement. This area is managed by a municipal public enterprise.

The municipal spatial plan, the general regulation plan and the detailed regulation plan have been drafted for the arrangement of this area. The implementation of these plans has never taken place. A change, in this respect, is a new urban plan for the detailed regulation of the riverbank belt, adopted in 2018. This plan represents the current initiative for the urbanization of the riverbank.

The riverbank area of the municipality of Bačka Palanka implies broad areas on the banks of the Danube, from the Bačka Palanka settlement to the Čelarevo settlement. The subject of this paper is the riverbank in the settlement of Bačka Palanka, which is part of the riverbank of the entire municipality. In this belt, where the Bačka Palanka settlement exits onto the Danube, the area of the banks must be activated through the introduction of programs, content, respect for natural values and adequate transport connections, so that the settlement can functionally exit onto the river. In this way, the inhabitants would get a new quality of life. The settlement would develop a tourism offer which is of both regional and broader importance, as part of the Danube Corridor.

The methodology used in the paper is a comparative analysis of the existing state and planning documentation, on the basis of which it is possible to view the planning process for the activation and urbanization of the Bačka Palanka riverbank. The synthesis of the mentioned results represents a contribution to the concept of arranging the main natural and spatial potential for the development of the settlement of Bačka Palanka.

2. ANALYZE THE EXISTING STATE

The riverbank is connected to the settlement by a collection street. That street leads from the center of Bačka Palanka to the very banks. Its profile has not been adequately resolved. One part of the street is a one-way with no bicycle path, while pedestrian movement has been acceptably resolved on the sidewalk along its length. At the very entrance to the banks area, at the sports hall, there is a large parking lot. Further in within the territory of the riverbank, there is no adequately resolved parking, so that the visitors park on green areas.

Public content includes a sports hall, an Olympic-size pool, water sports facilities with a restaurant and a čarda. In terms of illegal facilities, there are only three unfinished buildings without a purpose. There are no illegal individual housing developments. The aforementioned facilities are not sufficient in terms of adequate use of the banks by residents of Bačka Palanka. In terms of infrastructure, street furniture and landscaping, the space is completely inadequate.

There are three beaches. One beach is located on the Danube, while two beaches are located on Lake Tikvara. For many years, Lake Tikvara has been the center of kayaking in Serbia, with notable results achieved by athletes competing at global competitions The Lake is also a habitat for a great number of different species of birds.

The whole riverbank area is a third-category nature park. It is under state protection.

3. ANALYSIS OF SPATIAL PLANS

One of the higher-rank plans covering the observed area is the Spatial Plan for the Special Purpose Area of the International Waterway E80 Danube (Pan-European Corridor 7) [1]. It is an extremely broad-encompassing plan that addresses about

588 km of the course of the river. It encompasses the entire course of Danube's flow through the Republic of Serbia. This plan has taken note of the protected natural value of riverbank land running through Nature Park Tikvara. It has also recorded the natural values of the area.
The next plan of significance is the Spatial Plan for the Municipality of Bačka Palanka [2] (figure 1.). This plan foresees the construction of a marina and a passenger bay on the banks of the settlement itself.

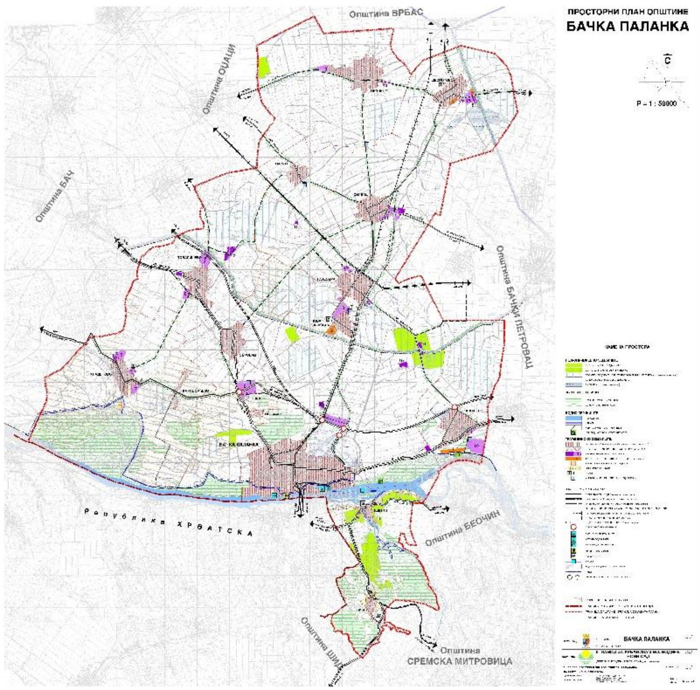

Figure 1. Graphic representation of the Bačka Palanka Municipality Plan

Both are designed to be built along Danube's course and have no physical contact with Lake Tikvara, in the spatial sense. What is not related to the activation of the riverbank area, along the settlement itself, but is planned downstream within the municipality of Novi Sad, is an international port with an intermodal terminal. It is meant to be an industrial zone with terminals for reloading goods and railway lines. Moorings have been foreseen further down, next to the Danube, at the Neštin settlement. In total, this plan foresees four categories for the entire municipality of Bačka Palanka: passenger docks and marinas within the protected part of the Bačka Palanka riverbank (analyzed area), international port and mooring (riverbank for the entire municipality).

At the level of spatial plans, the traffic connection between the center of the settlement and the riverbank itself, as well as the content along the Danube River were not analyzed. Detailed planning for riverbank landscaping was performed in urban plans for Bačka Palanka.

4. URBAN PLANNING ANALYSIS

The next level of planning, addressing the activation of the riverbank, is the General Regulation Plan for the Bačka Palanka settlement [3]. This plan further elaborates on the content to be found on the settlement's riverbank. In addition to existing content, these are: catering facilities, hotels, accommodation facilities, open sports fields. In this plan, the position of the passenger docks and the marina have been specified in greater detail.

The plan does not adequately address the traffic connection between the riverbank and the settlement. The existing collection road, with the existing roads and sidewalks in the existing cross-section, have been retained. No solution for bicycle traffic has been foreseen. The problem of stationary traffic within the riverbank has also not been resolved.

In terms of water traffic, the dimensions of the marina are approximate. Regarding the port for passenger traffic, only the location has been defined.

The remaining, most detailed planning level for the analyzed riverbank area, is the Detailed Regulation Plan for the Bačka Palanka Riverbank [4] (figure 2.). It expands on the sports content. In relation to the General Regulation Plan, this plan defines the regatta path and the ancillary sports facilities (picture 2). It also foresees new catering facilities.

Figure 2. Detailed Regulation Plan for the Bačka Palanka Riverbank

The conditions for environmental protection are in both the General as well as the Detailed Regulation Plans and have been prescribed by the Provincial Institute for Nature Protection. Primarily, the boundaries of protected natural goods of the III category have been defined, Nature Park Tikvara, and protection requirements.

"Within the area of Nature Park Tikvara, what is being limited is:

- change of land use for the needs of revitalizing natural habitats and improving the state of the area;

- arrangement of bathing areas, to the area determined by planning documents;

- construction of hotel facilities, for those that fulfill one of the valid quality certificates from the field of environmental protection, as well as other facilities that are in the function of preserving, protecting and promoting natural goods." [5]

The localities with a stricter degree of protection, II, are defined These are micro-localities with rare vegetation, trees that should be preserved as monuments of nature of importance. The same plan provides the conditions under which it will be possible to build the planned sports and catering facilities, so as not to endanger the existing natural value.

Surveys of the needs and opinions of the inhabitants, regarding the arrangement of the riverbank, were not performed during the preparation of the aforementioned plans.

5. CONCLUSION

The advantage of a landscaped Bačka Palanka riverbank is reflected in the fact that all lots are owned by the city, so that the arrangement of traffic, green and free spaces, as well as the construction of facilities and infrastructure, will not be a problem.

The greatest value of the analyzed plans is the introduction of new content: ports, marinas, catering facilities and regatta paths. These facilities should enable the activation of tourism, cultural events and service activities for domestic and foreign tourists. It should also enable better use of natural potentials and sports and recreational facilities by the residents of Bačka Palanka. The positive side of riverbank activation is also reflected in providing improved conditions conducive to the development of kayaking, through a new sports infrastructure. Another positive aspect is its contribution to environmental protection through the acceptance of all conditions prescribed by the provincial institute. None of these conditions are in conflict with planning solutions for the riverbank infrastructure.

The traffic issue has been resolved in an unsatisfactory way. This concerns inadequate access, for all traffic, from the city center to the riverbank and inadequate parking within the riverbank complex. Since adequate traffic access is the basis for the functioning, and a condition for tourism development, this issue must be subsequently addressed. Since the purpose of the riverbank has been primarily conceived as sports-recreational and tourist, for a fully functional connection between the riverbank and the settlement, it would be useful to introduce a trim track in addition to roads, bicycle paths and sidewalks of appropriate width. It could extend from the settlement to the sports complex and the riverbank terrain making a circular form around these contents, or around the lake. The bicycle path could also receive a circular form which would, in addition to accessibility, also increase the quality of recreational and sports activities. The trim track, together with the bicycle path, could extend further along the riverbank along the Danube River, within the municipality. The boardwalk along the Danube needs to be adequately landscaped.

Considering that the riverbank is becoming a kind of "gate" for Bačka Palanka, in terms of access from the Danube waterway, in addition to preserving its natural authenticity, we should also work on the representativeness and functionality of this stretch. Functionality implies the introduction of services and content which marina guests and tourists docking at the port consider necessary for a longer or shorter stay.

A survey of the needs and opinions of the inhabitants, regarding the regulation of the riverbank, should be carried out while finalizing the Detailed Regulation Plan for the riverbank. This is necessary in order for a specific space to come to life, to fully fulfill its function, to have all the elements and contents necessary for the majority of the inhabitants of Bačka Palanka, for the space to become an element of identity and identification of its inhabitants. It would be useful to obtain information on the opinions and experiences of users of other marinas and passenger ports along the Danube in the Republic of Serbia.

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REFERENCES

[1] Spatial Plan for the Special Purpose Area of the International Waterway E 80, the Danube Pan-European corridor 7, Official Gazette of the Republic of Serbia, No. 14/2015-96.

[2] Spatial Plan for the Municipality of Bačka Palanka, Official Journal of the Bačka Palanka Municipality, No. 20/2012.

[3] General Regulation Plan for the Bačka Palanka Municipality, Official Journal of the Bačka Palanka Municipality, No. 12/2020.

[4] Detailed Regulation Plan for the Bačka Palanka Riverbank, Official Journal of the Bačka Palanka Municipality, No. 12/2018.

[5] Detailed Regulation Plan for the Bačka Palanka Riverbank, Official Journal of the Bačka Palanka Municipality, No. 12/2018.

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AN INVESTIGATION OF GENDER TRANSPORT POVERTY AMONG YOUNG MIDDLE-CLASS WOMEN IN KARACHI

Key Words
Gender
Mobility
Transport-poverty
Experiences

Abstract

Although Karachi is an economic hub of Pakistan it lacks a systematised public transport system. The poor quality of service leads to widespread transport poverty. This is worse for women as it sits alongside cultural and social practices which restrict women's agency and personal mobility. owing to the prevalent local patriarchal attitudes. Little research has been conducted on how the deprivation of agency contributes to greater gender disparities in transport provision and leads to gender transport poverty.

The aim of this paper is to study the different aspects of transport poverty on women in Karachi, taking it as a representative lower-middle-income city (LMIC) in the global South, and to assess the impact of transport poverty on women's opportunities. A mixed methods approach – surveys, interviews and focus groups, autoethnography – was used to gain phenomenological insights into the everyday experiences of women while using public transport. The results show that gender transport poverty is manifest at all stages of the journey lifecycle and severely curtails women's participation, in the labour force and life of Pakistan. The paper presents the results and a multifaceted study to understand gender transport poverty.

1. INTRODUCTION

Equal access to mobility provides access to opportunities and the benefits of living in the cities. Forwomen, religious, social, and cultural norms may curtail their freedom and agency to travel. Such factors operate in addition to the transport poverty experienced by all citizens. In Pakistan, cultural norms and gender discourses prescribe the use of transport services, restricting women's mobility and making them dependent.

Pakistan is consistently ranked as the world's second worst country when it comes to gender equality [1]. In relation to mobility, masculinity is often coded as 'mobile' and femininity as static'. In practice, this means that men have ownership of public spaces, have more freedom to travel to work and for leisure purposes. Women have no agency in decisions about travel. They are expected to remain at home. They are not welcomed on public transport or in public spaces and leisure related journeys are restricted. The paper explores the effects of transport poverty on the lives of middle-class young women in Karachi, Pakistan, who are more educated and aspirational, yet at the same time are aware of their position in the world

2. THEORETICAL FRAMEWORK

Mobility in Low Middle Income Countries (LMICs) is a wicked problem, systemically linked to many socio-political and cultural problems [2 and 3]. Here, although underinvestment in public transport, transport infrastructure, rapid urbanization and rises in car ownership makes transportation a challenge for everyone, [4] argued that inadequate pedestrian infrastructure and poor transport design create a system hostile to women and commented that 'the nature of the entire transportation system of the city is then not only insensitive to the needs of women but also actively disables accessibility and induces poverty". [3 and 5]'s theoretical framework of transport poverty stressed the intersectional dimensions of transport-related social exclusion. The four conditions which can contribute to transport poverty:

- Mobility poverty; Non-availability of transport appropriate to individual needs.
- Accessibility poverty; The inability of transport to reach destinations that ensure a decent quality of life.
- Transport affordability; not being able to afford the cost of transport.
- Exposure to transport externalities; e.g., pollution, congestion, and accidents

Gender transport poverty [5] acknowledges the disproportionate burdens on women – lower income, multiple roles and socio-cultural mobility restrictions own can have an impact on the wider issues underlying gender transport poverty. Transport-related social exclusion recognizes that mobility is socially produced and is unevenly distributed along ethnic, class, gender, and religious lines [14]. In this model, transport poverty encompasses not only the lack of physical and financial resources but also the social and spatial deprivations which can influence an individual's mobility. Hence, socioeconomic status, marital status, gender, and age can also contribute to social disadvantage. These factors can lead to reduced mobility and marginalisation of groups [6]. For example, women's mobility may be influenced directly (e.g., through poor bus design) and indirectly through social and cultural norms which deny her agency and freedom to travel. When the public domain is masculinised women are subjected to more harassment [7, 8, 9]. Piecemeal solutions include gender-segregated transport [10, 11] zero tolerance of harassment, gender-aware planning [12] and products increasing attention on the aggressor [13]. It is not clear whether these can be effective without tackling the wider issues of gender inequality.

This paper argues that there is a need to further extend conventional measures of transport poverty to include gender-relevant themes. For this is important to consider why women do not travel and whether this is imposed or chosen [14] or a by-product of poor practices. This necessitates investigating the barriers that exert power on women's independence such as traditional gender roles [15].

Here one should not assume that everyone is free to travel. Freedom of movement is subjective, and gender has a significant role to play in determining one's mobility choices at an everyday level. This requires looking at both micro- and macro-level factors, that affects one's mobility to understand transport poverty on gender lines. For this purpose, the hexagon-spindle model [16] can be useful.

3. METHODS

A qualitative, phenomenological approach was used starting with a quantitative survey followed by qualitative studies. The participants belonged to a variety of professions and locations within Karachi. The mean age for women was 27.7 years and for men (a comparative group) was 25.5 years. Thematic analysis was undertaken of all material, starting with reading transcripts and coding discussion, followed by organizing and classifying the data into categories/ themes.

Table 1. Participant breakdown

Methods	Participants	Duration
Online survey	185 responses from 16-40 years old (94 women and 91 men)	Over 4 months
One-to-one interviews	28 interviews with 21-35-year-olds (18 women and 10 men)	90 minutes
Autoethnography	Researcher	Fieldwork observations in different locations
Focus group discussion	12 participants aged between 21-35 years (6 women and 6 men)	60 minutes in 2 groups.
Expert interviews	10 men:1 woman	30 minutes

4. RESULTS

All the results triangulated well. Taking a whole journey perspective, women's mobility is curtailed in the following ways:

During planning – having to assert their need to travel. Permission may not be granted for travel to work, to health care or recreational outlets), or may be subject to a number of restrictions, e.g., time and mode of transport, or require a male chaperone. Extra money is needed for emergencies as there are no fixed tariffs for on demand transport and women will be charged higher

Walking to the bus stop. Here women are subjected to harassment and criminality as they are not welcomed in the public realm. The pedestrian infrastructure is poorly maintained, with garbage routinely burnt on the roads. Bus stops are not lit, do not provide any information, and waiting makes a woman more vulnerable. There is no internet coverage of bus routes.

In relation to bus travel. Buses are infrequent, do not run to schedule, and operators may change routes, they are usually overcrowded and may not stop to let a woman board or get off the bus safely. There are no train services. Few women drive and they cannot ride motorbikes. The buses are poorly maintained and ventilated. Gender segregation inside gives women a third of the seats, but these are positioned in the worst places. Many women feel trapped in the buses, subjected to the make gaze and assault. Bus journeys are long, women may have to wear full bukhas, they arrive at destinations hot, stressed, and dishevelled. If they travel for work, they may be late and will be ridiculed if they appear to have used public transport. As buses become more infrequent and dangerous after 6pm, they have to arrange careems (on demand transport) or male chaperones to escort them home.

Taking paid employment is seen as a privilege. Permission is needed and certain occupations discouraged, even for educated women. In all cases women have to also manage their household duties. This may add 4 hours extra work each day. Additionally, because of they have to walk/use public transport/ or take careems their commutes are longer, more convoluted, dearer and stressful than their male counterparts.

Therefore, it was possible to summarize these in Figure 1 using the Hexagon - Spindle Model [16]. This enables the results to be mapped on to different sectors of the transport system e.g. organisational, contextual an personal sectors, and also shows the 'places' where problems arose for Karachi's young women.

The expert interviews revealed a deep rooted, meta narrative of lack of respect and concern for women's needs, central to the wicked problem of gender transport poverty and effecting every interaction women have, or are unable to have, with transport. Such factors are depicted in the outer rim of Figure 1. Consideration of such factos is a fundamental importance, because no service or organisation operates within a vacuum, and wier effects, such as people's agency may have a greater bearing on inclusivity than traditional ergonomics issues, such as vehicle design.

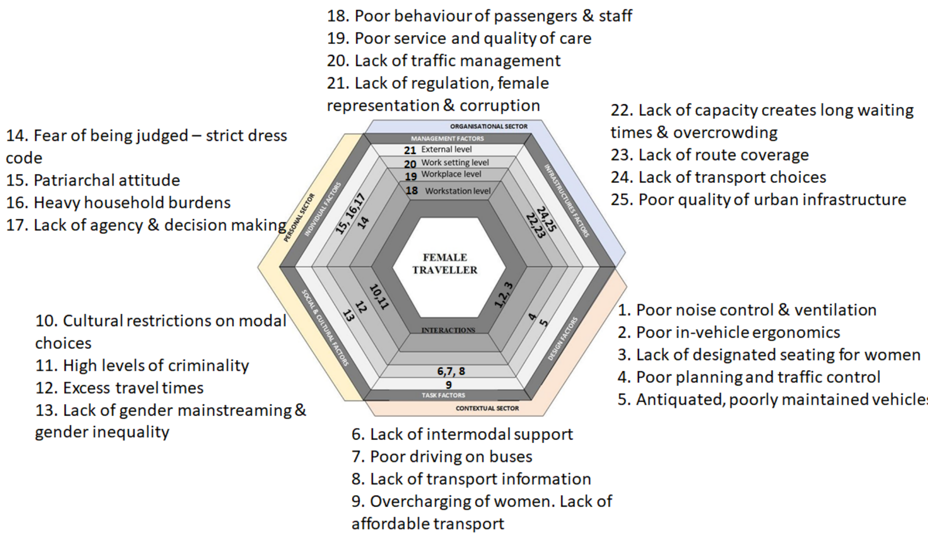

Figure 1. Summary of results mapped on to the Hexagon- Spindle Model

The Hexagon Spindle Model was used because it takes a systematic and holistic perspective of the whole journey and emphasises that if a problem occurs in one part of the journey, his will lead to changes in subsequent journeys. This was clearly shown in the narratives where women speak of having to use more expensive forms of transport (careems) for reasons such as avoiding long wait times at bus stops where they are subject to harassment, to escape overcrowding on buses/ not being able to get a seat, to arrive on time, or to travel when they like in safety. This is shown schematically in Figure 2 [17].

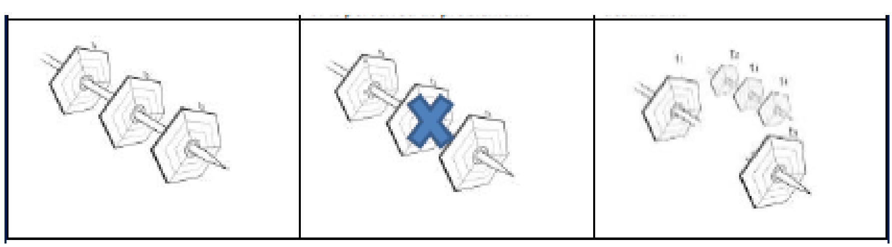

Figure 2. Consequences of problems for journey changes

Here, 3 journey stages are schematically depicted, a problem in one of the layers of the hexagon (Figure 1) in any part of the journey, will result in changes to travel patterns which are lengthier and more inconvenient. Mapping results onto the model helps to identify where policy, guidelines and recommendations could be introduced at a number of levels to address gender transport poverty. The following section provides examples of this.

5. RECOMMENDATIONS TO ADDRESS GENDER TRANSPORT POVERTY

The wide ranging guidelines produced by [18] have been designed to effect all areas of the transport system at different levels and requiring different levels of resources, which makes them achievable in small incremental steps. For example,

At a macro level issue. 2 areas may be addressed by policy and regulation. Firstly, gender equality with a recognition of women's rights to safety and employment; Secondly, enforcing and strengthening existing rules and regulations to make bus operators more accountable (e.g., for tariffs, routes, vehicle maintenance and training). The lack of an urban mobility plan means that public transport provision is unable to reduce social disadvantage or transport poverty.

At an organisational level, gender mainstreaming plans or gender action plans could be used to integrate women into employment, decision making bodies, or consultation processes.

At infrastructure level investment is needed in the pedestrian infracture, IT connectivity development of roads and addition of rapid train services. This requires a master plan, investment, and central coordination (expert interviews revealed such unclear division of roles and lack of accountability in transport departments).

At an operational level, transport operators remain largely unaccountable once they have their licence. Interviews revealed little driver training or vehicle maintenance, high-level of corruption to escape fines and win routes. Prevalent attitudes were that women should not work/be in the public realm, therefore only rudimentary/worse seating was provided for women, no attempts were made to safeguard their safety either on the bus, at bus stops or when getting on/off the buses.

In terms of vehicle design, fleets were old, poorly maintained, polluting, and ventilated. Few checks were made on their roadworthiness, and there was no restriction on how many people could travel in or on top of vehicles. In all cases women were disadvantaged because of their anthropometry and clothing, leading to discomfort and safety hazards. Private operators' priority was to pay off initial costs, not maintain the vehicles. Regulations and restrictions on type of vehicles entering the county, their maintenance and design could enable less polluting more inclusive and modern vehicles (e.g., with lower steps, ventilation, grab rails and better seat allocation, cc-tv cameras.

REFERENCES

[1] World Economic Forum. The Global Gender Gap Report, [online] Available from:http://www3.weforum.org/docs/GGGR16/WEF_Global_Gender_Gap_Report_2016.pdf, 2016.

[2] H.W.J. Rittel, and M. M Webber, "Dilemmas in a General Theory of Planning," Policy Sciences, vol. 4, 155–169, 1973.

[3] K. Lucas, G. Mattioli, E. Verlinghieri and A. Guzman "Transport Poverty and its Adverse Social Consequences". Proceedings of the Institution of Civil Engineers - Transport 169, vol. 6, 353-365, 2016.

[4] A. Anand, and G. Tiwari. "A Gendered Perspective of the Shelter-Transport-Livelihood Link: The Case of Poor Women in Delhi". Transport Reviews, Vol. 26, No. 1, 63–80, 2006.

[5] K. Lucas, "Transport and social exclusion: where are we now?" Transport Policy, vol. 20, 105–113, 2012.

[6] K. Lucas and T.P.Uteng, "Urban Mobilities in the Global South" Routledge: London, 2018.

[7] D.M. Thompson "The woman in the street: Reclaiming the public space from sexual harassment," Yale Journal of Law and Feminism, Vol. 6, 313–348, 1994.

[8] J. Osmond, and A. Woodcock, "Are our streets safe enough for female users? How everyday harassment affects mobility" International Conference on Ergonomics & Human Factors, Daventry, UK, 2015.

[9] M. Madan and M.K. Nalia, "Sexual harassment in public spaces: Examining gender Differences in perceived seriousness and victimization," International Criminal Justice Review, vol. 26, 2, 80-97, 2016.

[10] A. Dunckel Graglia, "Finding Mobility: Women Negotiating Fear and Violence in Mexico City's Public Transit System." Gender, Place & Culture, vol. 23, 5, 624–40, 2016.

[11] E.D. McLeod, " Pink Public Transport: A Necessary Evil?" Senior Projects, 188, Spring 2018.

[12] C.Rakodi, "Cities and people; towards a gender-aware urban planning process". Public Administration Development, vol.11, 6, 541-559, 1999.

[13] H. Saul, "The badge designed to tackle sexual harassment on public transport" Retrieved from https://inews.co.uk/news/badge-designed-tackle-sexual-harassment-public-transport/.2017

[14] L. Song, M. Kirschen and J. Taylor, "Women on Wheels: Gender and Cycling in Solo, Indonesia." Journal of Tropical Geography, vol. 40, 1, 140-15, 2019

[15] P.Hoodbhoy, "Women on motorbikes-What the problem?" The Express Tribune, [Online] 23 February. Available from: https://tribune.com.pk/story/511107/women-on-motorbikes-whats-the-problem/, 2013.

[16] A.Woodcock and M.Tovey, "Designing whole journey, multimodal transport provision," The Design Journal, vo.23,1, 91-112, 2020.

[17] A.Woodcock, "The contribution of ergonomics to the design of more inclusive transport services," Towards a Humane City Conference, Novi Sad, 2015.

[18] S. Iqbal, “What makes women in Karachi transport poor,” unpublished phD Dissertation, Coventry University, 2021.

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ADDRESSING THE DEVELOPMENT OF A HUMANE TRANSPORT SYSTEM BY RECOGNISING THE NEED FOR EQUALITY IN TRANSPORT ORGANISATIONS

Key Words
Gender
Employment
Transport

Abstract

Gender equality is a fundamental principle in the European Union and an essential prerequisite for economic growth, competitiveness, and sustainable development. Women account for 22% of transport workers, making this one of the most gender segregated sectors in European economy, with most found in support and administrative capacities.

A Pan European survey was conducted as part of the H2020 TInnGO project (https://www.tinngo.eu/) to investigate the experiences of female entrepreneurs and successful career women in different parts of the Transport Business Ecosystem (TBE) in 10 socially and economically divergent national contexts (United Kingdom, Germany, France, Sweden, Italy, Spain, Romania, Portugal, Latvia, Greece). In total, 61 interviews were conducted along with 14 follow up interviews which provided insights into their career paths, the barriers, enablers and qualities which had led to their business success.

Although the results showed some variation between countries, persistent themes emerged relevant to women’s underrepresentation in transport. Key factors which contribute to underrepresentation included misogynistic attitudes, male dominated hierarchies, recruitment bias, reluctance to acknowledge a woman's role and contributions, gender pay gap, male- dominated professional networks, the gender 'glass ceiling'.

All women cite the extra effort necessary to prove their value and abilities. Through their fortitude and determination, and national frameworks for encouraging women into STEM careers, mentorships schemes and networks. The gender gap is slowly reducing. The recommendations show how a sustainable paradigm shift in gender and diversity mainstreaming in transport.

1. INTRODUCTION

This study was conducted as part of the 'Transport Innovation Gender Observatory - TInnGO' project (https://www.tinngo.eu/), funded under the EU Framework Programme for Research and Innovation, Horizon 2020. The overall objective of TInnGO is to promote gender equality within the Transport Business Ecosystem (TBE), creating innovative know-how and strategic mechanisms for a sustainable change in the European transport sector, making use of the transformative strategy of gender - and diversity - smart mobility. The pan-European TInnGO Observatory is an information platform for innovation in the field of gender smart transport, providing a nexus for data collection, analysis, dissemination of gender mainstreaming tools and open innovation. To achieve this, 10 hubs were set up as part of the project in. United Kingdom, Germany, France, Scandinavia and Baltic region, Italy, Spain, Romania, Portugal and Greece. Their main objective is to extract and collect knowledge in mobility, gender and diversity from local and national sources, and deliver it to the TInnGO Observatory.

At a European Union level, gender equality is progressing slowly, but with marked disparities in key domains and among member states [1]. For example, women only form approximately 22% of transport workers [2] globally. The gender employment gap in the EU in 2019 was 11,7% with 67,3 % of women being employed compared to 79% of men (EU27 data); the gender pay gap in the EU stands at 14,1%. [3]; although women account for 52% out of the overall number of the European population, and yet only 34,4% of the EU self-employed and 30% of start-up entrepreneurs [4].

The transport sector is still one of the most gender - segregated in terms of both labour and the incorporated gender culture and roles. Hard working conditions, traditional gender stereotypes and prejudices, problems reconciling family- and professional life, as well as safety and security issues have been acknowledged as the main causes of women's underrepresentation in the sector. Whist receiving less pay, women in the sector have to work harder against a background of harassment and discriminatin to make their careers [5].

The TInnGO project aimed to provide a more nuanced understanding of labour market participation by providing a general and comparative picture of female entrepreneurship and of successful career women working in the TBE, across 10 EU countries using interviews and case studies. The aims of the study were:

1. To provide a comparative study of the situation of female entrepreneurs and successful women in the transport and mobility sector in partner countries in Europe.
2. To promote role models of successful business and career women in the transport and mobility sector, by showcasing motivational and inspirational portraits, thus providing arguments for women to embrace a career or invest in this domain (available on: www.tinngo.eu).
3. To explore the main challenges to women's success and factors which have contributed to their success.
4. To highlight proposals and recommendations made by women to encourage gender mainstreaming, and foster female entrepreneurship in the sector.

2. METHODS

A mixed method approach was followed in this mainly phenomenological exploration of senior women's experiences in the transport sector. The study was preceded by desktop surveys undertaken by each national hub to understand gender inequalities in employment in general, and transport and entrepreneurship in particular. Female participants were recruited purposely, based on recommendations, desktop research, and existing networks. Inclusion criteria were level of seniority and experience in the Transport Business Ecosystem (including planning, operations, design, manufacture and education) either through holding senior posts or running their own business.

The study was ethically approved by Coventry University, as Lead Partner of TInnGO with the operationalization of data gathering left to each hub, depending on the type, number and availability of participants. Semi-structured interviews or focus groups were held in native languages, results translated and compiled by each hub in a standardized manner and reports sent to INTECO for consolidation and analysis. Additionally, more in depth, phenomenological 'conversations with purpose' were held with 14 participants (1 or 2 from each hub, representing different career pathways and transport domains) to create 'motivational portraits'. These have been promoted on the TInnGO website to inspire women to enter the profession.

In such a way, each hub - Lithuania, UK, Spain, France, Italy, Greece, Romania, Germany, Scandinavia and Portugal - acted as a case study providing:

1. A description of the situation with respect to the national entrepreneurial environment, with a focus on women entrepreneurship in transport and mobility and women's presence in the transport- related employment.
2. Phenomenological accounts of the difficulties, gender barriers and challenges faced by working in the transport industry, key factors that have

contributed to their success in business and career, proposals for better gender mainstreaming and women entrepreneurship.

3. A ’motivational portrait‘ of 1 or 2 ‘remarkable women’ from the TBE who were either entrepreneurs or successful in a TBE organisation.

3. RESULTS

The results provide a phenomenological account of women’s work experiences in the transport sector in 10 European counties. They highlight systemic discrimination and belittlement of women in the transport sector. This goes partway to explaining why women’s participation in the sector remains consistently low. The EU average is 22%, in the countries participating in TInnGO, employment rates varied from around 26% in France and Latvia down to 16% in Greece and 14% in Romania[2].

The results showed that throughout their careers, women in all areas of the Transport Business Ecosystem have been faced with institutional, psychological and personal barriers and have had to fight to demonstrate their competence on a daily basis. The most frequently mentioned issues include:

- Prejudices, skeptical and depreciative attitude, misogynist language and behaviour from men colleagues, partners, clients, suppliers etc (particularly at the beginning of their activity);
- Gender discrimination at hiring, and in the job and in terms of career progress, women need to work harder to prove their value and skills. They are faced with the double standards in evaluation when compared to men. Unofficial limitations of professional progress (the so called 'glass ceiling');
- Internal bureaucracies related to maternity leave, motherhood and parenthood status, which slowed down / hindered their career progress. These affected personal perception related to the organizational environment and, in some cases, women moved jobs to escape this;
- The prevailingly male working environment, particularly at the beginning of work or when working on new task/with new partners was intimidating and non-welcoming;
- Reconciliating professional- and family life. The nature of some work in the transport sector is not family friendly. As the main carers in most families, women have to harmonise work- and family- related tasks can be an extra difficulty.

Although some felt that difficulties may not have been solely gender related, when starting talking about personal experiences, they refer to gender discrimination episodes, and provide concrete examples in this respect. For example a Swedish participant commentd: *“In my professional life, I have experienced that I have not been listened to, even if you have good ideas, it feels like you are not being heard in*

[2] https://ec.europa.eu/transport/facts-fundings/scoreboard/compare/people/women-public-transport_en

the same way as if a man makes the proposal." One from Spain, revealed that in her previous company in the marine sector, men would be shortlisted for interview over equally capable women. A participant from Italy remembers that in one company she worked with, women were addressed as ''Miss'', while men were addressed as ''Engineer'', even if they had the same role. A UK participant claimed she felt like she had entered a *"boys club"* and had left because of that.

Participants pointed out that this permeates the whole transport sector, and their whole career – from academic studies and / or training, to employment, promotion and management positions. For example, at university, women still form a significantly smaller percentage of students on STEM courses, so become used to being in a male dominated environment and having to work harder for the same level of recognition. From an intersectional perspective, gender stereotypes act in concert with other forms of discrimination such as age and racial discrimination.

In such a hostile environment woman must constantly prove themselves work harder, have better performance to be ranked at the same level as her male counterparts and overcome pointless barriers. This effects their self-esteem, confidence, and perceptions of peers of their abilities and capabilities. Several respondents said you need to have *"skin on your nose"* (i.e. a thick skin) when working in a male dominant workplace. Across all hubs, respondents commented on gender-based differences in competence assessment. A UK participant declared: *'I feel I have to work harder, to be tougher and more categorical, just as required in order to fit in the environment.'* In the opinion of a French entrepreneur, the most difficult thing was to `impose oneself, particularly for young women'.

Some women commented that the biggest challenges they were faced came from the external environment (i.e. not their own organisation). The levels of discrimination faced during their early careers led to a build-up of frustration and discontent, and in some cases, to leaving the company.

4. INCREASING WORKPLACE DIVESITY IN THE TRANSPORT SECTOR

It has been established across many inductriues that a diverse workforce leads to better profitability, satisfaction, creativity and empathic or tacit understanding of the market, users, or consumers. It may be assumed that the TBE would also derive such benefits if there was greater diversity. This is important because transport systems and vehicles are still largely designed by men for men, with little acknowledgement that the main users may be women, or people unlike themselves, who have different mobility needs. A humane, and inclusive city needs to be designed and perated by people who represent all sectors of society. This section provides a set of actions needed to increase gender equality and diversity across the transport sector, thereby ensuring that future transport is fit for purpose.

Gender mainstreaming through:

- Surveys to understand the lived experience of employess leading to the development of measureable and actionable Key Performance Indicators.

- Ensure equal pay measures and legislation to fill the pay gap and equal family benefits to address the discrimination and barriers linked to motherhood.
- Increase representation of women in boards and senior management.
- Develop further training opportunities to support and motivate employees to progress in their career and develop this sector.
- Provide coaching, mentorship and networking opportunities for female staff.
- Ensure all managers are trained in diversity and equality issues and can apply these to everyday situations to breakdown ‘macho’ culture and promote fairness in staff progression and opportunities.
- Provide opportunities for young people to experience careers in transport.
- Promote dedicated projects and decide economic and fiscal advantages for those who are oriented (companies and public and private associations) towards gender equality (in a concrete and measured way).
- Ensure that marketing, recruitment and human resource functions have gender and diversity sensitive policies and practices e.g. look at the images/language used in corporate/advertising material, look at when and how recruitment takes place, use gender blind applications, ensure equality in staff appraisals.

Policy recommendations:

- Gender equality must be set as an EU political priority, e.g gender pay gap, equality in maternity/paternity leave, recognition of need for flexible working to reduce dual burden of women.
- EU policies should focus on cultivating a gender balanced and inclusive mentality in educational institutions that prepare young women for their careers with further training in order to attract young ladies into STEM.
- Open datasets about female presence in the transport sector, establish innovative activities (e.g. hackathons, challenges) to highlight problems and motivate entrepreneurship and innovation in this field.
- Dedicated projects and experiments on at European level on "Gender Balance Smart Mobility" to address the "Gender Mobility Divide" with measurable and progressive objectives.
- Promoting entrepreneurship culture development in society within the national education systems and the support mechanisms in order to form and develop entrepreneur abilities and capacities, respectively, in school as well as throughout life.
- Higher education institutions must support students through specialized resources able to allow for practice in entrepreneurship.
- EU task force to create a level playing field with regard to gender and diversity e.g. ring fenced money and programmes for women entrepreneurs and SMEs: funding proposals should include a stated and measurable requirement to

provide gender and intersectional data; and include and deliver a gender and diversity impact and evaluation plan.

5. CONCLUSION

This phenomenological study has shown that across Europe, the transport sector remains unwelcoming to women. This is repeatedly demonstrated through accounts of misogynistic attitudes, male dominated hierarchies and networks, gender biases in recruitment, promotion and renumeration, reluctance to acknowledge a female employee's strengths, contributions and value.

If women and those from other diverse groups are not part of the workforce the development of transport will remain skewed in outlook and innovation, as there is little empathy or understanding of the needs of transport users.

Despite work related challenges, the professional women interviewed in this study remained committed and excited by their careers in transport. As transport becomes more mobility focussed and linked to sustainability and quality of life issues it is becoming more forward looking, broader in scope and appeal and offers many exciting new career paths. The transport sector needs to modernize to serve the needs of its employess and the citizens it serves.

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REFERENCES

[1] European Commission. Report on equality between women and men in the EU.[https://ec.europa.eu/info/sites/info/files/aid_development_cooperation_fundamental_rights/annual_report_ge_2019_en.pdf] 2020.

[2] European Commission. Mobility and Transport. Women in Transport – EU Platform for change, 2020.

[3] European Commission. The gender pay gap situation in the EU. [https://ec.europa.eu/info/policies/justice-and-fundamental-rights/gender-equality/equal-pay/gender-pay-gap-situation-eu_en] 2021.

[4] WEgate- European Gateway for Women's Entrepreneurship [https://wegate.eu/who-we-are] 2014.

[5] P. Turnbull, "Promoting the employment of women- Obstacles and policy options", Working Paper No. 298. Geneva : ILO , 2013.

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HOW DESIGN CAN SUPPORT GENDER AND DIVERSITY SENSITIVE SMART MOBILITY SOLUTIONS

Key Words
Gender
Design
Smart Mobility

Abstract

From June 2020, design research activities have been conducted as part of the 3 year, H2020, Pan European TInnGO project (https://www.tinngo.eu/) which aimed to create a sustainable paradigm shift in gender and diversity mainstreaming in transport. Such a shift is needed due to the lack of sex disaggregated gender data, gendered use of transport, gender gaps in employment and decision making. This lack of diversity together with difficulties in engaging 'hard to reach groups' in transport planning, means transport services and innovation continue to fail to consider gender and diversity. A central concept of TInnGO is to use design activities as 'provocations' to engage with people in new ways – e.g. through visualizations, vignettes and cocreation activities – to develop greater insights into mobility problems and drive gender and diversity sensitive smart mobility solutions. Signifantly disrupted by the Covid-19 pandemic, this became an on line activity supported by an Open Innovation Platform.

This paper draws on the experience of the TInnGO design team in their creation of over 30 design led provocations to stimulate discussion on how to create more humane cities, which are aesthetically pleasing and inclusive.

1. INTRODUCTION

The aim of this paper is to illustrate, in a Pan European context how design thinking in development of smart mobility concepts can provoke greater awareness of the issues faced by users of transport systems.

Historically, men have dominated engineering and built environment professions. This, together with practices which have prioritized the male compute and journeys in and out of the city, has left modern cities with a legacy of spatial planning which caters for the needs of males, separating work and private spheres, and limiting women`s opportunities to travel easily when fulfilling their roles as carers [1].This has created contemporary problems: cities with outmoded, legacy transport systems which support outdated modes of employment and city usage. It is now recognised that women's jpurneys are not well supported by siuch systems [2], even though they form a higher percentage of public and sustaninable transport users. Women typically combine unpaid care work with a paid job; they make more multimodal short journeys and trip-chain [3] (many small trips during the day: from work to school, from home to retail outlets). In a daily commute women make more trips related to shopping and children's education, which tend to be relatively short, whereas male commutes, tend to be longer [4].

We can therefore conclude that transport systems rarely cater for women`s mobility needs [5]. Cities are car-centric, designed around male models of traveling, in which private forms of motorised travel has dominated. This has been exacerbated by the male dominance of all areas of transport design and engineering, and a bias towards high cost infrastructure projects over more sustainable alternatives. Due to the intersection of socio-economic factors, women (and other diverse groups) form the majority of public and sustainable transport users [6]. They are also the main actors leading a positive change toward sustainable cities. However the use of sustainable transport measures exposes women and those from other disadvantaged groups to gender-based street (and other forms of) harassment [7]. These and other factors contribute to gendered perception of cities and public spaces, and feed into a range of gender inequalities and injustices persisting in urban areas [8], leading to gender transport poverty [9].

2. THE ROLE OF DESIGN

By using an empathic approach [10], the TInnGO project has facilitated co-creative activities to address the gender bias in design of smart mobility products and services; building around users' experience, particularly of excluded or marginalised groups. The application of visual design to present concepts or working ideas is a widely accepted methodology in industry and design education. Using design to induce a response, that can break down barriers to discussion is less common outside of design studios or education. Transport planners and local authorities might place a high emphasis on citizen engagement, but find it difficultespecially with hard to reach groups. As such, views of those groups may not be considered. Breaking this cycle is important if future transport is to be inclusive.

The TInnGO project sought to demonstrate the value of collaborative or participatory design, engaging new and different dialogues centred around the conceptual design of gender and diversity-sensitive smart-mobility. A portfolio of design concepts demonstrates the role of design thinking in a technology and science led sector. As with all new ways of working, or new findings; context is key. And context in the scope of design is paramount to understanding real need; and by virtue of better understanding the reasons, so the greater clarity of a design brief. we facilitated an

Those with experience of exclusion and gender disparity, often struggle to be heard. Through the OIP, we have tried to create new ways to inform design briefs by experience; resulting in gender inclusive, respectful and responsible concepts. In this way we hope to break the barriers of passivity, tokenism and confirmatory feedback of '*hard to reach groups*', whose exclusion merely replicates 'ex'clusivity.

3. THE TINNGO DESIGN CONCEPT AND THE OPEN INNOVATION PLATFORM

The TInnGO co-design model centred around 10 national EU hubs, recruiting and training citizen scientists meeting in local design studios. There they could discuss mobility problems, turn initial ideas into briefs or mind maps which could be transformed into sketches, by designers from the UK hub shared via our Open Innovation Platform (OIP) (https://oip.transportgenderobservatory.eu/) – a web-based gallery and forum. Here, these could be presented back to the group and other interested parties as design provocations to elicit further, deeper insights based on collective mobility experience, progressing an iterative design cycle. The concepts, termed as 'design provocations', are used to 'initiate critical reflection on issues that are often overlooked, obscured or accepted as natural practice' [11].

Our student design team (distributed, due to Covid in Indonesia, Spain, Pakistan, Serbia and India) had to develop empathy/envisage the problems of vulnerable user groups in different European cities based on (a)synchronous communication via MS Teams, Mural and Zoom. Design provocations were uploaded on to the OIP for comment by the wider 'non-design' TInnGO community, using a discussion-board format who mostly have no design background.

4. THE OPEN INNOVATION PLATFORM

The project's Open Innovation Platform (OIP) uses a simple discussion forum, project gallery and feedback mechanism to discuss needs, share experience, feedback on ideas and disseminate general project material providing team-wide accessibility and encouraging contributions from the wider community to expand the knowledge base of the project. The OIP consists of an Ideas Lab, Initiatives, and Discussion was launched in March 2020 and welcomes inputs from different, non-academic audience. It has received over 60,000 views,and 140 contributions with 43.6% from UK, 15% from Italy, around 12% from Germany and France, and 8.6% from Spain (all partner countries) The Ideas Lab and Initiatives are almost equally popular among viewers with 45.7% of all views accounted for former, and 47.9% counted in Initiatives section.

Although interacting with social media forums is now routine, discrimination, aggressive behaviour, 'trolling' and general unpleasant language remain all too familiar. Despite over 60000 interactions we have received no aggression, or trolling despite many topics being sensitive and writing about the need for change. There has been no hyper criticism of shared work, or presentations. We have shown disparity amongst people and produced ideas that try to resolve the problems. This begs the question if why TInnGO design provocations have not faced hosility?

All visitors may offer reflections on design ideas and posts including reference to personal, lived experiences of mobility issues when moving around the city, or comments on designs. This is an essential part of user-centred design and allows a richer understanding of how smart mobility can enable more humane cities.

Engagement tools like the OIP can complement other participatory methods in the transport and mobility planning process by providing another type of dialogue, based around sketches. Whilst dialogue between designers, transport stakeholders and users can be difficult, if not actually tokenistic, design provocations provide opportunities for deeper engagement, understanding and empathy all of which are key to creating more humane and inclusive cities. Table 1 presents examples of design provocations and responses on the OIP.

5. THE OIP AS A POSITIVE ENGAGEMENT TOOL

In terms of TInnGO, design students and tutors work over designs, from a received brief before uploading them and a short commentary on to the OIP, where they may be commented on by any visitors. Our experience over 12 months has been that the

OIP offers a number of benefits over face to face critiques. For example:

Feedback is non-confrontational and intentionally constructive. It is taken on face value, noted and integrated into the idea's narrative.

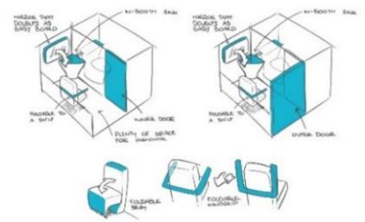
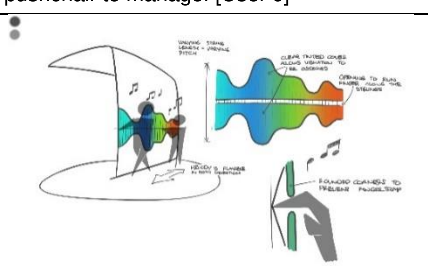
Discussion is asynchronous, allowing viewers time to reflect with others.

The 'provocation' is not the final design. It is a concept based on discussions, allowing the viewer to see the thinking and development stages. We have aimed for an 'understandable image' which can foster feedback about the idea, rather than its limitations, leading to comments such as ' if only it could do this…'.

The OIP's purpose and its designs are to start discussion. We are not asserting facts, or insisting on something changing – so we create a think-tank.

The design briefs and the genial, open manner in which we discuss a wide range of topics, and share experiences, comes very much from the heart; it is human experience and we uncover shared concerns using humour and anecdote. Discussion takes a positive angle, 'how can we make this better?', 'does anyone else know about this?', 'I know, why don't we…', rather than merely criticism.

Table 1. Example of designs and feedback

<table>
<tr><th>Design sketch</th><th>Short explanatory narrative</th></tr>
<tr><td></td><td>PublicToilets
Women spend almost twice as long in toilet than men, and are more likely to use facilities with a dependent child/adult or a person with additional needs.
The concept design addresses the problem of using the toilet by parents/carers’ whilst travelling with dependents who cannot be left unattended, but also need some privacy and a quiet place</td></tr>
<tr><td colspan="2">Feedback
Why can't we have a wash basin in the cubicle ? This should be standard for all toilet cubicles!
Somewhere to leave a bag or a fold down ledge/seat for a small child to wait in the cubicle with us. Bag theft occurs when handbags are left on the floor where there are gaps at the bottom of the door
Positioning of sanitary bins - we need them close but not brushing our thigh! Could they be wall mounted?` [User 8]
Who would have access to this and how? What is the footprint compare to the space available in station</td></tr>
<tr><td>
</td><td>Nurturepod
Inspired by a sketch of 2 acorns and the concept of protection afforded by natural forms, the NurturepodTM is an infant feeding space for displacement locations such as airport lounges. The idea was to provide a special, quiet moment where a parent could nurture/breatsfeed a child away from the gaze of other people, and break away from the medical aesthetic of spaces.</td></tr>
<tr><td colspan="2">Feedback
This looks like an inviting space, and could be made cosy, but thinking back to personal experiences, parents may prefer some more 'raised' seating inside here so that it is easier to get comfortable with a child- getting down almost to the floor is not easy when you have baby, toddler, bags and perhaps a pushchair to manage. [User 9]</td></tr>
<tr><td></td><td>Melodic Bus Stop
For children, anticipating the next bus could feel like an eternity. By attaching strings of varying lengths, children can have something to keep themselves entertained while also learning about how the varying length affects the note of the melody, invoking curiosity and creativity.</td></tr>
<tr><td colspan="2">Feedback
A lovely idea, would appeal to a range of users especially children and older people. Yet if applied say, to the West Midlands region, other issues would need to be considered. E.g.is the bus stop served by electricity points, will there be room for timetable information, safety messages and help points? Could it distract from existing digital advertising and be prone to crime and vandalism? For those customers with hearing impairments, a hearing loop system may need to be applied. Maintence costs and funding should also be considered in any design options. But I feel this concept could work well at interchanges or mobility hub sites, where people may have to change modes. [User 12]</td></tr>
</table>

Anonymity, privacy, security means the OIP is devoid of personal details. Usage is focussed on responses to design provocations, or experiential knowledge that may be difficult to express when face to face, either digitally or when co-located.

6. CONCLUSION

Mobility constitutes complex social activities and thus transport planning requires instruments addressing the knowledge of different actors, social groups, transport modes, technologies, organisations and authorities. New mobility solutions should address the needs of all citizens and respond to global sustainability goals. In order to address existing biases, and support design at a distance during the covid pandemics, we have demonstrated a participatory co-creative platform, which combines design provocation to initiate common action, which will lead to a new dimension of mobility in cities and towns.

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REFERENCES

[1] D. Spain, "Gender and urban space." Annual Review of Sociology, vol. 40, 581-598, 2014.

[2] A.Trujillo and M. Wilson, "Confronting Car Culture and Capitalism as Root Causes of Mobility Injustice1." Routledge Handbook of Radical Politics, vol. 3, 2019.

[3] X-S. Lu, T-L Liu, and H-J Huang. "Pricing and mode choice based on nested logit model with trip-chain costs." Transport Policy, vol. 44 76-88, 2015.

[4] National Travel Survey, https://www.gov.uk/government/statistics/national-travel-survey-2019, 2019.

[5] M. Bakran, “Travelling safely: the EU perspective in ITF, Women’s Safety and Security: A public transport priority,” International Transport Forum, Paris, France, 2018.

[6] M. Polk, “Are women potentially more accommodating than men to a sustainable transportation system in Sweden?” Transportation Research Part D, vol. 8, 75–95, 2003.

[7] J. Osmond and A. Woodcock. "Are our streets safe enough for female users? How everyday harassment affects mobility." Proceedings of the international conference on ergonomics & human factors. Taylor & Francis, London. 2015.

[8] S. Chant, "Cities through a “gender lens”: a golden “urban age” for women in the global South?" Environment and urbanization, vol. 25, 1, 9-29, 2013.

[9] K. Lucas et al. "Transport poverty and its adverse social consequences. " Proceedings of the Institution of Civil Engineers-Transport, vol. 169, 6, 2016.

[10] A. Woodcock, D. McDonagh, P.Magee and S. Iqbal, “Expanding horizons: engaging students with empathic thinking,” EPDE2019, UK, 2019

[11] P. Magee, A. Woodcock, K. Gut and J.Saunders, “In pursuit of meaningful insight: Covid remote collaboration and design as provocation,” EPDE2021, Herning, Denmark, 2021

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SELF-EFFICACY AND JOB SATISFACTION DURING ORGANIZATIONAL CHANGE – THE GENDER DIFFERENCE

Key Words
Self-efficacy
Job satisfaction
Organisational change
Transport departments
Gender

Abstract

This study contributes to our understanding on gender when it comes to perceived levels of self-efficacy and job satisfaction that are decisive to drive an organisational change within local authorities’ transport departments successfully. Data was gathered from 71 individuals working in the transport or mobile departments of seven local authorities participating in the H2020 CIVITAS SUITS and TINNGO projects, from 6 different countries, Greece, Spain, Italy, Romania, United Kingdom and Lithuania. Our results show that women require higher levels of self-efficacy during change to perceive the same levels of job satisfaction as men. This result leads to clear managerial implications for the management of change within organizations to be able to implement change successfully.

1. INTRODUCTION

In recent years, mobility planning has emerged as one of the key topics for local authorities [e.g. 1, 2]. In particular local authorities’ mobility or transport departments have been challenged by a variety of political and societal changes regarding future sustainable mobility planning. The mobility field has becoming increasingly complex with new partners entering the market, offering new products and services.

Additionally societies' requirements towards a sustainable and liveable future have also become a decisive challenge for future mobility planning [e.g. 3; 4]. Scholars [2] demonstrate clearly that citizens favour sustainable thinking, prefer resource efficient travelling and wider accessibility and inclusivity nowadays. Accordingly, many local authorities, especially in small to medium cities are facing challenging situations, affecting and disrupting their business model and their institutional logic. This threatens public sector employees in a number of substantive ways [5]. The changes require new organizational structures and processes within the local authority and challenge their employees with new ways of working, including techniques and tools they have not used before. Further, new roles and responsibilities are needed [especially if a city commits to producing a SUMP], which may make former routines obsolete and require increased flexibility and motivation [6, 7]. Thus, organizational change can be viewed as a critical event, which has the potential to evoke stress and other negative consequences in employees. Since organizational change by its very nature is non-linear, the most frequent psychological state resulting from organizational change is uncertainty [e.g. 8, 9, 10, 11]. Indeed, employees are likely to experience uncertainty over many different facets of a changing work environment.

One of the most cited reasons for change failure is resistance and a lack of support from employees [12, 13]. Research indicates negative consequences of employee resistance towards change such as decreased employee morale, psychological wellbeing, satisfaction, and productivity, and increased turnover, absenteeism, and theft [14, 15, 16, 17]. Due to the pivotal role of employees in the implementation of change projects, many scholars are calling for a shift towards a more person-centred focus in the analysis of change [18]. Based on the idea of demography theory [19], we want to extend our knowledge about this person-centred perspective by investigating gender as key factor that may affect employees' perceived job satisfaction during organisational change. Demography Theory is defined as "an important, causal variable that affects a number of intervening variables and processes, and through them, a number of organizational outcomes" [19], such as gender.

When studying gender, past research often used a minority perspective. By and large, research findings have shown that being a minority is especially disadvantageous for women, having a negative impact on their job attitudes, self-efficacy or self-image [20, 21, 22, 23]. As our study is focused on the experiences of employees in nine local authorities in the mobility or transport field, that are undergoing organisational changes. Transport is a fundamental sector in the European economy but also one of the most gender - segregated in terms of both labour occupancy and the incorporated gender culture and roles. Beside traditional gender stereotypes and prejudices, problems reconciling family- and professional life, as well as safety and security, the literature highlights that women must often perform better than men in a male-dominated working environment to be accepted within the workplace- all reasons for women's underrepresentation in this sector [24].

Data was gathered during intensive cooperation with the local authorities of six European cities and their wider stakeholders in the H2020 CIVITAS SUITS project.

Supporting Urban Integrated Transport Systems [SUITS] was a four-year research and development project, aiming to increasing the capacity of small to medium cities to plan and implement sustainable mobility measures. The project addresses the comprehensive organisational changes within the organisations in the transport sector which require new work processes, with new partners, regulations, new modes of transport and notably, and innovative technologies [see www.suits-project.eu].

Thus, with this study, we aim to add to the existing change and gender research base by using both the general gender literature and research on minority groups to look at the differences in the perception of self-efficacy and job satisfaction. More specifically, we investigate whether the influence of a perceived level of self-efficacy on job satisfaction is moderated by gender during organisational change.

2. THEORETICAL BACKGROUND

2.1. Self-efficacy and job satisfaction during organizational change

The general idea of efficacy has been measured differently across disciplines and ranges from mastery, or personal control [25], to self-efficacy [26], to self-directedness [Kohn and Schooler 1983]. Despite this ongoing interest in human agency, self-efficacy seems underutilized as a theoretical concept. According to the theory of social learning [28], self-efficacy refers to an individual's belief in his or her capability to execute a course of action needed to meet the demands of a particular situation. Thus, in the context of organizational change, change-related self-efficacy can be defined as an employee's perceived ability to function well on the job, despite the demands of a changing work environment [e.g. 1, 27]. Employees who doubt their ability to respond to the demands of a specific organizational change event are likely to focus attention on their feelings of incompetence, which will be accompanied by feelings of psychological distress, and a failure to deal with the situation [28]. In contrast, employees who have high levels of change-related efficacy are unlikely to be distressed by feelings of inadequacy and, for this reason, are expected to persist in their efforts to manage the organizational change process.

Job satisfaction has been one of the most common and most investigated concepts and is described as the degree to which an individual has positive and negative feelings about a job, other workers and work environment [29], thus in our study primarily related to positive or negative feelings towards the organisational change. Job satisfaction is prevalently known as an internal reaction against the work conditions [30]. The internal reaction is emotional and attitudinal response [29].

2.2. The role of gender regarding self-efficacy and job satisfaction

Research suggests that gender is strongly related to higher self-efficacy levels found for males compared to females [26, 58]. Additionally, social cognitive theory suggests that gender is mainly driven by a variety of social influences that are associated with a particular gender such as male, female or diverse [31]. Thus, scholars suggest that girls are less likely to develop a positive sense of their mathematical abilities as a result of their parents overestimating the difficulties they will experience in such endeavours [e.g. 72]. In turn, parents' beliefs about their children's abilities their children's interest and self-efficacy in science [32]. Further, research has found associations between the stereotypical male characteristic of instrumentality and greater social self-efficacy and, indirectly, to higher levels of perceived job satisfaction [58].

3. HYPOTHESES

3.1. The positive influence of self- efficacy on job satisfaction during organisational change

Literature has already shown that self-efficacy is consistently associated with job satisfaction [33, 34]. Self-efficacy affects job satisfaction mainly through its association with practical success on the job which is mandatory for a successful implementation of organisational change that is comprising technical and behavioural changes [33]. In fact, people high in self-efficacy deal more effectively with difficulties, persisting in the face of failure [35] which is very important during changes within an organisation [36]. Further individuals high in self-efficacy are more likely to attain valued outcomes according to their personal standards, from which they derive more satisfaction with the job. Additionally, the regulatory skills underlying self-efficacy make employees confident to solve conflicts that may occur with colleagues as responsibilities and tasks are changing, to overcome frustrations when changes are not perceived as benefit, to remain calm and in a good mood to stay motivated to implement organisational change, deriving more satisfaction from their work [58]. Thus, individuals who are confident in their abilities and competence to perform a job will be more satisfied. In the same vein, a meta-analysis of self-efficacy and organizational performance showed that self-efficacy was positively correlated with job satisfaction [37] and finally, scholars [38] reported, based on their study in a health care firm, the direct effect of self-efficacy on job satisfaction. Organizational change research showed that employees' coping efficacy was positively related to the appraisal of changes associated with an organizational merger [39, 40]. Thus, we assume that a higher level of job self-efficacy is likely to result in higher levels of perceived job satisfaction by employees during change.

H1. Higher levels of perceived self-efficacy lead to higher levels of job satisfaction for employees.

3.2. The moderating role of gender between self-efficacy and job satisfaction

Although evidence suggests a slight shift away from traditional sex-role stereotypes [41, 42, 43], it appears that some negative beliefs about a female's ability to perform certain tasks are deeply rooted and resistant to change [44, 45, 46, 47]. Research demonstrates that women are still often viewed as less effective leaders, and men are viewed as better suited for decision-making tasks for example during organizational changes [48].

Although some progress has been made in the integration of women into non-traditional careers, inequities persist. Most inequalities exist in upper-level managerial and executive positions where pay is highest [49, 50]. One barrier facing women who seek non-traditional roles is the existence of sex-based stereotypes consisting of undesirable traits. These are problematic because they are overgeneralizations that are often inaccurate, leading those in powerful organizational positions to limit the opportunities of females [51, 48]. A related concern is that women could internalize these negative beliefs, leading them to lack confidence in their ability to perform challenging tasks. Research suggests that women may lack confidence in their ability to successfully complete non-traditional tasks [52, 53]. This lack of confidence may have far reaching consequences because individuals who believe they lack the skills to master certain tasks may avoid these and turn to less challenging tasks [28]. In organizational settings, such low self-efficacy could damage a female's career advancement, in particular in industries that are characterized by male dominance, such as the transport sector. A woman who fears that she lacks the ability to perform such roles may avoid these assignments or turn them down. This is supported by research that shows self-perceived ability to perform tasks is a determinant of task choice [52, 54]. How far reaching are the effects of low self-efficacy? Research suggests that it has a significant impact on job satisfaction. Theoretically, self-efficacy can serve as a guiding force for behaviour intended to overcome performance obstacles [55]. Some researchers believe that self-efficacy and job satisfaction as a performance factor have a cyclical relationship. High self-efficacy facilitates job satisfaction, and high levels of job satisfaction nurture self-efficacy [55, 56]. Thus, raising self-efficacy has practical consequences for the perceived job satisfaction in organisations. Negative beliefs about one's abilities may result in reduced willingness to take risks, reduced desire to be visible, and negative self-presentation, which hinders career progress [51, 57]. This lowered self-efficacy may lead women to avoid activities that could further one's career [58]. Thus, we assume that high levels of perceived self-efficacy are more important for women to perceive high levels of job satisfaction than men.

Hypotheses 2. The relationships between perceived self-efficacy and job satisfaction is moderated by gender in the way that women have to perceive higher levels of self-efficacy to perceive the same levels of job satisfaction as men.

4. METHOD AND ANALYSIS

4.1. Sample and Procedures

Data were gathered during the H2020 CIVITAS SUITS and TINNGO projects.Participants in this study were 71 individuals working in the transport or mobile departments of seven local authorities from 6 different countries, Greece, Spain, Italy, Romania, United Kingdom and Lithuania. In all, 71% were male and the average age was 38.9 years [standard deviation [SD]= 11.406]. Participants were asked to respond to an online questionnaire, that was distributed with support from the transport departments in the local authorities in Rome, Torino, Valencia, Kalamaria, Palanga, West Midlands and Alba Iulia in 2017 from February to May. In a first step, personalized mailings were sent to all members of the selected transport departments asking them to participate in our study. Each mailing included a short summary of the proposed research and a link to the appropriate questionnaire. Two reminders were sent after one and three weeks. To rule out non-response bias, we compared early [the first 25%] and late [the last 25%] responders on a number of demographic variables, such as gender, age, and work experience. A multivariate analysis of variance identified no significant differences [Wilks' Λ=.10, F=.10, p=.98], indicating that non-response bias should not be a serious concern for our study [60]. To minimize the threat of common method variance, we implemented several procedural remedies. We included reverse-coded items, assured our respondents of their anonymity, and provided them with detailed instructions on how to fill out the survey [59].

4.2. Measures

A cross-sectional design was implemented. Participants were asked to complete demographic questions [age, team tenure, department tenure, organisation tenure, qualifications, department and role] and two scales online.

Self-efficacy was assessed according to Fugate's scale [61, 40] on change related self-efficacy based on the conceptual understanding of self-efficacy by key scholars in the field [28, 62]. The scale comprises four items such as “Whatever is changing around here, I am sure I can handle it” or “I get nervous that I may not be able to do all that is demanded of me by this change”. A scale that has been adopted several times already in literature [e.g. 63, 64].

Job Satisfaction was assessed by a two item scale that includes “overall, I am satisfied with my job” and “I am satisfied with the way that I conduct my job” [65].

Gender was asked by answering the question whether the participant is male, female or other.

5. RESULTS

An exploration of the differences in change self-efficacy and job satisfaction scores between male and female was performed using an independent-samples t-test. There was a significant difference in the scores of job satisfaction between male and female [t[70]=1.723, p=.023], with males indicating a higher level of job satisfaction [M=5.902, SD=.800] than female [M=5.350, SD=1.113]. Contrastingly there were no significant differences between male [M=5.235, SD=.798] and female [M=4.870, SD=.706] in change self-efficacy [t[70]=2.022, p=.094].

Results of the linear regression indicated job satisfaction was a significant predictor of self-efficacy [t[70]=5.148, p<0.01, R2=.278]. This is consistent with hypothesis 1 according to which self-efficacy is positively associated to high levels of job satisfaction.

The moderation effect of the relationship between change self-efficacy and job satisfaction was conducted using the PROCESS mediation macro in SPSS [see Hayes, 2013, Preacher and Hayes, 2004]. The moderation model showed to be significant [$R2=.356$, $F= 12.321$, $P<.01$] with the significant interaction between self-efficacy and gender [$b=.583$, $SE= .255$, 95% CI[.025, .075], $t=2.289$, $p<.05$] revealing that the relationship between self-efficacy and job satisfaction was moderated by gender. These results support hypothesis 2 which states that gender moderates the relationship between self-efficacy and job satisfaction.

From the slope analysis, it is possible to conclude that for high levels of change self-efficacy women tend to feel more satisfied than man. Contrarily for low and moderate levels of change self-efficacy men tend to be more satisfied. However, for both genders higher levels of change self-efficacy result in higher levels of job satisfaction.

6. DISCUSSION

In line with the idea of this study to show whether gender may make a difference between the level of perceived self-efficacy during change and job satisfaction, this study contributes decisively to our knowledge on perceived change self-efficacy and job satisfaction with regards to gender differences. Our results show that women require higher levels of perceived self-efficacy related to change as men to achieve the same levels of job satisfaction. Herewith, we can contribute to the field of work research related to the management of organizational changes and gender. While we firstly provide further evidence that a positive relationship exists between perceived levels of change related self- efficacy and job satisfaction, our study additionally highlights that women need to perceive higher levels of self-efficacy during organisational changes at the workplace to perceive the same high levels of job satisfaction as men.

The question arises why women have to perceive higher levels of self-efficacy related to change than men to perceive the same level of job satisfaction. The answer to this question may be anchored in the long history of gender roles in our society. Gender roles are strongly linked to gender-specific stereotypes, which are formed through the observation of women and men. These roles include assumptions about how women or men should behave in relation to their gender in order to be accepted by society. Discrimination against women in the workplace or disadvantages in their careers often occurred due to the discrepancy between the ascribed gender-specific attributes of women and the requirements for management positions – something that becomes of even more relevance in the transport industry in which women present only a minority group. Data provided by the Statistics National institute [INE] Spain based on the national economic activity code [CNAE] shows for example that 5,2% of people are employed in the transport sector and that 19,35% of these are female. This gender gap as remained similar over the past 10 years, and was in fact widening in 2019 with 829.200 male employees in the sector against and 198.900 female employees. A similar picture can be drawn in the other countries of this study, e.g. women in Italy represent 42,1% of the workforce, occupying the lowest position in Europe, for transport this is 21,9% [66].As a result, studies [67, 68] have found that women are more likely to encounter challenges on their career path compared to men. Results in the public sector [e.g. 69] show that women often encounter subliminal, invisible barriers or disadvantages within the corporate culture, for example fewer career opportunities, promotion only up to a certain level in the hierarchy and a lower salary, despite the same position as their male colleagues. One key finding of these studies is that the micro-political processes in organisations seem to have a fundamental impact on careers, as they are part of the informal system that allows insiders and rules out other people which could be also a reason for the perceived differences in change related self -efficacy between women and men as studies show that women tend to orientate themselves towards work processes so that everything runs according to regulations and thus often ignore the importance of internal political processes for their own careers and thus fail to recognize career-relevant relationships and networks or are reluctant to get involved [70, 71, 72].

Organizations can be viewed like political arenas: In this social construct, one is in constant competition for limited resources, power and influence. Accordingly, to be successful, individuals must have a certain level of political skill in order to achieve the desired success. If professional success can be influenced by a special behaviour, women should develop and use this ability to build strategic networks and alliances as well as to identify, win over and influence the key players in the company.

What does this mean for women, and the management of organizational change in the transport workplace? Women can actively influence their careers and benefit from proactive behaviour, especially political skills and strategic career planning. Personal attitudes and thus self-efficacy have a major influence on professional success. Organisations can support women in this through targeted support measures and training as developed in the Horizon project 'Transport Innovation Gender Observatory - TInnGO' project [https://www.tinngo.eu/]. Education and good practices examples may encourage equality and diversity in various spheres of life and diminish the present stereotypes. Presenting existing cases of gender aspect integration in different fields, especially such male dominant as the transport sector, the future employees could be encouraged to work and pursue the career. In addition, it is also necessary to break down deeply anchored assumptions and gender stereotypes in our society and to create awareness of unconscious prejudices about gender. Gender discrimination could lead to further promoting socio-economic differences between women and men.

6.1. Limitations

As in other studies, we will now highlight the key limitations of our study. First of all, our study results are based on a cross-sectional sample. Thus, we cannot show any procedural change regarding the behaviour or perceived self-efficacy between women and men during the organizational change. Future studies should try to observe potential changing attitudes and behaviours to enrich our knowledge on the relationships between self-efficacy related to change and perceived job satisfaction. Secondly, our sample is relatively small as it was very hard to get access to the transport departments in the local authorities that went through organisational changes that could be compared with each other. We were very pleased to get access to the local authorities through the H2020 CIVITAS SUITS and TINNGO projects that allowed us to collect this data. However, more comprehensive studies are needed in this field to demonstrate stronger results. Further,we encourage future research to highlight further minority groups such as transgender to understand the relationship between perceived level of self-efficacy during change and job satisfaction even more in detail.

7. CONCLUSION

This study highlights the relevance for the management of organisational change in the workplace to pay attention to gender when it comes to perceived levels of self-efficacy and job satisfaction that are decisive to drive a change successfully. Our study in different local authorities' departments in the transport field show that women require higher levels of self-efficacy during change to perceive the same levels of job satisfaction as men. This result leads to clear managerial implications for the management of change within organizations to be able to implement change successfully.

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REFERENCES

[1] Akgün, E. Z., Monios, J., Rye, T., Fonzone, A. Influences on urban freight transport policy choice by LAs. Transport Policy. 2019; 75: 88-98.

[2] Woodcock, A., Saunders, J., Fadden-Hopper, K & O'Connel, E. Capacity Building in Local Authorities for Sustainable Transport Planning, Springer Nature Singapore Pte Ltd; forthcoming.

[3] Nikolaeva, A., Adey, P., Cresswell, T., Lee, J. Y., Nóvoa, A., & Temenos, C. Commoning mobility: Towards a new politics of mobility transitions. Transactions of the Institute of British Geographers. 2019; 44[2]: 346-360.

[4] Nienaber, A., Spundflasch, S. & Soares, A. Delivering capacity building in small to medium local authorities, in Woodcock, A. Saunders, J., Fadden-Hopper, K & O'Connel, E. [eds.], Capacity Building in Local Authorities for Sustainable Transport Planning, Springer; forthcoming.

[5] Porras, J. I., & Silvers, R. C. Organization development and transformation. Annual review of Psychology. 1991; 42[1]: 51-78.

[6] Nienaber, A., Spundflasch, S., & Soares, A. Sustainable Urban Mobility in Europe: Implementation needs behavioural change. SUITS Policy brief X. SUITS funded from the European Union's Horizon 2020 research and innovation programme under grant agreement no 690650. Mobility and Transport Research Centre, Coventry University, 2020.

[7] Nienaber, A., Spundflasch, S., Soares, A., and Woodcook, A.. Distrust as hazard for future sustainable mobility planning. Rethinking employees' vulnerability when introducing new technologies in local authorities, Human Computer Interaction. 2021: 1-12. .

[8] Ashford, S. J. Individual strategies for coping with stress during organizational transitions. The Journal of Applied Behavioral Science. 1988; 24[1]: 19-36.

[9] Nelson, A., Cooper, C. L., & Jackson, P. R. Uncertainty amidst change: The impact of privatization on employee job satisfaction and well-being. Journal of Occupational and Organizational psychology.1995; 68[1]: 57-71.

[10] Sagie, A., & Koslowsky, M. Organizational attitudes and behaviors as a function of participation in strategic and tactical change decisions: An application of path–goal theory. Journal of Organizational Behavior. 1994: 15[1]: 37-47.

[11] Sverke, M., Hellgren, J., & Öhrming, J. Hospital corporatization: how are nurses' job perceptions and work-related attitudes affected?. Univ., Department of Psychology.1997.

[12] Bouckenooghe, D. Positioning change recipients' attitudes toward change in the organizational change literature. The Journal of applied behavioral science. 2010; 46[4]: 500-531.

[13] Ford, J. D., Ford, L. W., & D'Amelio, A. Resistance to change: The rest of the story. Academy of management Review. 2008; 33[2]: 362-377.

[14] Bordia, P., Hunt, E., Paulsen, N., Tourish, D., & DiFonzo, N. Uncertainty during organizational change: Is it all about control?. European journal of work and organizational psychology. 2004; 13[3]: 345-365.

[15] Eby, L. T., Adams, D. M., Russell, J. E., & Gaby, S. H. Perceptions of organizational readiness for change: Factors related to employees' reactions to the implementation of team-based selling. Human relations. 2000; 53[3]: 419-442.

[16] Miller, V. D., Johnson, J. R., & Grau, J. Antecedents to willingness to participate in a planned organizational change. 1994.

[17] Osterman, P. Work reorganization in an era of restructuring: Trends in diffusion and effects on employee welfare. ILR Review. 2000: 53[2]: 179-196.

[18] Manley, K., & Jackson, C. Microsystems culture change: a refined theory for developing person-centred, safe and effective workplaces based on strategies that embed a safety culture. International Practice Development Journal. 2019, 9[2].

[19] Pfeffer, J. Organizational demography. Research in organizational behavior. 1983.

[20] Cohen, L. E., Broschak, J. P., & Haveman, H. A. And then there were more? The effect of organizational sex composition on the hiring and promotion of managers. American Sociological Review. 1998; 711-727.

[21] Cohen, L. E., & Broschak, J. P. Whose jobs are these? The impact of the proportion of female managers on the number of new management jobs filled by women versus men. Administrative Science Quarterly. 2013; 58[4]: 509-541.

[22] Ragins, B. R., & Cotton, J. L. Mentor functions and outcomes: a comparison of men and women in formal and informal mentoring relationships. Journal of applied psychology. 1999; 84[4]: 5-29.

[23] Ragins, B. R., Cotton, J. L., & Miller, J. S. Marginal mentoring: The effects of type of mentor, quality of relationship, and program design on work and career attitudes. Academy of management journal. 2000; 43[6]: 1177-1194.

[24] Bener A, Al Maadid MG, Özkan T, Al-Bast DA, Diyab KN, Lajunen T. The impact of four-wheel drive on risky driver behaviours and road traffic accidents. Transp Res Part F: Traffic Psychol Behav. 2008; 11 [5]: 324–333.

[25] Bruce, M. A., & Thornton, M. C. It's my world? Exploring black and white perceptions of personal control. The Sociological Quarterly. 2004; 45[3]: 597-612.

[26] Gecas, V. The social psychology of self-efficacy. Annual Review of Sociology. 1989; 15: 291–316.

[27] Wanberg, C. R., & Banas, J. T. Predictors and outcomes of openness to changes in a reorganizing workplace. Journal of applied psychology. 2000; 85[1]: 132.

[28] Bandura, A. Self-efficacy: The exercise of control. New York: Freeman. 1997.

[29] Schermerhorn, J. R., Hunt, J. G., Osborn, R. N., & Uhl-Bien, M. Organizational Behavior. Asia: John Wiley & Sons [Asia] Pte Ltd. 2011.

[30] Gkolia, A., Belias, D., & Koustelios, A. Teacher's job satisfaction and selfefficacy: A review. European Scientific Journal. 2014: 10[22].

[31] Bussey, K., & Bandura, A. Social cognitive theory of gender development and differentiation. Psychology Review. 1999; 106: 676–713.

[32] Tannenbaum, H. R., & Leaper, C. Parent–child conversations about science: The socialization of gender inequities. Developmental Psychology. 2003; 39: 34–47.

[33] Judge, T. A., & Bono, J. E. Relationship of core self-evaluations traits—self-esteem, generalized self-efficacy, locus of control, and emotional stability—with job satisfaction and job performance: A meta-analysis. Journal of applied Psychology. 2001; 86[1]: 80.

[34] Perdue, S. V., Reardon, R. C., & Peterson, G. W. Person—environment congruence, self-efficacy, and environmental identity in relation to job satisfaction: A career decision theory perspective. Journal of employment counselling. 2007; 44[1]: 29-39.

[35] Gist, M. E., & Mitchell, T. R. Self-efficacy: A theoretical analysis of its determinants and malleability. Academy of Management review. 1992; 17[2]: 183-211.

[36] Jimmieson, N. L., Terry, D. J., & Callan, V. J. A longitudinal study of employee adaptation to organizational change: the role of change-related information and change-related self-efficacy. Journal of occupational health psychology. 2004; 9[1]: 11.

[37] Salgado, J. F., & Moscoso, S. Self-efficacy and organizational performance criteria. Apuntes de Psicologia. 2000; 18: 179-191.

[38] O'Neil, B. S., & Mone, M. A. Psychological influences on referent choice. Journal of Managerial Issues. 2005; 17[3]: 273-292.

[39] Scheck, C., & Kinicki, A. Identifying antecedents of coping with an organizational acquisition: A structural assessment. Journal of Organizational Behavior. 2000; 21: 627-648

[40] Fugate, M., Prussia, G. E., & Kinicki, A. J. Managing employee withdrawal during organizational change: The role of threat appraisal. Journal of Management. 2012; 38[3]: 890-914.

[41] Dambrot, F. H., Papp, M. E., & Whitmore, C. The sex-role attitudes of three generations of women. Personality and Social Psychology Bulletin. 1984; 10[3]: 469-473.

[42] Helmreich, R. L., Spence, J. T., & Gibson, R. H. Sex-role attitudes: 1972-1980. Personality and Social Psychology Bulletin. 1982; 8[4]: 656-663.

[43] Kravetz, D. Sexism in a Woman's Profession. Social Work. 1976; 21[6]: 421-426.

[44] Heilman, M. E., Block, C. J., Martell, R. F., & Simon, M. C. Has anything changed? Current characterizations of men, women, and managers. Journal of applied psychology. 1989; 74[6]: 9-35.

[45] Reskin, B. Sex segregation in the workplace. Annual review of sociology. 1993; 19[1]: 241-270.

[46] Schein, V. E. The relationship between sex role stereotypes and requisite management characteristics. Journal of applied psychology. 1973; 57[2]: 95.

[47] White, M. J., Kruczek, T. A., Brown, M. T., & White, G. B. Occupational sex stereotypes among college students. Journal of Vocational Behavior. 1989; 34[3]: 289-298.

[48] Rizzo, A. M., & Mendez, C. The integration of women in management: A guide for human resources and management development specialists. Praeger. 1990.

[49] Izraeli, D. N., Adler, N. J., & Izraeli, D. N. Competitive frontiers: Women managers in a global economy [pp. 3-21]. Cambridge, MA: Blackwell. 1994.

[50] Kemp, R. Technology and the transition to environmental sustainability: the problem of technological regime shifts. Futures. 1994; 26[10]: 1023-1046.

[51] Heilman, M. E. Sex bias in work settings: The lack of fit model. Research in organizational behavior.1983.

[52] Betz, N. E., & Hackett, G. The relationship of career-related self-efficacy expectations to perceived career options in college women and men. Journal of counseling psychology.1981; 28[5]: 399.

[53] McMahan, I. D. Expectancy of success on sex-linked tasks. Sex Roles. 1982; 8[9]: 949-958.

[54] Betz, N. E., & Hackett, G. The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. Journal of Vocational behaviour. 1983; 23[3]: 329-345.

[55] Gist, M. E., & Mitchell, T. R. Self-efficacy: A theoretical analysis of its determinants and malleability. Academy of Management review.1992; 17[2]: 183-211.

[56] Mathieu, J. E., Martineau, J. W., & Tannenbaum, S. I. Individual and situational influences on the development of self-efficacy: implications for training effectiveness. Personnel psychology. 1993; 46[1]: 125-147.

[57] Heilman, M. E., & Kram, K. E. Self-derogating behavior in women—fixed or flexible: The effects of co-worker's sex. Organizational Behavior and Human Performance. 1978; 22[3]: 497-507.

[58] Bandura, A. The anatomy of stages of change. American journal of health promotion: AJHP. 1997; 12[1]: 8-10.

[59] Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. Common method biases in behavioral research: a critical review of the literature and recommended remedies. Journal of applied psychology. 2003; 88[5]: 879.

[60] Armstrong, J. S., & Overton, T. S. Estimating nonresponse bias in mail surveys. Journal of marketing research, 1977; 14[3]: 396-402.

[61] Fugate, M., Kinicki, A. J., & Prussia, G. E. Employee coping with organizational change: An examination of alternative theoretical perspectives and models. Personnel Psychology. 2008; 61[1]: 1-36.

[62] Wanberg, C. R., & Banas, J. T. Predictors and outcomes of openness to changes in a reorganizing workplace. Journal of applied psychology. 2000; 85[1]: 132.

[63] Ng, T. W., & Lucianetti, L. Within-individual increases in innovative behavior and creative, persuasion, and change self-efficacy over time: A social–cognitive theory perspective. Journal of Applied Psychology. 2016; 101[1]: 14.

[64] Delahaij, R., & Van Dam, K. Coping with acute stress in the military: The influence of coping style, coping self-efficacy and appraisal emotions. Personality and Individual Differences. 2017; 119: 13-18.

[65] Trevor, C. O. Interactions among actual ease-of-movement determinants and job satisfaction in the prediction of voluntary turnover. Academy of management journal. 2001; 44[4]: 621-638.

[66] Shin DS, Park MH, Jeong BY. Effects of female worker's salary and health on safety education and compliance in three sectors of the service industry. Work. 2020; 65:63–70.

[67] Kumra, S., & Vinnicombe, S. A study of the promotion to partner process in a professional services firm: How women are disadvantaged. British Journal of Management. 2008; 19: 65-74.

[68] Hoobler, J. M., Lemmon, G., & Wayne, S. J. Women's managerial aspirations: An organizational development perspective. Journal of Management. 2014; 40[3]: 703-730.

[69] Sabharwal, M. From glass ceiling to glass cliff: Women in senior executive service. Journal of Public Administration Research and Theory. 2015; 25[2]: 399-426.

[70] Bilimoria, D., Perry, S. R., Liang, X., Stoller, E. P., Higgins, P., & Taylor, C. How do female and male faculty members construct job satisfaction? The roles of perceived institutional leadership and mentoring and their mediating processes. The Journal of Technology Transfer. 2016; 31[3]: 355-365.

[71] Davey, K. M. Women's accounts of organizational politics as a gendering process. Gender, Work & Organization. 2008; 15[6]: 650-671.

[72] Eccles, J. S. Bringing young women to math and science. In Gender and thought: Psychological perspectives [pp. 36-58]. Springer, New York, NY. 1989.

[73] Ferris, G. R., Davidson, S. L., & Perrewe, P. L. Political skill at work: Impact on work effectiveness. Mountain View, Calif.: Davies-Black Pub. 2005.

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THE INFLUENCE OF THE SHARED E-SCOOTER SYSTEM ON MODAL SHIFT

Key Words

Mobility

Traffic congestion

Transport demand management

Sustainable transport mode

Abstract

In many cities around the world, e-scooters have emerged as a new sustainable mode of transport. In addition to owning their personal scooter, users in many cities can rent an e-scooter within the shared e-scooter system. The shared use of e-scooters, as an innovative transportation strategy, mainly includes the possibility to pick up and return an e-scooter at any location within a certain zone. Thus, this dockless design of an e-scooter sharing system provides a flexible and efficient option for first/last-mile trips. Bearing that in mind, the aim of this paper is to analyze the modal shift potential of shared dockless e-scooters in Belgrade using different tariff policies. Considering that the introduction of a shared dockless e-scooter system in Belgrade represents a hypothetical situation, a stated choice approach was used. Appropriate descriptive and analytic statistics were used in statistical analysis. The obtained results point out whether and to what extent the application of an appropriate e-scooter shared system would contribute to the reduction of traffic congestion in the Belgrade central zone. Also, based on the obtained results, it is possible to identify the factors that discourage people from using shared e-scooter systems.

1. INTRODUCTION

In the last few years, there has been an expansion in the use of shared e-scooters as one of the micromobility modes by urban residents across the globe [1, 2, 3, 4]. E- scooters can be privately owned, but the large increase in the use of e-scooters can be explained by the introduction of shared e-scooter systems in cities. Since the launch of the first shared e-scooter system in late 2017 (California, USA), e-scooter systems have spread across hundreds of cities worldwide [5]. Paris was one of the first European cities where shared e-scooters were introduced (in June 2018) [6]. As of June 2021, Paris and Berlin have been the hub of e-scooter sharing in Europe, followed by Madrid and Stockholm [7].

The shared e-scooter system is currently one of the most popular micromobility sharing services which usually operates in a dockless form [8]. The dockless shared e-scooter system allows users to pick up and return an e-scooter at any place within a defined area. Using a mobile application, users can check the availability of e-scooters in real time and pay the charge automatically through a registered account [8, 9]. When the e-scooter battery is low or maintenance is needed, one of the provider's employees collects the e-scooter and brings it to a charging place. Once the battery is fully charged, the e-scooter is then redeployed to strategic locations and users can use it again [10].

Shared e-scooters faced a quick acceptance by users all around the world, and the rates of usage were reported to be higher than shared bicycles when implemented [11]. Namely, after less than one year of availability in some cities in the USA, a remarkably large number of people (3.6%) reported having used them, while 70% of the respondents said that they perceived shared e-scooters as an alternative way to getting around [12]. However, in Tricity (Poland) the public e-scooter sharing system has been significantly less popular than the e-bike sharing system. Namely, when asked about reasons discouraging them from riding, Tricity citizens complained about shared e-scooter prices and were concerned about their safety [13]. During the Covid-19 pandemic, shared e-scooters became a great asset in many cities worldwide, because they promote social distancing and help cities not to rely only on private cars to replace public transport rides, especially for short distance trips [11]. In Braga, it was found that the city still relied on shared e-scooter modes as a mobility option after the pandemic, also promoting special fares for people to start using the service [11]. Generally, many experts are of the opinion that shared e-scooters may become an important component of mobility planning in the coming years, when cities begin to recover from the COVID-19 pandemic [14].

Shared e-scooters are mostly used for short trips in terms of distance and duration. The average distance travelled by shared e-scooters in the USA is about 1.6 km, generally covered in 12 min [15], while in European countries it amounts to around 1.75 km to 1.96 km covered in 13 to 15 min [16]. The charge of this service varies significantly depending on the provider and the city in which the system operates. In the USA the average 12-minute scooter shared trip costs from $2.80 to $4.70 depending on the system [15]. In the city Tricity (Poland) the user pays around €2.21 for a 3 km ride on an e-scooter. The shared e-scooter system is usually more expensive than public transport services comparing the prices for the same trip. For example, in the city Tricity (Gdansk, Poland) the shared e-scooter price is about three times higher than a ticket for a bus or tram [13].

While previous research concur that shared e-scooters are mostly used for very short trips in the afternoon and at weekends mostly [17, 18], it was concluded that the spatial distribution and purposes of e-scooter trips vary according to the local context [19]. Generally, in the previous research it was determined that the intention to use this service was influenced by socio-demographic characteristics of users, service price, trip characteristics, infrastructure characteristics and environmental factors [8, 13, 17, 20, 21].

Having in mind the above mentioned, the aim of this paper is to define an appropriate methodology which should help to determine whether and to what extent the residents of Belgrade would use a dockless shared e-scooter system with certain infrastructure and different tariff policies. The proposed methodology should assist decision makers in evaluating the shared scooter system and deciding on its implementation.

2. METHODOLOGY

A survey of users' attitudes on e-scooters’ usage in the current conditions, as well as in hypothetical situations that would imply the existence of the appropriate cycling infrastructure and a dockless shared e-scooter system was conducted for the purpose of this paper. Respondents were asked to answer the question whether they would use an e-scooter (personal or shared) for different trip purposes (work/school purpose and other purposes) if they had the appropriate cycling infrastructure and the option to use a dockless shared e-scooter at different charges. The authors of the paper defined three price levels, based on the prices of this system in other cities, taking into account the economic indicators that are valid in local conditions, as well as the price of public transport in Belgrade. All three price scenarios include a fee of 20 RSD for unlocking the scooter, while the other part of the charge - payment per minute of driving varies among the scenarios (15 RSD/min, 10 RSD/min and 5 RSD/min).

The research was conducted online. The online survey was distributed as a link via email. After the incomplete questionnaires with inconsistent responses had been removed from the sample, the valid sample used in the further analysis consisted of 392 respondents. In addition to the previously mentioned questions, the questionnaire contained general questions about demographic and socio-economic characteristics of the respondents.

3. RESULTS

3.1. Sample characteristics

The study included 392 participants. Out of the total number of the participants, 51.8% were female, while 48.2% were male. According to the respondents’ age, 9.5% of the participants were under 18, 45.6% between 19 and 25, 20.5% between 26 and 35, 13.6% between 36 and 45, while 10.9% of the respondents belonged to the age group between 46 and 55. Out of the total number of the respondents, 3.4% have a personal e-scooter.

3.2. Using an e-scooter

Out of the total number of the respondents, 3.4% have a personal e-scooter. For trips with work/school purpose, 1.4% of the respondents use an e-scooter most frequently, while 0.4% of the respondents use an e-scooter and public transport (PT) most frequently. For trips with other purposes, 2.9% of the respondents use an e-scooter most frequently, while 0.5% of the respondents combine an e-scooter and PT most frequently (Table 1). The average distance covered by e-scooter is 2.6 km for trips with work/school purpose and 3.4 km for trips with other purposes.

When analyzing the respondents' willingness to use an e-scooter in a hypothetical situation when the complete cycling infrastructure is built, the results show that for trips with work/school purpose 2.7% of the respondents would most often use an e-scooter, while 1.3% of the respondents would combine an e-scooter and PT. For trips with other purposes, 3.6% of the respondents would use an e-scooter, while 1.4% of the respondents would combine an e-scooter and PT (Table 1).

Table 1 also shows the percentage of users who would use an e-scooter in the case of the built cycling infrastructure and implemented shared e-scooter system at different service prices. For example, in the case of the lowest price, 7.8% of the respondents would use a shared e-scooter (e-scooter only or combination with PT) for trips with work/school purpose, while 9.2% of the respondents would use it for the trips with other purposes. In the case of the highest price these values are significantly lower (3.3% for trips with work/school purpose and 4.3% for trips with other purposes).

Table 1. The share of e-scooter users in the current situation and in hypothetical situations - built bicycle infrastructure/built bicycle infrastructure + implemented shared e-scooter system

			Work/school purpose	**Other purposes**
The current situation		Personal e-scooter	1.40%	2.90%
		Personal e-scooter + PT	0.40%	0.50%
Bicycle infrastructure		Personal e-scooter	2.70%	3.60%
		Personal e-scooter + PT	1.30%	1.40%
Bicycle infrastructure + Shared e-scooter system	**Price (15 RSD/min+20 RSD start)**	Personal e-scooter	2.50%	3.10%
		Personal e-scooter + PT	1.20%	1.30%
		Shared e-scooter	2.30%	3.10%
		Shared e-scooter + PT	1.00%	1.20%
	Price (10 RSD/min+20 RSD start)	Personal e-scooter	2.30%	2.70%
		Personal e-scooter + PT	1.10%	1.10%
		Shared e-scooter	4.10%	4.80%
		Shared e-scooter + PT	1.60%	2.10%
	Price (5 RSD/min+20 RSD start)	Personal e-scooter	2.00%	2.40%
		Personal e-scooter + PT	1.10%	0.90%
		Shared e-scooter	5.50%	6.30%
		Shared e-scooter + PT	2.30%	2.90%

The obtained results showed that for trips with work/school purpose, the number of shared e-scooter users would grow significantly with the fall in service prices. Also, the percentage of using one's personal e-scooter decreases with the reduction of shared e-scooter prices (Figure 1).

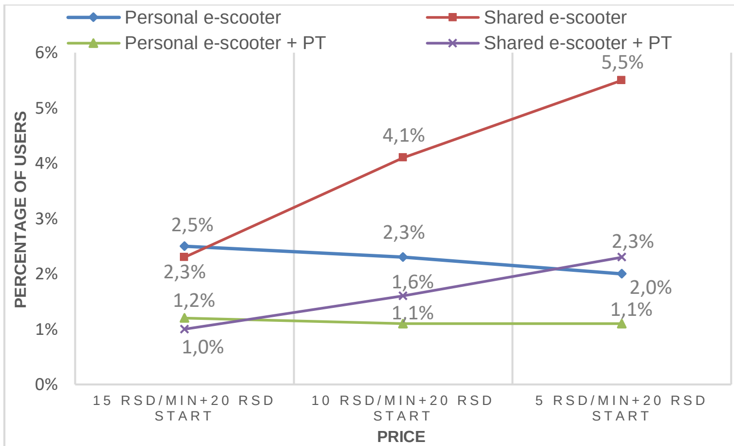

Figure 1. Percentage of the shared e-scooter usage for trips with work/school purpose depending on the service price

On the other hand, for the stated hypothetical situation and for trips with other purposes, a similar trend could be observed. However, the percentage of shared e-scooter users was higher for this purpose, as opposed to the trips with work/school purpose (Figure 2). Based on the above given figures, the percentage of potential shared e-scooters can be determined, depending on the service price.

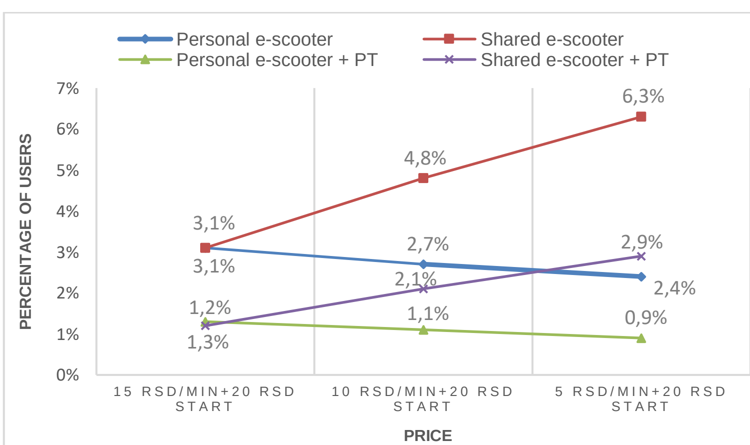

Figure 2. Percentage of the shared e-scooter usage for trips with other purposes depending on the service price

4. CONCLUSION

Based on the data analyzed, the conclusions of this research are as follows:

- for trips with work/school purpose 1.8% of the respondents use an e-scooter (scooter only or combination with public transport), while for trips with other purposes 3.4% of the respondents use an e-scooter;

- in the hypothetical situation in which the complete cycling infrastructure is built, 4% of the respondents would use an e-scooter for trips with work/school purpose, while for trips with other purposes 5% of the respondents would use this transport mode;

- in the hypothetical situation which includes the built bicycle infrastructure and shared e-scooter implementation, in the case of the lowest service price, 7.8% of the respondents would use a shared e-scooter for trips with work/school purpose, while 9.2% would use it for trips with other purposes. In the case of the highest service price these values are lower (3.3% and 4.3 % of the respondents, respectively).

Urban planners and municipal authorities need to consider the potential of this new micromobility mode when developing infrastructure and creating new sustainable policies. The proposed methodology should help to determine whether and to what extent the residents of Belgrade would use a dockless shared e-scooter system with certain infrastructure and different tariff policies. The directions of future research should be aimed at increasing the number of participants of the research, as well as examining wider price ranges for shared e-scooters.

REFERENCES

[1] H. Fitt and A. Curl, “The early days of shared micromobility: A social practices approach,” *J. Transp. Geogr.*, vol. 86, p. 102779, Jun. 2020, doi: 10.1016/J.JTRANGEO.2020.102779.

[2] T. Timić, D. Glavic, and M. Milenković, “Micromobility – vehicles, multimodality, infrastructure,” *Put i saobraćaj*, vol. 66, no. 4, pp. 59–64, Dec. 2020, doi: 10.31075/PIS.66.04.07.

[3] D. Glavić, A. Trpković, M. Milenković, and S. Jevremović, “The e-scooter potential to change urban mobility—belgrade case study,” *Sustain.*, vol. 13, no. 11, Jun. 2021, doi: 10.3390/SU13115948.

[4] D. Glavić and M. Milenković, “Electric Micro Mobility Vehicles - Technologies, Opportunities, Assessment and Forecast,” in *Towards a Humane City*, 2019, pp. 199–205.

[5] R. Mitra and P. M. Hess, “Who are the potential users of shared e-scooters? An examination of socio-demographic, attitudinal and environmental factors,” *Travel Behaviour and Society*, vol. 23. pp. 100–107, 2021, doi: 10.1016/j.tbs.2020.12.004.

[6] A. De Bortoli, Z. Christoforou, and Y. Wang, “Consequential LCA for territorial and multimodal transportation policies: method and application to

the free-floating e-scooter disruption in Paris Handling editor," 2020, doi: 10.1016/j.jclepro.2020.122898.

[7] Mobility Foresights, "Electric Scooter Sharing Market in US and Europe 2021-2026," 2020.

[8] H. Lee, K. Baek, J. H. Chung, and J. Kim, "Factors affecting heterogeneity in willingness to use e-scooter sharing services," *Transp. Res. Part D Transp. Environ.*, vol. 92, p. 102751, Mar. 2021, doi: 10.1016/J.TRD.2021.102751.

[9] S. Gössling, "Integrating e-scooters in urban transportation: Problems, policies, and the prospect of system change," *Transp. Res. Part D Transp. Environ.*, vol. 79, p. 12, 2020, doi: 10.1016/j.trd.2020.102230.

[10] H. Moreau, L. de J. de Meux, V. Zeller, P. D'Ans, C. Ruwet, and W. M. J. Achten, "Dockless e-scooter: A green solution for mobility? Comparative case study between dockless e-scooters, displaced transport, and personal e-scooters," *Sustain.*, vol. 12, no. 5, 2020, doi: 10.3390/su12051803.

[11] G. Dias, E. Arsenio, and P. Ribeiro, "The role of shared e-scooter systems in urban sustainability and resilience during the covid-19 mobility restrictions," *Sustain.*, vol. 13, no. 13, pp. 1–19, 2021.

[12] Populus, *The Micro-Mobility Revolution: The Introduction and Adoption of Electric Scooters in the United States;* San Francisco, CA, USA: Populus Technologies, 2018.

[13] T. Bieliński and A. Ważna, "Electric scooter sharing and bike sharing user behaviour and characteristics," *Sustain.*, vol. 12, no. 22, pp. 1–13, 2020, doi: 10.3390/su12229640.

[14] R. Mitra and P. M. Hess, "Who are the potential users of shared e-scooters? An examination of socio-demographic, attitudinal and environmental factors," 2020, doi: 10.1016/j.tbs.2020.12.004.

[15] NACTO, "Shared Micromobility in the U.S. 2019," 2020.

[16] Civity Management Consultants, "E-Scooter in Deutschland - EindatenbasierterDebattenbeitrag," 2019.

[17] O. Caspi, M. J. Smart, and R. B. Noland, "Spatial associations of dockless shared e-scooter usage," *Transp. Res. Part D Transp. Environ.*, vol. 86, no. July, p. 102396, 2020, doi: 10.1016/j.trd.2020.102396.

[18] G. McKenzie, "Spatiotemporal comparative analysis of scooter-share and bike-share usage patterns in Washington, D.C.," *J. Transp. Geogr.*, vol. 78, pp. 19–28, Jun. 2019, doi: 10.1016/J.JTRANGEO.2019.05.007.

[19] Bozzi & Aguilera, "Shared E-Scooters : A Review of Uses , Health and Environmental Impacts , and Policy Implications of a New," 2021.

[20] G. Oeschger, P. Carroll, and B. Caulfield, "Micromobility and public transport integration: The current state of knowledge," *Transp. Res. Part D Transp. Environ.*, vol. 89, p. 102628, Dec. 2020.

[21] M. Milenković, D. Glavić, and M. Maričić, “Determining factors affecting congestion pricing acceptability,” *Transp. Policy*, vol. 82, pp. 58–74, 2019.

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THE EFFECT ON MOBILITY TRENDS DURING THE PANDEMIC

Key Words

Mobility

Pandemic

Transport

Restrictions

Abstract

As mobile device location data becomes more available, new analyzes reveal significant changes in the way you move when an unplanned event occurs. With different control policies from local and state government, the outbreak of Covid-19 has dramatically changed movement behavior in affected cities. Many countries have closed their borders and imposed curfews in sharp reductions in transport demand also on regional and continental level. Different countries have dealt with these challenging circumstances in different ways - and, in some cases, the directives vary from city to city. Cities in developing countries and emerging economies face bigger challenges than ever before. At the beginning of the Coronavirus Pandemic (Covid-19) google and apple started to collect detailed statistics on the movement of people using location data from mobile devices. The paper analyzes the data obtained and shows the results for various areas of movement such as shops, recreation areas, parks, public transport and other. A comparison was made of the collected data in the Republic of Croatia and Republic of Serbia, which had a solid measure, and Kingdom of Sweden which had very mild measures during a pandemic. Therefore, a study was made on how measures affected the mobility of people in individual countries with different measures.

1. INTRODUCTION

The Coronavirus Pandemic has a significant impact on countries around the world and many states have introduced restrictions to transport. Different countries have dealt with these challenging circumstances in different ways, in some cases, the directives vary from city to city. How effective these policies have been in reducing people's movement can be seen from the data that Google present in their Covid-19 mobility reports. Using anonymous data provided by apps like Google Maps, the company has created a regularly updated dataset that shows how people's movements changed during a pandemic [1].

This mobility data may provide helpful insights to local governments and health authorities and may also be used as a foundation for new public policies by showing the change in volume of people mobility in their communities.

2. METHODOLOGY AND RESOURCES

We can learn about this from the data that Google presents in community mobility report. United Nations and other organizations sources and categorized the data into the following categories: Social distancing, Movement restrictions, Public health measures, Social and economic measures and Lockdowns [2].

Table 1. Policy measures considered in the analysis

Category	Measure	Description
Social distancing	Limit public gatherings	Cancelation of public events. Limit to the number of people that can meet in public and private spaces.
	Public services closure	Public services and facilities are closing access to the public. In some countries, services are available online.
	Changes in prison policies	Change in policies around prisons to mitigate the spread of the disease. This may include early release but also suspension of day-release programs, suspension of visits etc.
	Schools closure	Authorities have closed schools.
Lockdown	Partial lockdown	Partial lockdown includes: 1. The population cannot leave their houses apart for specific reasons that they have to communicate to the authorities. 2. All stores that are not related to alimentation or pharmacies are not open.
	Full lockdown	Full lockdown includes: 1. The population cannot leave their houses apart for specific reasons that they have to communicate to the authorities. 2. All non-essential services closed and production stops.
	Lockdown of refugee camps	Limitations to the population living in camps and/or camp like conditions.

Google released community mobility reports that show movement trends by region, across different categories of places. For each category in a region, reports show the changes in two different ways. Compares mobility for the report date to the baseline day. Calculated for the report date and reported as a positive or negative percentage. The reports chart movement trends over time by geography, across different categories of places such as retail and recreation, groceries and pharmacies, parks, transit stations, workplaces, and residential.

Table 2. Description of mobility reports categories

Category	Description	Data Source
Retail and recreation	Restaurants, cafes, shopping centres, theme parks, museums, libraries, and movie theatres.	Google
Grocery and pharmacy	Grocery markets, food warehouses, farmers markets, specialty food shops, drug stores, and pharmacies.	Google
Parks	National parks, public beaches, marinas, dog parks, plazas, and public gardens.	Google
Transit stations	Public transport hubs such as subway, bus, and train stations.	Google
Workplace	Places of work.	Google
Residential	Places of residence.	Google

3. RESEARCH RESULTS

Using anonymous data provided by apps like Google Map, the company has created a regularly updated dataset that shows how people's movements changed during a pandemic. This data set measures the number of visitors to certain categories of places on a daily basis and compares this change to the starting day before the outbreak. Baseline days represent the normal value for that day of the week, which is given as the average over five weeks from January 3 to February 6, 2020. To make this easier to understand, we converted the raw data, from January 17, 2020 to August 17, 2021, to the current average of seven days as shown in the data in the following graphs.

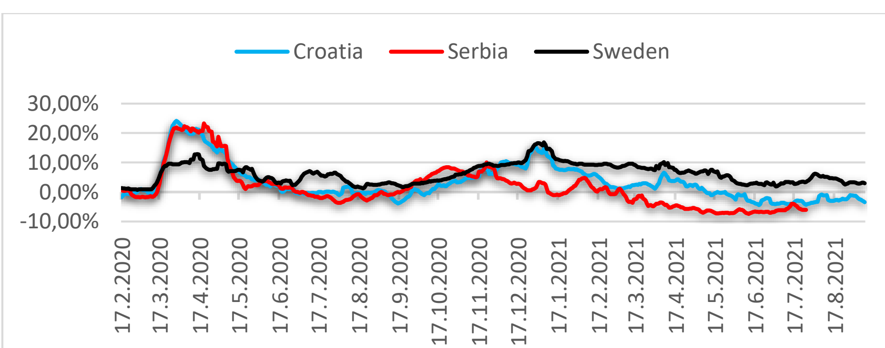

Figure 1. Mobility Trends to residential areas [4]

Data in the Figure 1 displays mobility trends to residential areas according to which a significant increase in the number of visitors to residential areas is visible after March 11, 2020 when the World Health Organization declared the outbreak of a new coronavirus (Covid-19) a global pandemic. Sweden's strategy to manage the spread of Covid-19 did not include any form of locking, unlike the approach adopted by most other countries like Serbia and Croatia. Which is evident in the first few months towards mobility to residential areas compared to other countries. Instead, the strategy is largely based on strong recommendations for society. Although Sweden did not have any form of locking, the Covid-19 pandemic over a relatively short period of time brought about changes in society, significantly disrupting daily life.

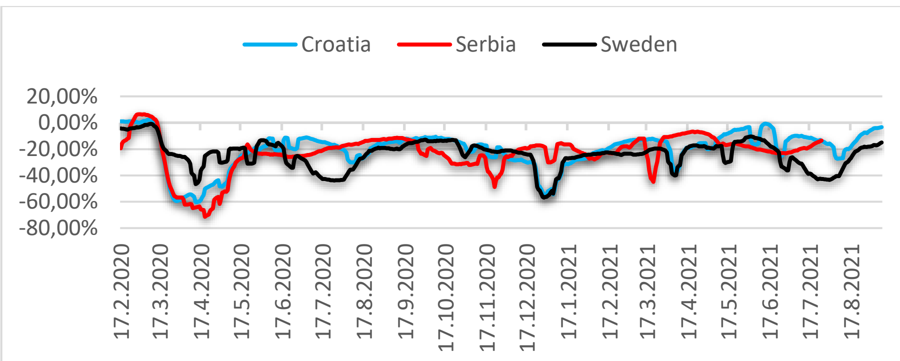

Figure 2. Mobility Trends to workplace areas [4]

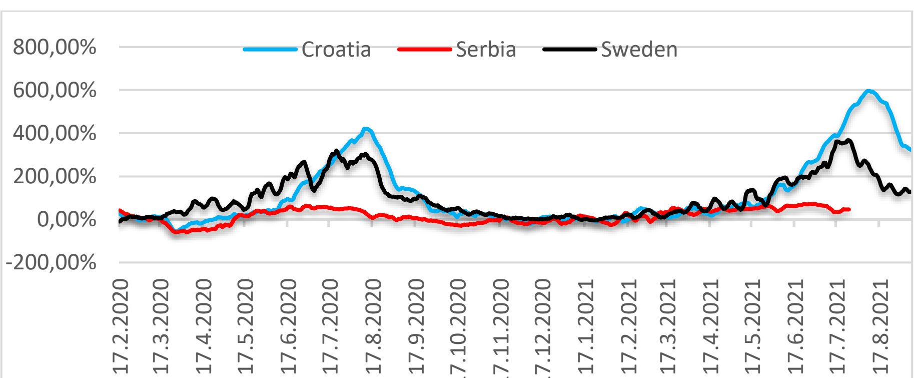

Figure 3. Mobility Trends to parks and outdoor areas [4]

People increase their activity at home and reduce their mobility in workplaces in the early months. Results confirm the conjecture and show that, in the early stage of the pandemic, workers in the subsectors reduce their activities in workplaces and increase their activities at home when the number of new daily cases increases. This suggests that people tend to increase their activities at home and reduce their activities in the workplace. Until the pandemic, housework was generally considered a non-standard, flexible work arrangement, where the workplace was the employer's place. Of course, during the pandemic, employees worked from home out of necessity rather than by choice, and the formalized flexible work requirement regime fell to some extent. Many employers are also considering a long-term reduction in office space and moving to hybrid work, allowing employees to split their time between working from home and working in the office.

Previously mentioned reduction of epidemiological measures leading to increased mobility of driving and walking which reaches its maximum in August 2020 and 2021 due to the large number of tourists. At the end of September and the beginning of October 2020, the number of infected people will increase, so measures will be reintroduced, such as the suspension of classes in schools and colleges, restaurants and cafes will be closed, and restrict the public events, which leads to a sharp decrease in mobility shown in the chart.

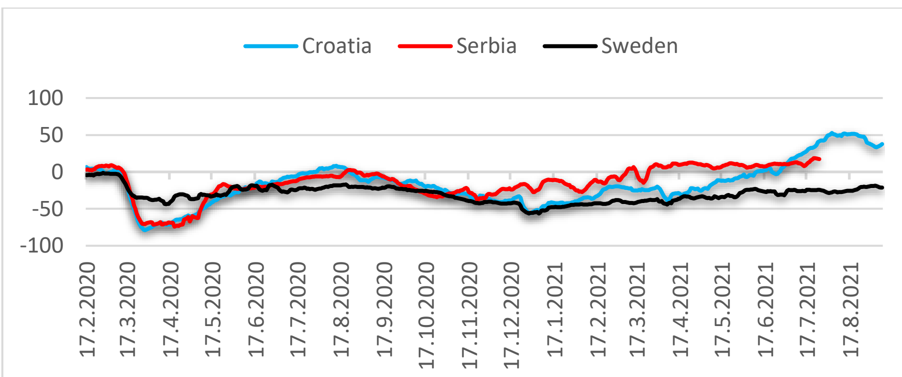

Figure 4. Mobility Trends to transport stations areas [4]

On March 21, 2020, the Croatian National Headquarters issued a decision to strictly limit detention on the streets, squares and other public places, as well as a decision to suspend public transport in order to prevent an increase in the number of infected people. Intercity lines for trains and buses are also being cut off. Public transportation in Sweden was operating and the borders to most EU countries remained open. Swedish spent less time home compared to other Europeans during the Covid-19 crisis. In Sweden, most policy measures announced by the authorities were mainly recommendations.

Comparison is made in the table below of the collected data in the Republic of Croatia, Republic of Serbia stronger restrictions and Kingdom of Sweden which had very mild measures during a pandemic [6].

Table 3. Review of absolute and relative changes in visits by all categories

Category	Country	Observed period		Absolute Change	Relative Change
		Feb 17, 2020	Sep 09, 2021		
Retail Recreation	Croatia	9.33 %	39.43 %	+30.10 %	+322 %
	Serbia	8.00 %	16.29 %	+8.29 %	+104 %
	Sweden	-4.00 %	1.86 %	+5.86 %	+146 %
Grocery & Pharmacy Stores	Croatia	3.67 %	54.71 %	+51.05 %	+1,392 %
	Serbia	-2.00 %	35.86 %	+37.86 %	+1,893 %
	Sweden	-3.33 %	6.71 %	+10.05 %	+301 %
Public transport stations	Croatia	6.33 %	37.57 %	+31.24 %	+493 %
	Serbia	3.00 %	17.29 %	+14.29 %	+476 %
	Sweden	-4.33 %	-21.29 %	-16.95 %	-391 %
Parks and outdoor spaces	Croatia	26.33 %	320.43 %	+294.10 %	+1,117 %
	Serbia	42.33 %	46.43 %	+4.10 %	+10 %
	Sweden	-10.00 %	129.14 %	+139.14 %	+1,391 %
Workplace	Croatia	1.00 %	-3.29 %	-4.29 %	-429 %
	Serbia	-19.33 %	-13.57 %	+5.76 %	+30 %
	Sweden	-4.33 %	-15.00 %	-10.67 %	-246 %
Residential	Croatia	-1.67 %	-3.43 %	-1.76 %	-106 %
	Serbia	0.67 %	-6.00 %	-6.67 %	-1,000 %
	Sweden	1.33 %	3.00 %	+1.67 %	+125 %

The analysis suggests that lockdown have the strongest causal impact on increasing presence at home and reducing visits to workplaces, public transport hubs, grocery, pharmacies, open public spaces. The impact of public services closure and schools closure is significant but of a smaller magnitude. Results indicate that the most effective COVID-19 policies for reducing mobility are the public services and facilities closures, the partial lockdown and the full lockdown.

4. CONCLUSION

During the first wave of the pandemic, mobility plummeted across Europe. The effect was stronger in countries with stricter closure policies, while countries with policy-oriented or partial closures also significantly reduced mobility. The Covid-19 disease pandemic has so far had an unprecedented impact on transport in general, but on the sector as a whole, the consequences of which are being felt in the reduced number of passengers, and thus the financial consequences. A clearly visible side effect of the Covid-19 pandemic is less need for daily mobility. This can mainly be attributed to the expansion of teleworking, restrictions on movement imposed in countries and a declining sense of security in public transport. Long-term changes in teleworking or virtual mobility can result in temporal changes, including less frequent travel. Improving the accessibility of cycling and walking could improve traffic safety, health and the environment. During the pandemic, many cities began to expand their existing cycling and walking infrastructure, first as temporary solutions, only to gradually, wherever possible, make them permanent. Continuing the trend, many regulators will focus on environmental issues when adopting mobility guidelines. Urban mobility and, in particular, its management are going through a period of profound change to making sustainable mobility possible in towns and cities. After the COVID-19 pandemic, we valued life with better air quality and less noise. Restrictions on movement have shown us the extent to which our neighborhood streets and public spaces are essential to community cohesion. By suddenly entering the “new normality” we have learned the hard way that changing behavior at the community and individual level can happen at a much faster pace than we thought.

REFERENCES

[1] Badr, H.S.; Du, H.; Marshall, M.; Dong, E.; Squire, M.M.; Gardner, L.M. Association between mobility patterns and COVID-19 transmission in the USA: A mathematical modelling study. Lancet Infect. Dis. 2020, 20, 1247–1254.

[2] Lapatinas, A., The effect of COVID-19 confinement policies on community mobility trends in the EU, EUR 30258 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-19620-4, doi:10.2760/875644, JRC120972.Journal Article

[3] Apple reports on trends of mobility. [Online]. Available at: https://covid19.apple.com/mobility [Accessed Sep. 09, 2021].

[4] Google Community Mobility Reports reports [Online]. Available at: https://www.google.com/covid19/mobility/ [Accessed Sep. 09, 2021].

[5] World Health Organization. [Online]. Available at: https://www.who.int/ [Accessed June 27, 2021].

[6] Our World in Data. [Online]. Available at: https://ourworldindata.org/covid-google-mobility-trends [Accessed June 27, 2021].

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THE IMPACT OF THE COVID-19 PANDEMIC ON THE DEVELOPMENT OF THE MAAS

Key Words
MaaS
COVID-19
Urban mobility

Abstract

From a global perspective, international trends and the expansion of urban areas are the cause of increased demand for travel, and thus transport, which in turn leads to the impossibility of organizing the above in the same "neighborhood". As transport infrastructure measures are mainly based on the traditional benefit-cost ratio, new and innovative approaches to the transport sector are needed.

In this context, MaaS – Mobility as a Service, as a key emerging concept, aims to establish combined and / or integrated mobility as a service. The idea is to sell passengers a personalized package of multimodal mobility services (car sharing, public transport, taxi, bicycle), which is paid in only one transaction for each trip or time period, instead of separate transactions with each individual transport provider.

The digitalization trend and the global COVID-19 pandemic, which has increased teleworking and reduced demand for mobility, have also indirectly affected the development of this service. In that case, certain market sectors could develop, but in the current situation of the COVID-19 virus pandemic, collective transport is losing its share as a way of traveling. In the long run, COVID-19 could have a lasting impact on mobility as it encourages changes in the macroeconomic environment, regulatory trends, technology and consumer behavior.

1. INTRODUCTION

The occurrence of bottlenecks, traffic congestion, increased fuel consumption and environmental pollution are the fundamental problems of large urban areas, especially if it is a tourist area where the local population use the roads and visitors also who are always looking for some kind of transportation during or after their stay. Given certain criteria of local economic, social and environmental policy, mobility services should be adapted to different target groups, and without modern technical and operational solutions new services cannot be compatible with the current private transport system, which means that transport providers and the IT sector must be closely integrated into development, including a unique travel opportunity. The introduction of the MaaS (Mobility as a Service) concept is reflected in the reduction of dependence on private cars with a strong emphasis on changing the user's daily life. Thus, the concept is designed for all citizens to meet their needs for seamless travel mobility from point A to point B, ease of booking and payment of all integrated services through a single platform. Also, MaaS opens up the possibility for visitors to access a wide selection of public and private carriers via a digital platform at their fingertips. The trip for each user is planned separately according to the previously collected data on the demand and supply of transport services, combining them with information on the preferences of the participants themselves. Simply put, the traveler can plan, book and pay for any trip, anywhere and at any time.

2. MAAS CONCEPT

Public transport operators have made considerable efforts in recent years to provide a single public transport ticket in such a way as to enable all passengers to use the services of different carriers in the same city or region. However, following trends and the use of new modes of transport, changes in the lifestyle of younger generations, the trend of urbanization, changing user expectations, urban innovation, the rapid growth of technology - all of the above affects and shapes future mobility. Transport policy makers have been trying for years to make public transport more attractive to allow a gradual transition from private cars to more alternative modes of transport, which can mainly be achieved through new modern mobility technologies that must provide a high level of flexibility and accessibility [1].

With the introduction of the new Mobility as a Service (MaaS) trend, the situation will be visibly different, so the first key change will be that transport users and service providers communicate about their needs at some point through their digital service platform. Another key change is the emergence of a whole new package of shared services, which means that users will be freer in terms of their expectations, so multiple operators (multiple types) of transport services will specify more accurate features of the transport service: arrival time, origin and destination, degree of flexibility, type / the level of comfort required, the price he is willing to pay, etc. By offering a wide range of services, providers will be able to accept or reject users, depending on their expectations, while regulators will easily monitor service availability and adjust market strategy and policy decisions accordingly. This should result in customer-led services that adapt to real market conditions at any time and in any place, to the general benefit of all stakeholders involved [2].

2.1. Brief History About MaaS

Nico Tschanz and Hans-Dieter Zimmermann presented the first vision of the concept of mobility as a service (MaaS) in 1996 at a conference in Innsbruck, Austria. Their idea was a "smart information assistant" that will be used as a platform for transport service providers where they can search, combine and book trips as well as access to other services such as hotel reservations, insurance purchases, etc. [3].

Sampo Hietanen, CEO of a non-profit organization from Finland that deals with the improvement of intelligent transport, presented the concept of MaaS, in the true sense of the word at a conference at the Heurek Science Center, 2014. His basic idea was based on observing mobility through the needs of users who should replace the purchase of a car by purchasing services and combining different modes of transport, in order to optimize the flow of traffic. For this concept to work, switching from one means of transport to another must be as easy and comfortable as possible for users, and all transport must stand behind one service, application, where laws and regulations must be aligned with user and application interfaces, technology and billing options [1].

2.2. Application *WHIM*

The concept underlying the MaaS is that urban mobility must become fully multimodal, while access to a wide range of services will be coordinated through different service providers, given the fact that the digital revolution can offer new opportunities for all involved. To trust the MaaS service provider that manages the platform and join the integrated mobility offering, business partners expect impartiality and fairness to be stable and reliable enough to stay in the market in the long run. Mobile service operators must also have full confidence that the MaaS service provider will provide quality service to its customers. As the development, deployment and effective implementation of MaaS rely heavily on data availability and management, issues related to data exchange and related business models should be considered as part of the urban mobility tool and strategy.

In order for the MaaS to develop, public authorities need to facilitate access to and availability of high-quality data and must set up a framework to ensure that they themselves have access to data from different (public and private) data sources. Using information obtained and collected in real time on the demand and supply of transport services and combining them with information about customers, the service provider (MaaS Provider) plans trips for users, tailored to their needs, where to travel, when to be at destination, etc.) and wishes (choice of means of transport, with whom they want to travel, what additional services are offered during the trip, etc.). The trips may consist of several sections on which the service is provided by different companies, but for the passenger it is only one trip, which is arranged by one instance and contact. The same instance agrees with the client on a payment solution that allows him to pay for the trip in one transaction, either for one trip or through an account that is charged once a week or monthly [4].

Whim was first introduced in 2015, after which the application as such expanded to other cities (Antwerp, Birmingham and Vienna) and also began working with carriers in two major Asian cities, Tokyo and Singapore. With a subscription to Whim and its mobile app, the user can purchase a public transport ticket, order a taxi and rent a car or public bicycle. Whim has different pricing models - pay on the go, subscription to fixed price modes offered, or a combination of the above [5].

3. MAAS AND THE COVID-19 VIRUS PANDEMIC

MaaS's ambitions go beyond simply launching for a smartphone app, which facilitates access to a range of mobility services. The desire to adopt the concept as a solution is widely supported with the primary goal of achieving ambiguity in urban mobility, in order to reduce the negative impact of increased external costs. Currently, advocating for the benefits of multimodality is a major challenge. Experts argue that attention must be focused on a horizon that does not require such radical changes in everyday life. Certain market sectors could develop, but in the current situation of the COVID-19 virus pandemic, collective transport is losing its share as one of the modes of travel. Also, the largest metropolises around the world are committed to achieving reduced CO_2 emissions by 2050. The Paris Agreement and several United Nations documents highlight the need to reduce greenhouse gas emissions by 40% over the next 10 years. Experts argue that efforts to achieve the goal must focus on reducing local travel, ie distances that are less than 80 kilometers because they make up 70% of all emissions. In this context, the MaaS seems to be the only way to launch the much-needed promotion of modalities and decarbonisation of transport, simplifying and expanding access to alternatives to private vehicles [6].

The COVID-19 virus pandemic, which followed in early 2020, was an economic shock for many sectors, showing a significant drop in GDP for many EU countries. In the long run, COVID-19 could have a lasting impact on mobility as it encourages changes in the macroeconomic environment, regulatory trends, technology and consumer behavior [7].

Trends, however, may vary by region, so the responses and outcomes of mobility professionals will vary by location. The public transport sector is particularly affected, both large-scale travel (air, rail, bus transport) and daily travel. During the lock-up period, the use of urban public transport has dropped dramatically to avoid social contact and reduce the risk of infection. Routine activities such as work, study, socializing, shopping, etc., are now performed safely, within the four walls of the house. The first change is reflected in the reduction of demand for mobility, and the reason for this is the restrictions and implemented measures that have led to a reduced need for transport, but also to a positive impact on the environment to reduce greenhouse gas emissions.

As the pandemic continues, physical distance has and will have a significant impact on behavior and mobility tendencies. Many will switch to a mode of transportation that reduces the risk of infection, but the exact shifts will largely depend on their habits before COVID-19. People who own a private vehicle will increasingly use it, while those who previously relied on public transportation could switch to other means, such as cycling or walking.

Since the start of the pandemic, cities have gradually taken steps to slow the spread of the virus in public transportation. These are the measures taken at the earliest when the pandemic began, so locking measures reduced people's ability to move around the city, and their relaxation and ability to move more freely was accompanied by fear of using public transportation. According to experts, the risk of infection in public transport is related to the time of exposure, the behavior of drivers and the use of self-protection measures, the large number of people and ventilation conditions [8].

According to several studies conducted in Germany, France, the UK, the US and Japan, the risk of contracting COVID-19 while traveling by public transport is between 0% and 1.2%. In order to respond to the concerns of passengers, cities and road authorities responded to the situation by implementing the following measures: establishing new protocols for regular cleaning of vehicles and buildings, the use of masks, automatic opening / closing door when entering / exiting passengers, limiting the capacity of the vehicle, the use of funds for disinfection, regular air ventilation, physical distancing, contactless payment and increasing the frequency of services during peak hours.

The crisis of reduced mobility has also impact shared mobility services and e - scooter, bicycle, moped and car service providers. Most people did not believe that car sharing and shared micro-mobility (bicycles, e-scooters and mopeds) were a safe option to travel during the pandemic, which posed serious challenges for cities and service providers looking to increase the share of more sustainable modes of mobility. During the first months of the pandemic and subsequent closure, several cities took action in this regard. If no active measures are taken to get people back to using public and active modes of transport after a pandemic, cities will move from blockade to standstill. Such measures will need to specifically address people’s mistrust or fear, as well as other mobility-related behaviors developed during a pandemic. A measure taken by many cities during the pandemic and particularly highlighted in the media is the widening or creation of new bike lanes, in many cases, taking up space from motor vehicles and giving it to bicycles. Not only has the incentive to use bicycles been in line with many mobility strategies, but it has also proven to be a noticeably safe way to travel during a pandemic. In many cities, some time is needed to improve the infrastructure of bike paths, and the pandemic has helped speed up those plans.

Temporary infrastructure, better known as pop - up bike paths, has proven to be a good strategy and as such can be considered a viable solution. It seemed likely that cities learned a lot during the first wave and are now implementing it, while adapting short-term actions to long-term measures, and also applying strategic planning for long-term change and investment. Most thinking and learning is at a very early stage, and much of the strategic thinking has been put on hold during the crisis. So far, the actions have been mainly based on the city's own experience, and there is a significant difference in the actions taken as well as on the perceived need for longer-term changes in mobility strategies and innovative transformation of the mobility system. At the same time, the exchange of ideas and solutions is increasingly supported by a multitude of resources, gathering good examples, reports and research, creating a multitude of knowledge from which cities can benefit. This is valuable because long-term strategic decisions in cities on the future mobility system must be based on best practice, taking into account both the pandemic and the wider set of requirements for sustainable urban systems.

4. CONCLUSION

MaaS has the potential to bring various benefits to cities, which largely depend on the market structure and the chosen operational model, as well as the governance model, service specifics and the involvement and effectiveness of all factors, including local / regional / national authorities. In fact, users are offered the opportunity to easily choose the mode of transport that best suits their requirements for each individual trip. MaaS can take into account general user preferences related to travel aspects such as speed, comfort, safety, price, etc. It could also provide better intermodal connectivity within the region. Although traditional public transport services, such as buses, trams and taxis, are well used in urban centers, the same does not apply to suburban and rural areas and to services provided early in the morning or late in the evening. A clear view of all modes of transport will make the real cost of mobility more transparent, and an efficient combination can save costs for users. Also, it could be used for social inclusion, reduced isolation and improved access to services, education, employment and social interaction. A tailored approach to the MaaS can offer inspiration for the development of sustainable transport solutions for all citizens, especially those who find it difficult to use traditional public transport, such as the elderly and the disabled, facilitating access to door-to-door transport. This creates a situation in which the essence and format of innovation and mobility need to be considered, with learning in the practical part. It is necessary to take action in the coming years, both short-term and long-term, in order to transform mobility systems in line with future requirements. This drive for transformation, the many stakeholders involved, the complexity of the challenges and the size of funding are parameters that emphasize the need for cities to prepare and organize for innovation. In conclusion, there is an urgent need for innovative measures and the transformation of the mobility system.

REFERENCES

[1] N. Domjan, “Mobility as a Service”, graduate thesis, University North, July 2021., pp. 26-27.

[2] M. Enoch, “Mobility as a Service (MaaS) in the UK: change and its implications”, Foresight, Government Office for Science, December 2018.

[3] S. Hietanen, “A Brief History of MaaS Global, the company behind the Whim app”, March 2019.

[4] ERTICO – ITS Europe, “Mobility as a Service (MaaS) and Sustainable Urban Mobility Planning”, European Platform on Sustainble Urban Mobility Plans, September 2019., pp 12-17.

[5] Y. Crozet, J. Coldey, “Mobility As A Service (Maas) - a Digital Roadmap For Organisational Authorities”, CERRE: Centre on Regulation in Europe, January 2021.

[6] McKinsey & Company, “The impact of COVID-19 on future mobility solutions”, May 2020.

[7] G. Lozzi, E. Marcucci, V. Gatta, V. Pacelli, M. Rodrigues, T. Teoh, “COVID-19 and urban mobility: impacts and perspectives”, rapid-response briefing, European Parlament, September 2020., pp. 13-20.

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SIMPLE - SIMPLE SOLUTIONS FOR MORE SAFETY FOR VULNERABLE ROAD USERS

Key Words

Vulnerable road users

Multimodal sensors

I2P/P2I

Mobile app

Abstract

In the research project SIMPLE (road Safety IMProvement for vulnerabLE users), we are currently developing a real-time capable system for assessing the traffic situation at confusing intersections and a warning system by an interdisciplinary project team – with the aim to improve the safety of all road users.

The focus is on the automatic prediction of conflict situations with the help of audiovisual sensors and the timely transmission of information to all affected road users - from pedestrians to autonomous vehicles.

The research team is currently developing a mobile phone app and is testing various signaling variants using sound and / or vibration. A major challenge here is that the signal must be clear, reliable and distinctive in order to neither distract nor fail its effect.

If necessary, people with visual, hearing and mobility impairments can request an extension of the crossing time at the traffic lights. When an emergency vehicle approaches, an early warning is given, and the emergency vehicle is given priority.

The further development of the system is intended to provide general safety information about where dangerous crossings are and how and where it is safest to cross the road.

Currently the technical environment for tests to be conducted in 2022 is defined and implemented. The tests will be performed with vulnerable road user – specifically people with disabilities – at selected traffic junctions.

1. INTRODUCTION

An almost real-time detection of the current traffic situation is an important technical support solution in traffic management. The aim of SIMPLE is to automatically determine movement paths of road users and based on that detect dangerous situations for optimal protection of vulnerable road users. Based on the results of the FFG project SIMMARC [1], the development of an expanded and improved demonstrator system in terms of real-time capability and functionality is underway. This system intends to meet the requirements of continuous operation, scalable to different intersection topologies, based on near real-time multisensory data analysis.

The following goals are pursued in developing this demonstrator system:

(1) Development of components for analysing sensor data (from camera and microphones) to capture the traffic situation in real time. That includes classification, localization, and the estimation of speed and direction of travel of road users.

(2) Development of a component that calculates collision probabilities and generates warning messages, not only about possible collisions, but also about the stay of road users in difficult conditions to report critical areas.

(3) Development of a mobile application to inform vulnerable road users on potentially hazardous situations using acoustic and visual signals, depending on the whereabouts in the intersection area. Also, the location of a disabled person using this app will be reported to the local C-ITS infrastructure (P2I).

(4) Interfaces to existing and deployed C-ITS systems with the option to transmit warning messages to people (infrastructure to person I2P) and vehicles (infrastructure to vehicle I2V).

2. METHOD

As a first step, the relevant requirements for the system were collected and documented. In addition to the purely technical requirements for the selection of sensors and standardized communication protocols, the requirements from different focus groups (pedestrians and disabled people) regarding the needed support was investigated. Specific interest was put on collecting views on how the system can provide warning information to vehicles and target groups (informative, engaging, visually, auditory, tactile, in combination).

In parallel the architectures of the hard- and software systems for the novel system for the warning of vulnerable road users in C-ITS enabled environments were defined.

2.1. Requirements of target groups and vulnerable road users

With the involvement and co-coordination of the Forum Besser Hören - Center for the hard of hearing in Carinthia/Austria as well as the Blinden- und Sehbehindertenverband Kärnten (Association of the blind and visually impaired Carinthia/Austria) and Neuroth (a company providing inter alia hearing aids), small workshops and expert interviews with various target focus groups took place (the participants were hearing and / or visually impaired, physically impaired, unimpaired).

As a result of these discussions, a questionnaire was created to capture the specific requirements of the various target groups in connection with the use of the infrastructure and the interaction with other road users.

The main questions were:

- How are different situations in the street space perceived?
- What are the problems in connection with these situations?
- How can SIMPLE support these target groups?
- In what form can users be additionally supported (auditory, visual, tactile, in combination)?
- How are different use scenarios of SIMPLE assessed?

2.2. Software architecture

The architecture of the envisaged demonstration system with its software components and interfaces is shown in Figure 1 and is inspired by SIMMARC [2]. The sensor data analysis and thus the recording of the traffic situation takes place within the video and audio analysis components, which produce geo-referenced position data for road users. The audio analysis application consists of two parts: a classification part and a localization part. Both work in real time and have the highest possible classification and localization performance.

The traffic situation analysis component determines from the position, direction and type of road users on which routes (towing curves, pedestrian paths defined by the traffic route plan) they are traveling. With additional speed and acceleration data, collision predictions are made. Using a rule-based definition of potentially hazardous situations, the traffic analysis application then determines whether a warning should be issued. The description of the warning situation, the position of the road users to be warned and the estimated time until the potentially dangerous situation occurs are then transmitted to the mobile app gateway.

The task of the mobile app gateway is, on the one hand, to forward the collision warnings to the road users concerned (mobile phone user application), and to report the positions of road users using the SIMPLE mobile app to the traffic analysis component. On the other hand, it communicates with the C-ITS gateway and forwards warning messages from the traffic situation analysis component or requests for traffic light control as well as position data from mobile app users to the C-ITS infrastructure, i.e. to control traffic lights (e.g. to extend a green phase). Direct communication with autonomous vehicles is not planned within the scope of the project. But C-ITS messages emitted by the SIMPLE System could be received by autonomous vehicles or the SIMPLE mobile app could also be used in vehicles.

The messages to the mobile phone application are to be sent via a mobile network (UMTS or LTE) in the form of standardized CAMs (Cooperative Awareness Messages) and DENMs (Decentralized Environmental Notification Messages), which are mainly used today in research on V2X communication in autonomous vehicles. For traffic light control the use of SRE/SSE in combination with MAP and SPAT messages is envisaged. The communication between the mobile app and the Simple System is REST-based.

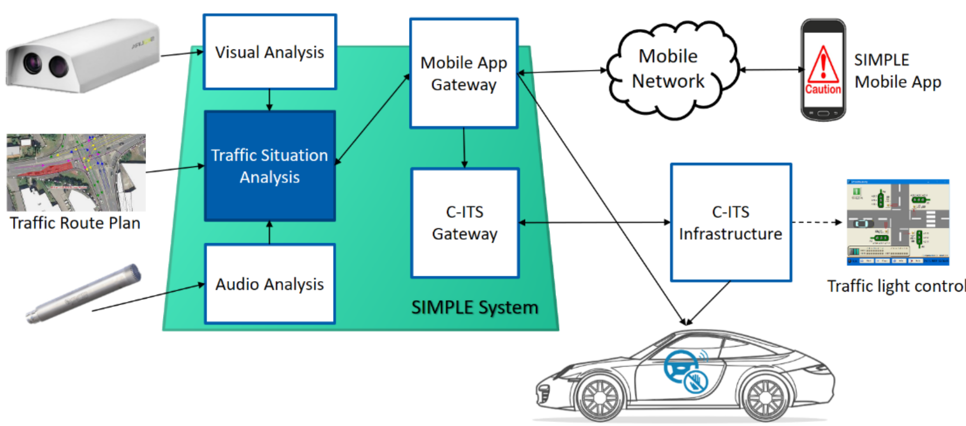

Figure 1. Software components and interfaces of the SIMPLE demonstration system (© SIMPLE consortium)

2.3. Deployment

Video cameras and directional microphones are used as sensors to record the traffic situation. Additional data on the location of road users come from the mobile phone application, which is also used to warn road users.

In order to be able to cover the largest possible surveillance area with a camera, a light-sensitive wide-angle camera is used. The AXIS Q1615 MK III camera with a wide-angle lens (horizontal 115 °) has been selected for use in the project.

For the audio analysis a microphone array was chosen, that was suitable for outdoor applications and thus be waterproof and windproof.

Bluetooth tokens will be used in order to enable more precise localization of pedestrians (who use the mobile application) on selected positions (e.g. traffic light posts).

2.4. Field of use and demonstration

For the selection of suitable test regions and ultimately also potential marketing areas, an Austria-wide screening was carried out. Different types of intersections were recorded and categorized according to the following criteria:

- Control type (unregulated, with priority control, signal-controlled)
- Equipment of the signal system
- Existing user groups and means of transport

For the pilot study the following three scenarios are considered:

(1) Extension of the green phase of the traffic lights for certain users

(2) Influencing the traffic lights program and warning to road users via the mobile app when an emergency vehicle is approaching

(3) Warning road users via the mobile app when turning right and the crossing of a pedestrian occurs at the same time

3. RESULTS

3.1. Focus groups and vulnerable road users

At the beginning of the year 2021, 127 people across Austria were asked about their satisfaction and how they felt in various traffic situations using questionnaires. Amongst the participants, 20 were visually impaired, 9 were hearing impaired and 9 were both visually and hearing impaired.

It showed that additional support is particularly required at unregulated intersections without a zebra crossing and without traffic lights, but also at regulated, but very confusing crossings. Additional support would be very important for 34% respectively 22% of the interviewees (see Figure 2).

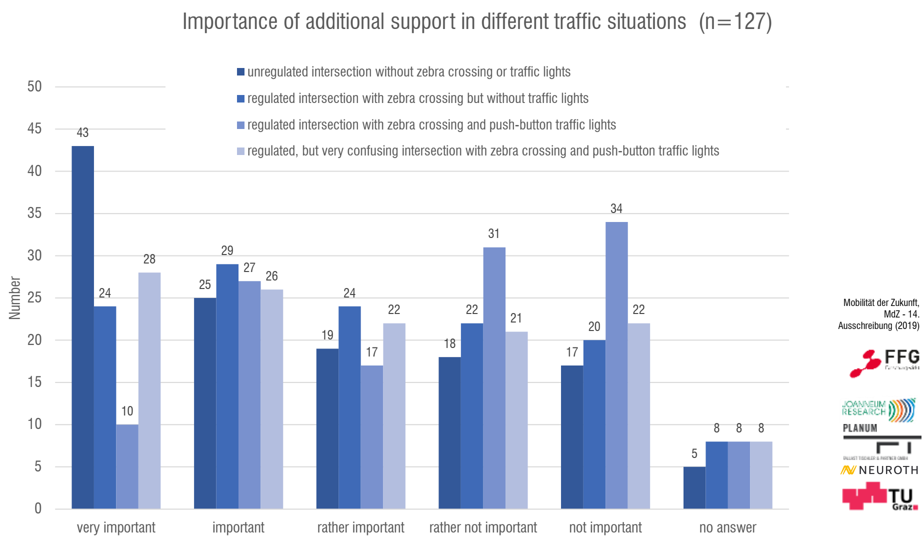

Figure 2. Importance of additional support in different traffic situations (© SIMPLE consortium)

Emotions such as anger, fear and stress are very high at unregulated intersections without a zebra crossing and without traffic lights. Confidence is highest when there are regulated intersections with a zebra crossing and a push-button traffic light (see Figure 3).

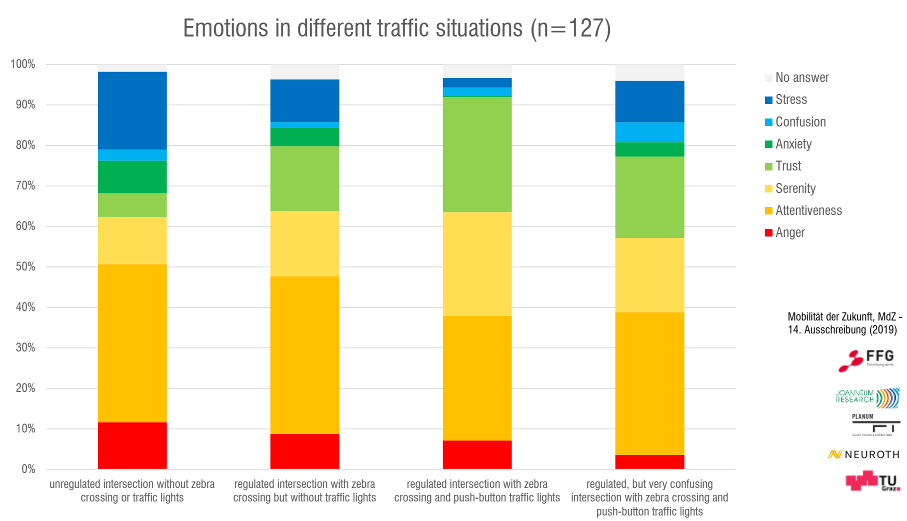

Figure 3. Emotions in different traffic situations (© SIMPLE consortium)

The most prominent requirements of the interviewees were data protection, ease of use of the app (few interactions and few settings), individually configurable notifications / signals, and a system that could be used internationally and could be switched on an off as required.

The interviewees spoke out for longer green phases at traffic lights for visually impaired, hearing impaired or mobility impaired people. The signals used to provide information on the traffic situation should be unambiguous, reliable and distinctive.

3.2. Multimodal Traffic Analysis

The visual traffic analysis is working in several phases. In the first phases road users are detected by means of a deep-learning based, object detection method. This gives 2D-bounding poxes and classifies the road users in several types (pedestrian, bicycle, motor-bike, car, truck, bus etc). Additionally, significant points are extracted and tracked. Based on the 2D-bounding box, the tracked points, and the calibration information the 3D-bounding boxes are derived and from that estimates for the velocity and acceleration. Figure 4 shows one frame with the visualization of the detected road users.

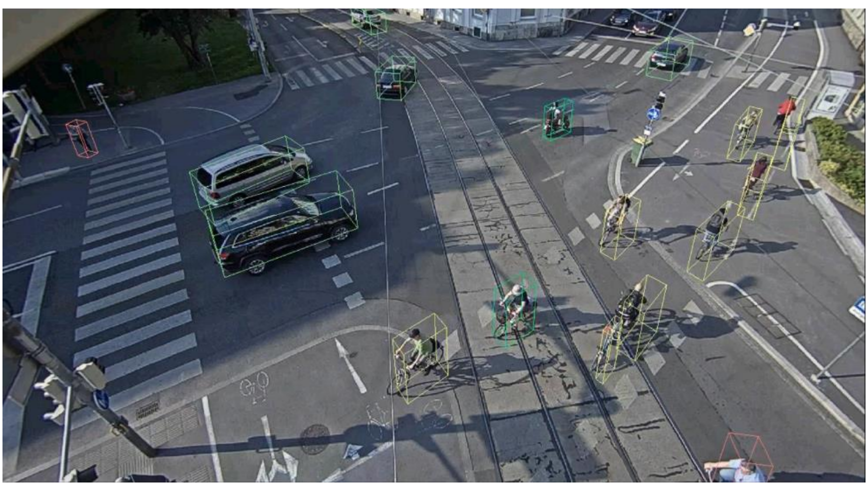

Figure 4. Results from the visual traffic analysis. The 3D-boxes show the position and type of the different road users.

For the detection of martin horns, a dataset of approximately 45 days, recorded in a previous project [1] has been used for development and evaluation. As the martin horn is a very loud and distinct event, it can be detected reliably. On our test set of 10 hours, which contained approximately 10 minutes of martin horn, we achieved a frame-wise detection F-measure of 95.9%. The most common confusion is with car horns, which sound very similar, especially if the martin horn is only activated for a short period.

4. CONCLUSION

The approach presented in this paper aims on improving the safety of vulnerable road users in future situations where autonomous vehicles will be more and more prominent. By providing them with a mobile app, they can participate on an equal footing in C-ITS-using traffic scenarios, and so get “visible” earlier to autonomous vehicles. The design of the user interface of such an app is of particular importance as the app users have on the one side, to be reliably informed about potential hazardous situations and on the other side, must not be distracted from monitoring the traffic situation.

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REFERENCES

[1] Krebs F., Thallinger G., Neuschmied H., Graf F., Huber G., Fallast K., Vertal P., Kolla E., Evaluation of SIMMARC: An Audiovisual System for the Detection of Near-Miss Accidents, In: Martins A., Ferreira J., Kocian A. (eds) Intelligent Transport Systems. From Research and Development to the Market Uptake. INTSYS 2019. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 310. Springer, Cham. https://doi.org/10.1007/978-3-030-38822-5_13

[2] Thallinger G., Krebs F., Kolla E., Vertal P., Kasanický G., Neuschmied H., Ambrosch K. (2018) *Near-Miss Accidents – Classification and Automatic Detection*. In: Kováčiková T., Buzna Ľ., Pourhashem G., Lugano G., Cornet Y., Lugano N. (eds) Intelligent Transport Systems – From Research and Development to the Market Uptake. INTSYS 2017. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 222. Springer, Cham. https://doi.org/10.1007/978-3-319-93710-6_16

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DEVELOPMENT OF URBAN MOBILITY FOR INTRODUCTION OF A PEDESTRIAN ZONE IN THE CENTER OF BITOLA USING A MICROSIMULATION MODEL

Key Words
Sustainable Urban Mobility Plan
City of Bitola
VISSIM

Abstract

The SUMP – Sustainable Urban Mobility Plan – introduced by the European Union in 2013, is a strategic mobility tool intended to promote sustainable activities at an urban level. The SUMP wants to improve the quality of life of citizens and to involve people and stakeholders in the decision-making process. SUMP contributes to achieving balance of social equity, environmental quality and economic development. It represents a new approach to traffic planning and does not replace, but complements and builds on the existing strategic documents of the city. Consequently, in the process of traffic and urban development, walking, cycling, public transport should be put into the first place, and then the use of private cars in a sustainable way. This paper is focused of developing sustainable urban mobility plan in center of city Bitola for safe urban space. In order to protect pedestrian and bicycle traffic, two variant of traffic solutions are envisaged, which envisage closing part of the streets for traffic, connection with a pedestrian street which result with continuous pedestrian street, introduction of a zone of calm traffic, application of a "contra-flow" bicycle lane on streets with one-way traffic regime and "Zone 30". For the variants of the traffic solutions were used a microsimulation model VISSIM.

1. INTRODUCTION

The SUMP – Sustainable Urban Mobility Plan – introduced by the European Union in 2013, is a strategic mobility tool intended to promote sustainable activities at an urban level. As key components, this requires a thorough assessment of the current situation and future trends, a widely supported common vision with strategic objectives, and an integrated set of regulatory, promotional, financial, technical and infrastructure measures to deliver the objectives – whose implementation should be accompanied by systematic monitoring and evaluation. The development and implementation of the Sustainable Urban Mobility Plan (SUMP) aims to reduce the negative impact of transport, improve the accessibility of persons and provide high quality of life, integrated and combined solutions and services for the movement of persons and goods. In contrast to traditional planning approaches, SUMP places particular emphasis on the involvement of citizens and stakeholders, the coordination of policies between sectors (especially transport, land use, environment, economic development, social policy, health, safety, and energy), and broad cooperation across different layers of government and with private actors [1] [2]. The concept also emphasises the need to cover all aspects of mobility (both people and goods), modes and services in an integrated manner, and to plan for the entire "functional urban area", as opposed to a single municipality within its administrative boundaries.

In this paper is presented introduction of beginnings for future development of SUMP in center of the city Bitola for safe urban space. In order to protect pedestrian and bicycle traffic, two variant of traffic solutions are envisaged, which envisage closing part of the streets for traffic, connection with a pedestrian street which result with continuous pedestrian street, introduction of a zone of calm traffic, application of a "contra-flow" bicycle lane on streets with one-way traffic regime and "Zone 30". For the variants of the traffic solutions were used a microsimulation model VISSIM. Traffic modelling and simulation is one of the frequent tools used in road infrastructure design. Software tools designed for traffic simulations are an important supportive tool in decision-making and in choosing the optimal solution. The traffic on the selected area is modelled and simulated.

2. RESEARCH AREA PROBLEM

The subject in this paper is proposal of variant traffic solutions for improvement of the overall level of traffic service and increase of the safety of all traffic participants for street network in the central city area in Bitola. The purpose is to assess the operational performance of the existing street network and determine the impact of the planned changes in the traffic regime on the street network in the central city area in Bitola.

The problem in the central city area is congestion. The current situation of traffic in the city center of Bitola result with congestion from the large volume of traffic and parked vehicles in the city center is located the main pedestrian street Sirok Sokak which is intersected by a street for motor traffic. Pedestrians and cyclists do not have their own movement areas, so safety is on low level.

The limits of the research scope are:

- to the north: 1st of May boulevard;
- to the west: st. Kuzman Josifovski, st. Borka Levata and st. Stevo Patako;
- to the south: st. Solunska;
- to the east: st. 4th November.

The spatial scope also includes the approaches to the intersections that are on the border of the spatial scope, in a length of at least 20 meters. The boundary of the spatial scope is shown in Figure 1.

2.1. Research methodology

In order to make optimal traffic solutions for the central city area in Bitola, activities were undertaken for data collection from basic documentation and traffic research on terrain which includes:

- manual counting and classification of vehicles according to the directions of intersections;
- manual counting of pedestrians at pedestrian crossings;
- manual recording of vehicle license plates on cordon;
- manual measurement of time and speed of travel on the route;
- monitoring the behavior of drivers in conditions of free flow and when standing in a column of vehicles.

Locations of terrain researching are presented on Figure 2.

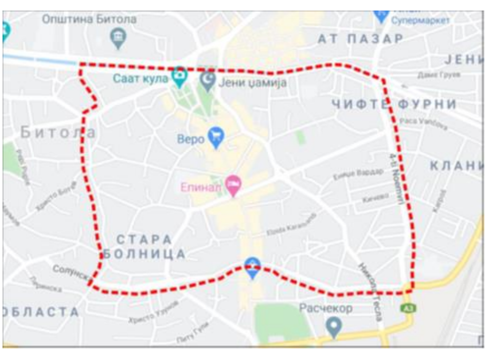

Figure 1. Boundary of the spatial scope

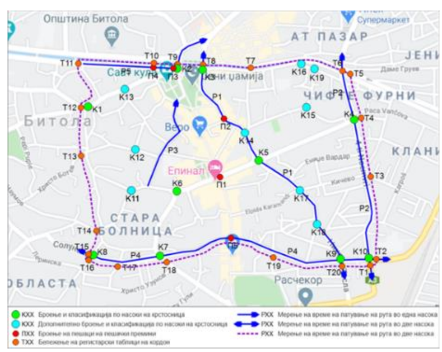

Figure 2. Locations of terrain traffic research

The purpose of terrain research is to obtain information about the total the traffic load at the intersections in order to determine the peak hour in the morning or afternoon period and the relevant hourly traffic load, as well as obtaining information on the distribution of flows by directions of movement and the structure of the flow. At most intersections, the traffic load is highest in the period from 15:00 to 16:00, due to which this period is determined as the peak hour.

2.2. Results of data collection

The total number of vehicles as well as the number of vehicles by vehicle categories in the peak hour for each intersection is given in Table 1. It can be seen that from the analyzed intersections, the busiest intersection is the intersection K5 (Nikola Tesla St. - Dimitar St. Ilievski Murato), while the smallest number of vehicles appears at the intersection K1 (street Kuzman Josifovski - Pitu and street Car Samoil).

Table 1. Relevant traffic load for characteristic intersections

Intersection	Cycle	Motorcycle	Vehicles	BUS	TV	Total
K1	31	38	354	1	5	429
K2	33	41	1178	11	22	1285
K3	19	24	926	2	35	1006
K4	25	30	986	21	119	1181
K5	56	68	1272	2	72	1470
K6	15	18	748	1	30	812
K7	63	76	908	1	40	1088
K8	18	23	669	0	22	732
K9	10	13	674	13	12	722
K10	23	28	1086	28	117	1264

The results of the pedestrian counting of pedestrian flows for the peak hour indicate that in the spatial scope, pedestrian flows are most pronounced at the pedestrian crossings located on the streets Dimitar Ilievski - Murato and Solunska which intersect with st. Sirok Sokak.

Based on the cordon recording of the license plates in the peak hour, results were obtained that refer to the number of vehicles entering and leaving the cordon. From the performed analysis of the registered license plates of the vehicles that entered or left the cordon, it was determined that more than 50% of the vehicles made transit, i.e. did not complete the trip in the spatial scope.

According to the results obtained from the observation of the drivers' behavior show that in 85% of the cases the drivers in free flow conditions move at a speed of up to 35 km/h, while the average distance between vehicles standing in a column is 1.6 meters.

3. DEFINING OF TRAFFIC VARIANTS

In defining variants process, respectively proposed measures in them, the concept of planning sustainable urban mobility with a focus on people and places and ensuring accessibility and quality of life in order to deal with problems related to urban transport (traffic congestion and air pollution) and moving to a new one culture of urban mobility. This implies prioritizing spaces for walking, cycling and public city passenger transport.

Two variant solutions for phase realization are proposed.

Variant 1 which provides for the following major changes in traffic mode:

- transformation of the parking lot at the House of Culture into a public space – square,
- establishment of two-way traffic on Vienenska Street only for residents and visitors of accommodation facilities,
- closure for traffic of motor vehicles on part of st. Pece Maticevski and Dimitar Ilievski - Murato on the move from entrance / exit in Hotel Epinal to the building of the former JAT and transformation into a pedestrian zone, ie merging with the pedestrian street Shirok Sokak,
- introduction of "Zone 30" on the streets in the area covered by spatial conditions for providing sidewalks with a minimum width for safe pedestrian traffic, and
- introduction of "Zone of calm traffic" on streets in the area of coverage where there are no space conditions for providing sidewalks with a minimum width for safe pedestrian traffic with treatment at the entrance to the street.

The proposed traffic solution for variant 1 according the above changes in traffic mode is given in Figure 3.

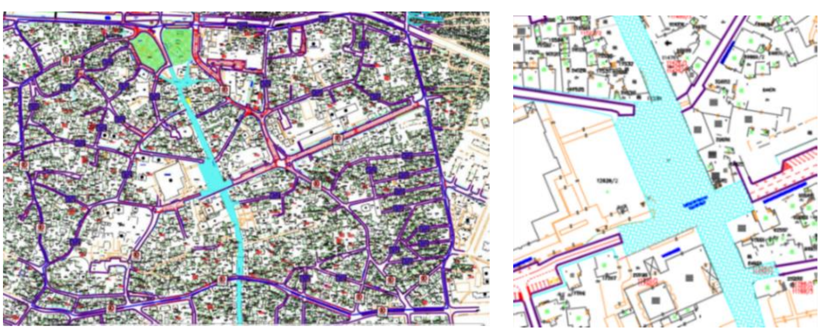

Figure 3. Proposed traffic solution for variant 1

Variant 2 which provides for the following major changes in traffic mode:

- retention of changes from variant 1,
- change of the existing one-way traffic regime and introduction of one-way traffic regime on streets with existing two-way traffic regime,
- application of "counter flow" bicycle lane on the streets with one-way traffic regime and "Zone 30",

- closing for motor vehicle traffic on st. Wide alley of move from st. Jorgo Osmano to Blvd. May 1st and transformation into pedestrian zone, i.e. junction with pedestrian street Shirok Sokak,
- introduction of two lines for public city passenger transport,
- removal of street zone parking on st. Car Samoil and st. Borka Levata,
- transformation of part of st. Josif Josifovski in a pedestrian street in accordance with the approved basic traffic project, and
- transformation into a pedestrian street on a branch of Blvd. 1st May at the school St. Cyril and Methodius to the intersection with st. Nikola Tesla.

The proposed traffic solution for variant 2 accordingly the above changes in traffic mode is given in Figure 4.

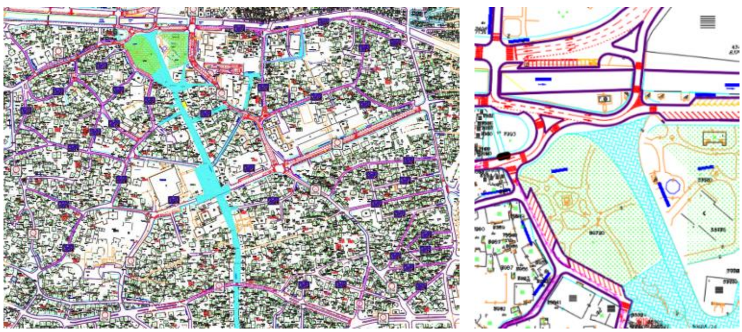

Figure 4. Proposed traffic solution for variant 2

4. DEVELOPMENT OF MICRO - SIMULATION MODEL

For the development of the micro-simulation model, i.e. making a microscopic dynamic simulation, the tool for micro-simulation modeling VISSIM was applied. The primary goal of the micro-simulation model is to evaluate the operational performance of the existing and street network as well as to determine the impact of the planned changes in traffic regime on the street network in the spatial scope. The process of developing the basic model for the base year in VISSIM in principle consists of three parts:

- modeling of a network of roads,
- entering traffic data, and
- calibration and validation of the model.

The network of roads, which is located in the spatial scope, is shown in Figure 5.

The process of creating models for scenarios in principle consists of 3 parts:

- defining scenarios,
- assessment of the future traffic demand,
- changes in the traffic network and transport service.

Figure 5. Network of existing roads in VISSIM

Traffic analysis includes performance at the intersection and corridor level performance in the microscopic simulation model developed in VISSIM for the current situation and proposed variants in the three time sections.

5. CONCLUISION

Planning for Sustainable Mobility is a strategic way of tackling transport and transportation problems in the modern way of life.

The development and implementation of the Sustainable Urban Mobility Plan (SUMP) aims to:

- reduce the negative impact of transport
- improve the accessibility of persons and provide high quality of life
- integrated and combined solutions and services for the movement of persons and goods

Unlike conventional methods of traffic planning which are constituents of all traffic studies done in the previous period, the contemporary method incorporated in SUMP means a significantly wider array of instruments of traffic demand management. The measures proposed in this manner mean a great number of soft measures of the encouragement of greater use of sustainable transport means.

The results for the cross-level effectiveness measures show that variant number 1 offers slightly better performance than variant number 2, but in order to encourage a change in travel habits by creating better conditions for the use of sustainable modes of transport.

The closure of the streets in question does not have a major impact on motor traffic, but it does have a major impact on the development of pedestrian and bicycle traffic.

The development of urban mobility affects the reduction of motor traffic in the downtown area.

REFERENCES

[1] Guidelines. Developing and Implementing a Sustainable Urban Mobility Plan, European Commission, 2014.

[2] Guidelines For Developing and Implementing a Sustainable Urban Mobility Plan, 2019

[3] Garau, Chiara, Francesca Masala, and Francesco Pinna. "Cagliari and smart urban mobility: Analysis and comparison." (2016)

[4] Memo – green paper "Towards a new culture for urban mobility"

[5] CH4LLENGE Monitoring and Evaluation Manual: Assessing the impact of measures and evaluating mobility planning processes, European Commission, Brussels, 2016.

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APPLICATION OF A LOGIT MODEL IN PUBLIC TRANPSORT MODELLING – CASE STUDY OF CITY VELIKA GORICA

Key Words

Trips

Statistic method

Similar geographic characteristics

Socio-demographic characteristics

Abstract

Transport modelling represent one of tools that help various researchers and engineers in the field of transport planning and engineering. Using transport modelling can help to detect the number and characteristics of trips for specific area or regions. Trips can be separated regarding to transport mode (e.g., car, bicycle, public transport, walking, etc.). Public transport has shown numerous benefits comparing to private cars. Determine real and possible number of trips of every transport mode are achieved by using logit model. Logit model is mostly used statistic method for detecting modal split in transport modelling. Data collected by survey conducted in the City of Velika Gorica will be used to calculate logit model of trips. Trips will be separated between public transport and private cars. Goal of paper is creating a logit model that can be used as an initial model in other cities that have similar geographic and socio-demographic characteristics.

1. INTRODUCTION

Transport planning as general idea of creating future sustainable transport systems today is practically impossible without transport modelling, especially in the cities. Transport modelling represent one of tools that help various researchers and engineers in the field of transport planning and engineering. Using transport modelling can help to detect the number and characteristics of trips for specific area or regions.

Trips can be separated regarding to transport mode (e.g., car, bicycle, public transport, walking, etc.). Public transport has shown numerous benefits comparing to private cars. Determine real and possible number of trips of every transport mode are achieved by using logit model. Logit model is mostly used statistic method for detecting modal split in transport modelling. Data collected by survey conducted in the City of Velika Gorica will be used to calculate logit model of trips.

Trips will be separated between public transport and private cars. Goal of paper is creating a logit model that can be used as an initial model in other cities that have similar geographic and socio-demographic characteristics. Paper consists of literature overview, methodology and data collection, public transport model and conclusion.

2. LITERATURE OVERVIEW

Literature overviews consist of seven papers that main goal is presenting different segment of public transport modelling. First paper [1] defines that requiring not only a well-functioning assignment method, but also reliable passenger data to create transport models. Reliable passenger data means a time-dependent origin-destination matrix. To solve the problem of the lack of time-dependent passenger data, paper[1] have developed a forecasting method. It consists of three stages. The results were reliable, so authors stated that results of model could be used in the planning process [1].

Paper [2] states limitations of conventional four-stage models that they do not consider subjectivity, imprecision, ambiguity, and vagueness involved in human decisions. In this direction, fuzzy logic is found to be the most suitable technique because it considers linguistic variables and expressions. Keeping this in view, the authors propose to develop a methodology to consider fuzzy logic technique at different stages to develop travel demand models. Further, to demonstrate the suitability of the developed fuzzy logic travel demand model, selected public transport policies are simulated considering appropriate parameters [2].

Authors [3] shows problem with detecting needed size of the sample at a surveying, to be able to produce reliable data for OD matrix estimation. The paper [3] deals with the issue of needed sample size and reliability of results.

Paper [4] present how petrol prices have been increasing and decreasing at a formidable rate. Despite the increases and drops in retail in petrol prices over the last three years, there is a sense of optimism in some camps that prices will rise when the global financial crisis is over, and that finally we will have pricing signals to encourage earlier investment in substitutes that include public transport, more fuel-efficient cars as well as lower polluting vehicles. This note uses TRESIS, an integrated transport, land use and environmental strategy impact simulation program, to assess the influence of higher fuel prices on short run and long run passenger travel activity in Melbourne. Authors [4] evaluate petrol prices in the range AU$2 to AU$10 over the period 2009-2017, to establish likely impacts on car use, modal share, greenhouse gas emissions, and public transport revenue.

Paper [5] shows that are major concerns that as the total travel demand rises back toward prepandemic levels, the overall transport system capacity with transit constraints will be insufficient for the increasing demand. Paper [5] uses city-level scenario analysis to examine the potential increase in post-COVID-19 car use and the feasibility of shifting to active transportation, based on prepandemic mode shares and varying levels of reduction in transit capacity. Also paper [5] provides a strategic planning tool for policy makers facing challenging transportation system decisions in the aftermath of the COVID-19 pandemic.

Paper [6] shows that studies on the elasticity of demand for urban public transport services have a very high theoretical and application value, proven by the fact that despite the knowledge already possessed new studies in this field are permanently undertaken worldwide. The paper [6] presents the hitherto results of studies in the field of price elasticity of demand for public transport services. Also results of studies on price elasticity of demand have been presented, based on empirical data related to the sales of tickets for public transport services in the Upper Silesian conurbation in Poland. Moreover, the paper identifies the non-price factors that determine changes in demand for urban public transport services. The obtained results became the basis to discuss estimation limitations of demand elasticity in the urban public transport and allowed to determine directions of further studies [6].

Presented papers show a great possibility of public transport modelling use in creating future traffic solutions, not just infrastructure segments, but also in policies and other soft measures.

3. METHODOLOGY AND DATA COLLECTION

Methodology and data collection for this paper have been created and used from project titled “Analysis of public transport system in the City of Velika Gorica”. During project, data have been collected at main bus terminal in the City of Velika Gorica and in all schools at city are (both elementary and high) as survey with numerous questions. Survey consisted of socio-economic parameters and transport parameters.

Data used in this paper will consist of three transport parameters collected:

- Travel time of public transport system between various zones centroids,
- Travel time of private cars between various zones centroids and
- Selected mode of travel.

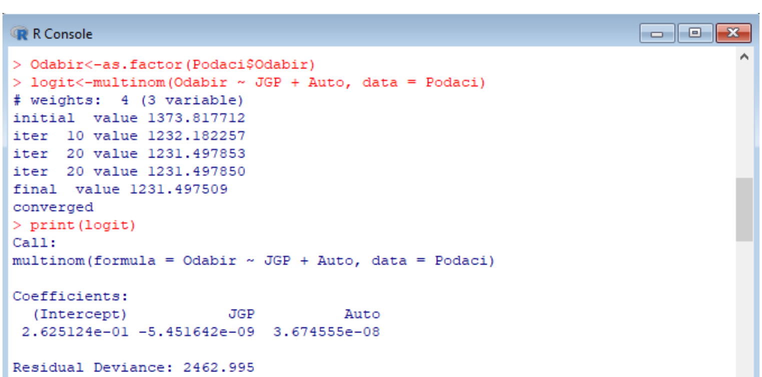
This sets of data were prepared by using programming tools MS excel and analyzed by statistical programming language R.

Table 1. Data preparation for programming tool R

Number	Public transport	Private car	Mode of travel
1	43.13	32.06	2
2	163.54	49.93	2
3	163.54	49.93	2
4	117.92	30.41	2
5	90.38	25.73	2
6	90.38	25.73	2
7	86.62	31.65	2
8	86.62	31.65	2
9	86.62	31.65	2
10	86.62	31.65	2
11	86.62	31.65	2
12	86.62	31.65	2
13	125.47	21.94	2
14	125.47	21.94	2
15	86.62	31.65	2
16	86.62	31.65	2
17	2.45	13.20	2

4. PUBLIC TRANSPORT MODEL

Public transport model for City of Velika Gorica is developed during project “Analysis of public transport system in the City of Velika Gorica”. One part of that model was creating logit binomial model to check possible effect of different measure that could be implemented in future. Public transport model consists of routes and timetables based on working day for administrative area of City of Velika Gorica and submodel of origin-destination trips that have been determined from survey (approximately 2.000 completed surveys which have been increased according to the number of passengers counted. Final step was assigning trips to public transport routes.


R Console

```
> Odabir<-as.factor(Podaci$Odabir)
> logit<-multinom(Odabir ~ JGP + Auto, data = Podaci)
# weights:  4 (3 variable)
initial  value 1373.817712
iter  10 value 1232.182257
iter  20 value 1231.497853
iter  20 value 1231.497850
final  value 1231.497509
converged
> print(logit)
Call:
multinom(formula = Odabir ~ JGP + Auto, data = Podaci)

Coefficients:
  (Intercept)           JGP          Auto
 2.625124e-01 -5.451642e-09  3.674555e-08

Residual Deviance: 2462.995
AIC: 2468.995
```

Figure 1. Codes from programming tool R

Figure 1 shows programming interface of programming language R with syntax for creating logit models based on data about travel times for public transport and private cars with selected options between available modes. Red text in the figure 1 present commands and blue text are result of conducted commands.

Table 2 shows coefficients of created logit model. Intercept represent first (single) coefficient, while others two coefficient (JGP and Auto) represent influence on dependent variable of the model.

The dependent variable of this model is one of two possible modes of travel that respondents have selected (public transport – JGP and private car – Auto). Independent variables are time travels of both modes. Values in the Table 2 present coefficients which have various level of influence on possibility for selected specific mode of travel.

Table 2. Coefficients values after creating of logit model in programming tool R

Coefficients		
(Intercept)	**JGP**	**Auto**
2.625124e-01	-5.451642e-09	3.674555e-08

Coefficient from table shows (except coefficient Intercept) very small values. That number can be argued with structure of responders from conducted survey. Most of the responders were passenger that can only use public transport to conduct their travel to their activity location. Although data show that travel time of private car are in almost all cases smaller than travel time of public transport, results of logit model and real data show that very larger number responders in such situation is forced to use and choose public transport.

5. CONCLUSION

Paper presented how public transport modelling can contribute during transport planning before phase of implementation. Literature overviews show various segments that have benefit from public transport modelling. Using logit model must satisfy several conditions to be useful as part of modelling. First is real and reliable data. Second is detecting parameters that have significant influence on passenger decision which travel of mode to use when travelling. Third is data to use as comparison to model results. There is more conditions but this three is minimum to develop logit model that can be used for public transport modelling of future solutions.

REFERENCES

[1] R. Horváth, “A Simple Method to Forecast Travel Demand in Urban Public Transport”, *Acta Polytechnica Hungarica,* vol. 9 (4), pp. 165–176, Jan. 2012.

[2] S. Pulugurta, E. Madhu, R. Kayitha, “Fuzzy Logic–Based Travel Demand Model to Simulate Public Transport Policies”, *Journal of Urban Planning and Development*, vol. 141 (4), Dec. 2015.

[3] B. Horvath and R. Horvath, “Estimation of sample size to forecast travel demand in urban public transport”, in *Proceedings of the 2015 International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS),* 3-5 June *2015*

[4] D. A. Hensher, J. K. Stanley, “What if petrol increased to $10 per litre in Melbourne? Implications for travel behaviour and public transport demand: technical note”, *Road and Transport Research*, vol. 18 (3), Sep. 2009.

[5] F. Ciuffini, S. Tengattini, A. Bigazzi, “Mitigating Increased Driving after the COVID-19 Pandemic: An Analysis on Mode Share, Travel Demand, and Public Transport Capacity”, *Transportation Research Record: Journal of the Transportation Research Board*, ISSN: 0361-1981, 2021.

[6] A. Urbanek, “Public Transport Fares as an Instrument of Impact on the Travel Behaviour: An Empirical Analysis of the Price Elasticity of Demand,” in *2018 TranSopot Conference: Challenges of Urban Mobility, Transport Companies and Systems*, 2018, pp. 101-113.

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CHARACTERISTICS OF TRAFFIC FLOWS AT ROUNDABOUTS IN THE CITY OF BANJA LUKA BEFORE AND DURING COVID-19 CRISIS

Key Words

Traffic flow
Motorized vehicle
Pedestrians
Roundabout
COVID-19
Case study

Abstract

COVID-19 pandemic caused many restrictive measures. Most of these measures were in the relationship with the restrictions of mobility which caused some differences in traffic flow demands. In this paper the comparative analysis of traffic flow characteristics at roundabouts in the City of Banja Luka was conducted. The analysis included two different states of traffic condition: the first one, normal condition before COVID-19 crisis, and the second one, during the state of emergency caused by the pandemic. The analysis shows the difference between some of motorized vehicle and pedestrian traffic flow parameters.

1. INTRODUCTION

After the proclamation of the pandemic caused by the virus COVID-19 almost all countries started with the implementation of different restrictive measures with the aim of preventing the virus spreading. The restrictive measures mostly meant social distance, which significantly affected the reduction of needs and possibilities for travel conducting, thus mobility and the number of trips. On the other hand, a part of population whose need for travel continued significantly affected the change in the mode of transport [1-4].

During previous two years, the phenomenon of COVID-19 virus impact on different social and economic segments was the subject of many research studies. The case studies usually showed a significant decrease in the number of journeys. The impact of COVID-19 on the mobility differs by the travel purpose. According to the source [3] in European countries the number of trips for the purposes of retail and recreation decreased by 40-65%. The impact of COVID-19-related restrictions on mobility to parks is relatively low (between -30 and -40%) by the end of March 2020, and increases again quickly in early April 2020 to a level close to and even above the January baseline. Also, the data analysis shows that the percentage of trips to workplaces decreased by at least 40% by mid-April. Trips with the aim of reaching the public transport station also have a significant decrease, and by the end of the April of 2020 the number of these trips was around 50% lower than in the period before the pandemic. The deviation was noticed with the travel purpose related to the mobility within narrow residence where the number of these trips increased by 12-25%.

According to the survey conducted among the respondents older than 18, it has been established that the occurrence of COVID-19 pandemic affected the way of transport means use [4]. The respondents declared how much they use a certain means of transport, given in percentages. The survey results showed that 19% of the respondents mostly use the passenger car. On the other hand, more than 60% of the respondents declared that they use mass transit and train less than before the pandemic. In this way, the change of modal split occurs, which, on the other hand, can reflect traffic flows in the street network.

Within this paper the analysis of traffic flows at the roundabout in the city of Banja Luka, The Republic of Srpska, Bosnia and Herzegovina, was conducted. The case study analysis included motorist, pedestrian and cycling flows, that is, their characteristics determined on the sample before and during the COVID-19 pandemic. The aim of the analysis was to show the influence of the current repressive measures on the characteristics of traffic flow.

2. METHODOLOGY

The recording before COVID-19 crisis was conducted in August 2019, and the recording during COVID-19 crisis was conducted in April 2020. Both recordings were conducted on the same day of a week (Thursday), at relatively the same period of day and out of the peak hour. During the recordings, it was sunny with the temperature of 25-35 ºC, without fog, rain, gales or any other unfavourable climate conditions, the roadway was dry and without any damages, and the traffic without the situations which would influence unhindered and safe traffic.

During the recording in the April of 2020, in the city of Banja Luka, the following restrictive measures were in force:

- For persons over 65 years of age it was forbidden to leave their homes;
- Urban public transport and suburban public transport were suspended;
- All educational institutions were closed all day;
- Shopping malls, restaurants, fitness centres, hotels, restaurants, footwear and clothing stores, bookmakers, cinemas, theatres, beauty salons were closed all day;
- Any industry where it is not possible to realize recommendations on the distance between workers were all day closed.

2.1. Description of the research location

The analyzed intersection is in Banja Luka (Bosnia and Herzegovina), a town with around 180,000 inhabitants. The intersection of Boulevard Desanke Maksimović/Boulevard vojvode Petra Bojovica – Boulevard vojvode Stepe Stepanovića was used for data collecting. The position of the intersection in WGS-84 coordinate system is on coordinate 44.766366, 17.209049. The intersection is placed in the urban area of the town, and its type belongs to large town roundabouts.

Figure 1. Orthophoto image of the analyzed intersection

Table 1. Geometrical characteristics of the roundabout

Geometrical parameter	Dimension
Inscribed circle diameter (m)	57.2
Central island circle diameter (m)	34.8
The roundabout width (m)	9.4
Number of lanes at the roundabout	2
Width of lanes at the roundabout (m)	4.7

Table 2. Geometrical characteristics of the approaches

Geometrical parameter	Approach			
	1	2	3	4
Number of lanes on the approach	2	1	2	2
Entry width (m)	8	4.2	8.4	9.2
Width of the lane on approach (m)	4[1]	4.2	4.2[1]	4.6[1]
Entry radius (m)	23	17.9	20	23.7
Exit width (m)	9.4	4.7	9.4	5.8
Number of lanes on departure	2	1	2	1
Width of lanes on departure (m)	3.6[1]	4	3.7[1]	3.8
Exit radius (m)	26.9	20.2	26.2	20.2

[1]Note: both lanes have the same width.

2.2. Data collection and data analyzing methods

Data collecting was conducted by recording real traffic flows at four urban roundabouts. The recording was carried out by means of a drone "DJI Mavic 2 Pro", which was set at a certain height above the analyzed roundabouts and it recorded traffic. For determining traffic flows characteristics the method of video recording processing and analysis was used. This method proved to be extremely efficient for traffic flow parameters measuring, because its use minimizes the influence of the research on the drivers. The applied methodology enabled the analysis in the real traffic flow, where the speed of the traffic flow depends exclusively on the degree of the interaction between the vehicle and the geometric characteristics of the roundabout.

For traffic analysis of the video data, the authors used “Data From Sky – Traffic Survey” platform. “Traffic Survey” is a video-analytics platform for fully automated extraction of accurate traffic data using artificial intelligence and machine learning methods [5]. The use of this platform indicated an extreme convenience in other similar research studies [6-7].

The collected data were primarily processed within the purpose software package “Data From Sky VIEWER“, where from the original reports were formed. The final data processing was conducted in MS Excel.

3. RESEARCH RESULTS AND DISCUSSION

3.1. Motorized traffic flows

In the analysis of vehicles flow by approaches it was determined that there is a difference in the total number of vehicles at the intersection before and during the pandemic of COVID-19. Namely, the case study analysis showed that the total traffic of motor vehicles at the intersection was increased by 35%, from 1,543 veh/h to 2,084 veh/h. The following table shows the values of the flows by the direction of movement depending on the analysis period.

Table 3. Volumes at the analyzed intersection

approach	direction	Before COVID-19			During COVID-19		
		Volume (veh/h)	% from total by direction	% from total by approach	Volume (veh/h)	% from total by direction	% from total by approach
1	left	290	19%	**38%**	355	17%	**36%**
	through	189	12%		251	12%	
	right	105	7%		143	7%	
2	left	93	6%	**18%**	162	8%	**17%**
	through	170	11%		186	9%	
	right	16	1%		8	0%	
3	left	12	1%	**17%**	20	1%	**17%**
	through	162	10%		232	11%	
	right	81	5%		105	5%	
4	left	58	4%	**28%**	93	4%	**30%**
	through	151	10%		174	8%	
	right	216	14%		355	17%	

The comparative analysis of the percentage distribution of the flow by approaches in relation to the total achieved vehicles flow at the intersection before and during the pandemic indicates that there are no significant deviations. Based on this, it can be concluded that the flow demand increase was evenly distributed.

On the other hand, significant deviations have been noticed in the structure of the traffic flow. The analysis has shown that during the pandemic the percentage of vehicles decreased, while the percentage of medium and heavy vehicles increased from 4% to 11% of the presence in the flow

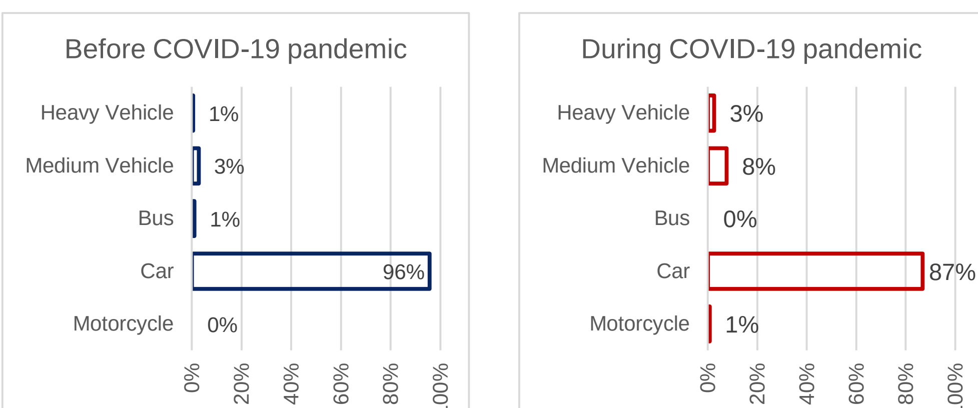

Figure 2. Distribution of traffic flow by vehicle classes

Considering the increase in the demand of flow, the change in average flow speed occurred, as well. The average speed of all vehicles in the flow before the pandemic was 23.2 km/h, while during the pandemic its value was 21.4 km/h. The following figures shows heat maps of traffic flow speed.

a) before COVID-19 pandemic *b) during COVID-19 pandemic*

Figure 3. Average speed of motorized traffic flow at the roundabout

3.2. Non-motorized traffic flows

In the case study analysis pedestrians and cyclists were taken as the participants of the non-motorized flows at the observed intersection. Within the first part of the analysis of these flows the maximal concentration of non-motorized flows was observed in the area of the intersection. Figure 4 shows a graph display of the concentration of the analysed objects, in this case pedestrians and cyclists as the participants of the non-motorized flows.

a) before COVID-19 pandemic *b) during COVID-19 pandemic*

Figure 4. Object (pedestrian+bicycle) concentration at the roundabout

On the basis of the displayed figures, it can be concluded that the concentration of non-motorized flows is higher than in the period of the repressive measures. In the situation before COVID-19, the concentration is within the limits 1-3, while in the situation during the pandemic it is within the limits 2-5.

The processing of the collected material implies the increase of the number of participants of non-motorized flows in the following way:

- Pedestrian flows increased by 159%, that is, the pedestrian flow at the intersection in the observed period during the pandemic was 285 ped/h, unlike the same period before the pandemic, when the pedestrian flow was 110 ped/h;
- Cyclists flow increased by 62%, that is, the flow of cyclists at the intersection in the observed period during the pandemic was 21 cyc/h, unlike the same period before the pandemic, when the flow was 16 cyc/h.

Observing from the aspect of the speed of pedestrian and cyclist movement, the established differences are of no significance. Pedestrian flow speed before the pandemic was 1.8 m/s, and during the pandemics it was 1.9 m/s. Cyclists flow speed before pandemic was 7.3 km/h, and during the pandemic it was 8.4 km/h.

4. CONCLUSION

Global pandemic of COVID-19 affected different aspects of everyday life, among others the characteristics of travel. The conducted research studies have shown that mobility decreased for most travel purposes, in some cases up 50%. Also, the pandemics has apart from the stated also affected modal split, mostly trips where public transport is used.

In the case study the characteristics of traffic flows at the roundabouts in Banja Luka were analysed. The analysis included one-hour traffic samples before the pandemic and during the pandemic, with restrictive measures in force. On the basis of the comparative analysis, the following differences have been identified as the key ones:

- The total flow of the motorized vehicles during the pandemics was higher by 35% than the flow volume before the pandemic.
- The percentage of passenger cars and buses in the traffic flow during the pandemic is lower in relation to the values before the pandemic.
- In the traffic flow of non-motorzed participants in traffic during the pandemic, 159% more pedestrians and 62% more cyclists were noticed in relation to the flow recorded before the pandemic.

The obtained results at first deviate from the previous research studies which imply that due to the pandemic there was a decrease in the mobility rate. The authors assumption is that the decrease of total mobility does not necessarily mean the reduction of the number of vehicles in the network, if the mobility change also means the change in the modal split. In the concrete case, during the pandemic public transport traffic was suspended, therefore, the previous users of public transport, who still have the need for mobility, were forced to make a redistribution to other transport modes. Apart from this, schools and a part of industry closing created additional free time which was possible to use for recreational trips which were not restricted.

Considering the sample size and the researched parameters, it is neither possible to make more powerful conclusions than the above mentioned, nor define the trends. The stated assumptions of the authors can serve as hypotheses for further research studies which would be conducted on a larger sample, in the sense of space and time.

ACKNOWLEDGMENT

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REFERENCES

[1] Vitello, P., Fiandrino, C., Capponi, A., Klopp, P., Connors, R.D. and Viti, F.: The Impact of SARS-COVID-19 Outbreak on European Cities Urban Mobility. 2021, Front. Future Transp. 2:666212. https://10.3389/ffutr.2021.666212

[2] Junghwan K., Mei-Po K.: The impact of the COVID-19 pandemic on people's mobility: A longitudinal study of the U.S. from March to September of 2020, Journal of Transport Geography, Volume 93, 2021, 103039, ISSN 0966-6923, https://doi.org/10.1016/j.jtrangeo.2021.103039

[3] Medimorec, N., Enriquez, A., Hosek, E., Peet, K. and Cortez, A.: Impacts of COVID-19 on Mobility - Preliminary analysis of regional trends on urban mobility, SLOCAT Partnership Secretariat, 2020.

[4] Siemens Mobility, Intelligent Traffic Systems in a world shaped by the COVID-19 pandemic, July 2020.

[5] Data From Sky, https://datafromsky.com/trafficsurvey/

[6] Apeltauer, J., Babinec, A., Herman, D., and Apeltauer, T.: Automatic vehicle trajectory extraction for traffic analysis from aerial video data, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XL-3/W2, pp. 9–15, 2015, https://doi.org/10.5194/isprsarchives-XL-3-W2-9-2015

[7] Agerholm, N., Tønning, C., Madsen, T. K. O., Bahnsen, C. H., Moeslund, T. B., & Lahrmann, H. S.: Road user behaviour analyses based on video detections: Status and best practice examples from the RUBA software. In Proceedings of the 24th ITS World Congress, pp. 1-10. [EU-SP1137] ITS World, 2017.

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Novi Sad 11th and 12th November 2021

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ANALYSIS OF THE SPEED OF CYCLING TRAFFIC IN NOVI SAD

Key Words
Speed
Cycling roads
Sections
Segments
Segment parts

Abstract

Within this article, based on the conducted research, the velocities of cycling traffic on all exisitng cycling paths and lanes in the street network of Novi Sad, were analysed. The analysis included 240 segments of the street network of cycling roads, which were, for the sake of analysis of speed variations, divided into four typical segement parts. Three typical segment parts were defined at the crossing, that is, the intersection of the cycling path or lane with the road intended for the traffic of motorized vehicles, and the fourth segment part is between the intersections, that is, segment part 3 and segment part 1 of the following section. The results of the analysis showed that in the largest part of the network of cycling roads in Novi Sad the average achieved speed is around 12.5 km/h, which can be considered favourable. However, the research showed that there is a significant part of the network of cycling roads where the achieved velocity is significantly lower than the average one.

1. INTRODUCTION

One of the basic parameters for defining the level of service in the street network is travel speed. Namely, speed is the basic parameter which affects the total travel time and indirectly the decision of citizens which transport mode they are going to use for the realization of mobility needs. The improvement of drive mechanism and a wide range of different types of bicycle in the market which are adapted to the needs of all potential users, as well as the occurrence of electric bicycles, positively affected a more widespread use of bicycles in cities. Many research studies in the cities which have an adequate cycling infrastructure showed that the travel time by bicycle is identical to the total travel time by car. These are the reasons for which in many European cities the bicycle started to be widely used for meeting the needs of mobility.

Novi Sad is a city which has a long tradition of bicycle use for the realization of mobility needs. Immediately after the appearance of the first bicycle in Vojvodina in 1880, Novi Sad got the first bicycle shop in 1894, and in 1900 its first cycling path [1]. In traffic counting on bridge sections for the needs of a traffic study in 1967, 7,200 bicycles were registered and 1,900 passenger cars. However, in the following years, with the increase of motorization rate, the participation of bicycles in modal split was reduced, and the trend continued to the end of the first decade of 21st century. Within the research, for the needs of NOSTRAM study in 2009, the participation of bicycles in modal split was 2.52% [2]. In accordance with the conclusion of the study, many measures were taken to increase the mobility based on bicycle use.

For the development of cycling traffic a network of cycling paths is necessary and it has to be harmonized with mobility needs. The network of cycling roads in Novi Sad is constantly being expanded, thus the current length of cycling roads in Novi Sad is over 100 km. Apart from the significant bicycle roads network expansion, certain parts of the city, such as Centar, Podbara, Salajka, Telep, Petrovaradin and Sremska Kamenica, almost have no cycling paths. In most cases the reasons are objective, most often it is the profile of the inherited street network which does not make it possible to form a cycling path. Apart from these, the terrain configuration, that is, longitudinal inclination, which is distinctive on the part of the city in Srem, in certain cases it represents the limiting factor.

In accordance with the taken measures related to the development of the basic cycling infrastructure and the popularization of the policy of sustainable urban mobility, the negative trend of bicycle use has been stopped. In the research study conducted in 2017 for the needs of SMART PLAN [3], the participation of the bicycle in the modal split was 8.84%. However, considering the tradition, climate and geographical characteristics, Novi Sad has the potential to significantly increase the participation of cycling traffic for meeting the needs of mobility. Apart from further expansion of the network of cycling paths and cycling parking lots, it is necessary to conduct activities and take measures for the increase of cycling traffic speed, that is, the increase of level of service of this transport mode. In the first step it is necessary to analyse and identify parts of the network of traffic roads with lower speeds, and after that, in the following steps, determine the causes and define the measures for its increase.

2. REASEARCH METHODOLOGY

Within this article, the research on speeds on cycling roads was conducted. In Novi Sad these cycling roads were mostly formed alongside the primary street network, based on the data from a previos study [4].

Data collecting related to the characteristics of the cycling infrastructure and the speed realized on the network of cycling roads was conducted in the field reasearch which included necessary data recording on all built cycling roads, by means of the video camera “GoPro HERO BLACK 7“ set on a bicycle.

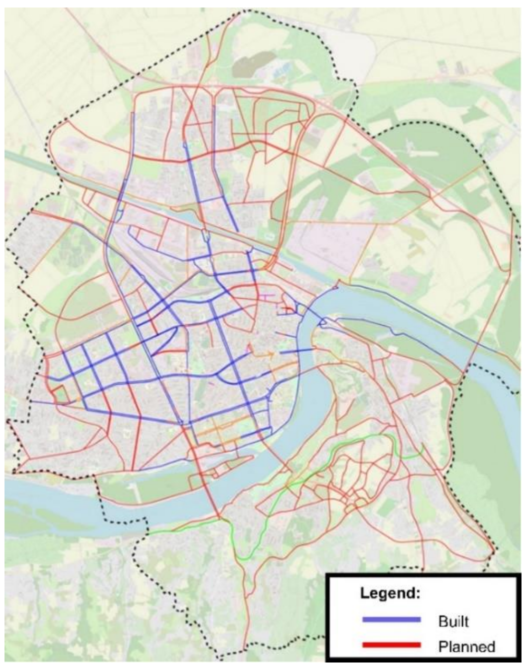

Figure 1. Network of cycling roads in Novi Sad

In this way the recording of the real situation was made, and the recordings were the starting point for further data basis forming, with all the parameters necessary for the analysis. The camera used for data collecting, apart from the video recording of a high resolution, also records the data on the exact position in the space at the moment of recording and the current bicycle speed. The position of the recording is registered in the intervals of 1 second, and it is defined by the point defined in coordinates of geographic latitude and longitude, by “WGS84“ referential geodesic coordinate system.

Figure 2. Touring-video recording of the cycling infrastructure

The collected video material was processed in a software package designated for this type of video material “DATAKAM Player“ by the defined parts of the network of cycling roads, that is, sections. Sections of the cycling network can contain one or more segments which are defined along the street, between two bordering intersections - entrance and exit. Segement labelling was done by means of numeration in the way that the first part of the label contains the number of the section, and the second part the position in relation to the belonging road for motorized traffic, that is, north, south, east or west, in relation to the roadway. The research on speed was conducted on the complete network of cycling roads, which included in total 204 defined segments between the intersections.

During the video material processing, the segments of the cycling paths were divided into segment parts. The purpose of segment division into segment parts was the analysis of speed, which in the following steps enables the analaysis of the influence of different factors on speed (pedestrians, parking, the quality of the roadway of cycling roads, other obstructions, etc). Entrance bordering intersection is at the beginning, and exit at the end of the segment observed in the direction of recording, that is, at the beginning of the following section. The beggining of the segment is measured from the beggining of cycling path crossing at the exit bordering intersection. A signalized intersection is always the bordering intersection, and in exceptional cases the bordering intersection can also be unsignalized intersection or a roundabout. In the aim of determining the speed variation, the segment was divided into the following typical segment parts:

Segment part 1	The zone of intersection is equal to the length of cycling path crossing at the intersection.
Segment part 2	The zone immediately after the intersection, where there is the increased probability for cyclists obstruction, the length of 30.0 metres.
Segment part 3	The central zone of the segment where there is a small probability for cyclists obstruction by other traffic participants (except on the places of crossing with approachable roads which are specially recorded).

Segment part 4	Pre-intersection zone where there is an increased probability for cyclists obstruction in the length of 30.0 m.

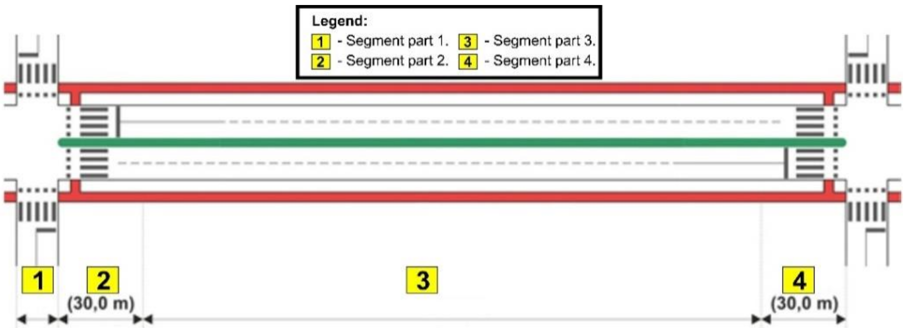

Figure 3. Division of segments into segment parts

3. RESEARCH RESULTS

The speed of the cycling flow is a general indicator of the problem in the network of cycling roads. The measured speed by segment parts on cycling roads segments in Novi Sad are shown in the following figure.

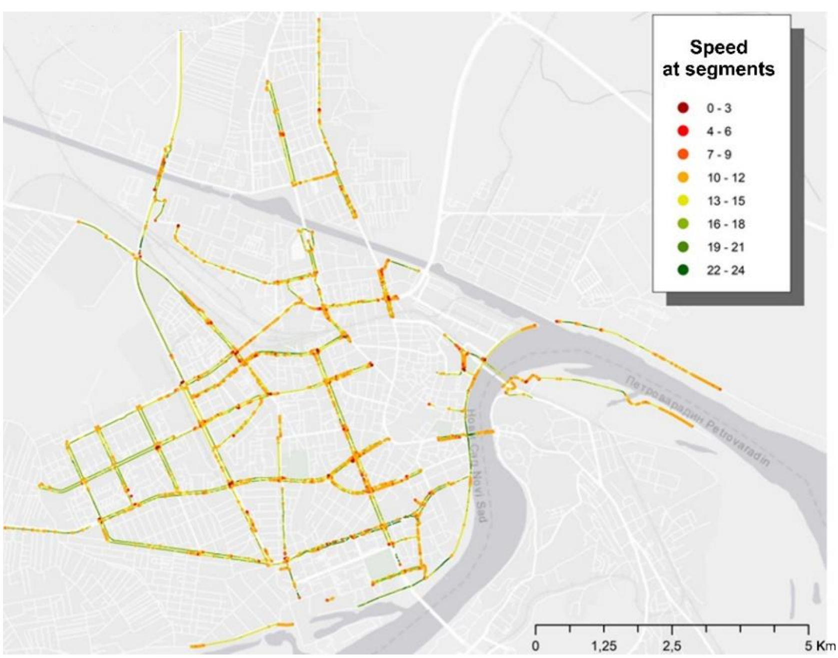

Figure 4. Speed by segment parts on cycling roads segments

The average speed in the network of cycling roads is 12.5 km/h. On the largest part of cycling roads, that is, on more than 78% of the total length, the achieved average speed was higher than 12 km/h. The following graph shows the speed distribution on the network of cycling roads.

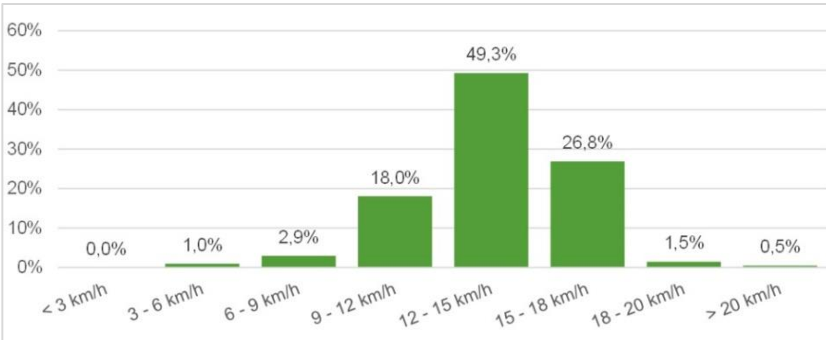

Figure 5. Speed distribution on cycling roads segments

The analysis of the formed data base implies that the speed distribution by the defined segment parts of cycling road segments is significantly different, which is ahown in the following graph.

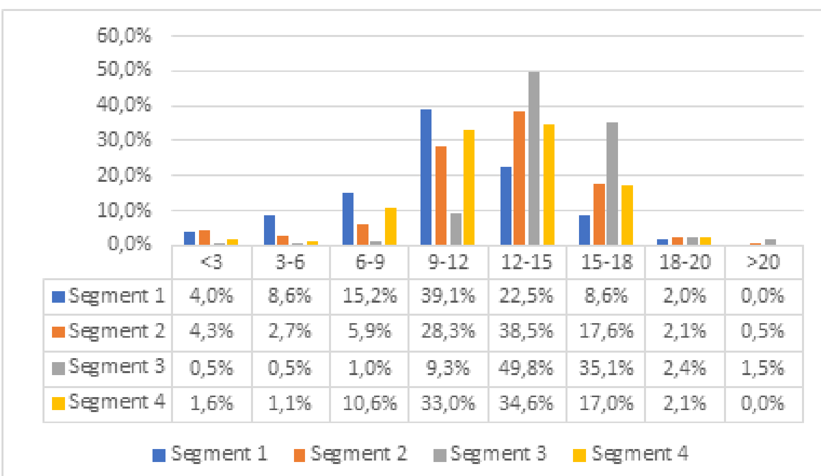

Figure 6. Speed distribution by segment parts of cycling road segments

The achieved average speed by segment parts of cyling road segments, as well as the average speed achieved in the total network of cycling roads are shown in the following graph.

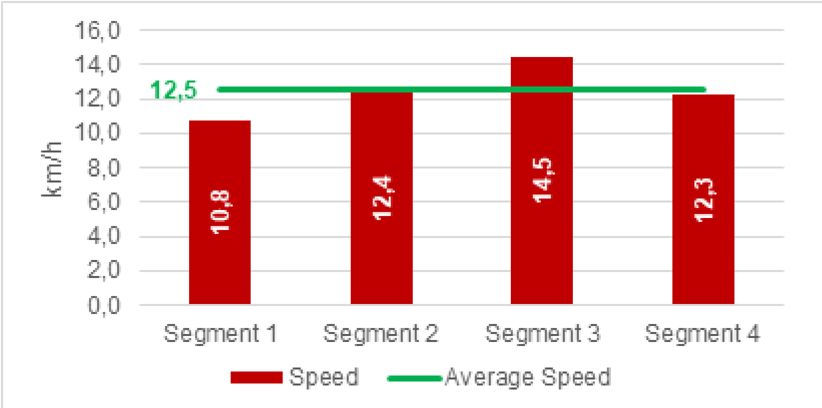

Figure 7. Average speed by segment parts of cycling roads segments

4. CONCLUSION

The possibility of travel for the purpose of meeting the mobility needs at a certain speed represents one of very important elements when planning a trip and the choice of transport mode. One of the basic advantages of bicycle travel is a relatively constant speed in city traffic conditions, which in cases of high demands for the flow of motorized traffic in the street network, can be equalized with the average speed of travel by car and vehicles of public transport. This effect is particularly distinctive on shorter relations in urban city environment.

The analysis of cycling traffic speed on the complete network of cycling roads in Novi Sad showed that the average speed of travel by bicycle is 12.5 km/h. According to the manual HCM [5], the established speed value is considered favourable. Namely, this speed features favourable conditions for cycling traffic. However, on around 22% of the total number of segments of the cycling roads network, especially those in the central city zones, the bicycle travel speed is under 12.0 km/h. In the following step it is necessary to analyze samples on the identified segment parts with the speed below the average one and define the measures for the improvement of cycling traffic conditions.

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REFERENCES

[1] http://www.mojnovisad.com

[2] Novosadski transportni model – NOSTRAM, JP Zavod za izgradnju grada Novi Sad, 2009.

[3] SMART PLAN, Faculty of Technical Sciences, Novi Sad, 2019.

[4] Unapređenje mobilnosti zasnovane na biciklističkom saobraćaju na teritoriji grada Novog Sada, ADOMNE d.o.o. Novi Sad, 2019.

[5] Highway Capacity Manual 2000, Transportation Research Board, Washington D.C., 2000.

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NETWORK MODEL OF THE MUNICIPALITY ODŽACI

Key Words

Traffic planning

Transport models

Model of traffic offer

Abstract

In this article first we set the theoretic basis related to brief description of the transport model and macro-planning. Most of the article is related to defining the network model of the municipality Odžaci, alongside the previously described procedures of transport model design. The existing state of the system has been defined and the specific process of zone system creation has been described, based on postal address codes.

1. INTRODUCTION

The importance of an efficient transport system is reflected in enabling unhindered mobility of people and goods. Cities face numerous problems, out of which many result from the very transport system and represent the obstacles for providing an efficient transport and simultaneously providing quality life.

By means of traffic planning a balance is established between traffic offer (transport ability) and traffic demand (transport demands). The development of computer technology and its application in the field of traffic planning provided conditions for conducting better quality analyses and finding solutions to the previously mentioned problems.

In the process of transport system planning, a very significant phase is model forming and using. The transport model, as it was previously mentioned, consists of the systems of offer and the systems of demand. The system of offer describes the availability of transport systems and infrastructure, while the system of demand includes the models which determine the demand for the transport, which is based on socio-economic characteristics of the given area.

In this article the focus is on a detailed definition of the network model as one of the fundamental phases in the creation of the transport model, on the example of the municipality Odžaci. The network model of the municipality was defined and the basic data on the zones within the observed area were entered by applying the software package *Visum.*

Specificity of the article and the model is reflected in the use of the data from unusual sources for the creation of the zone system. The reason for the application of the postal address codes results from the lack of the existing socio-economic data in the whole Serbia and the region as a basis for defining the traffic models and further traffic system management.

2. POSITION OF THE MUNICIPALITY, THE RELATIONSHIP OF URBAN AND RURAL SETTLEMENTS

The municipality Odžaci is in the western part of Bačka, on the left bank of the Danube. It is surrounded by municipalities Apatin, Sombor, Kula, Vrbas, Bačka Palanka, Bač and it is bordered with The Republic of Croatia on the river Danube. Figure 1 shows previously described position of the municipality Odžaci.

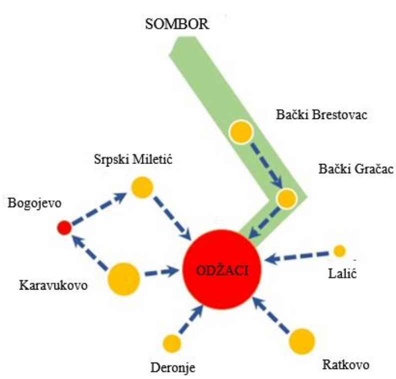

Figure 1. The relationship of the settlement, municipality centre and the town of Sombor

By its territory size it belongs to smaller municipalities on the territory of Vojvodina, and it belongs to the regional centre Sombor. The centre of the municipality, the settlement Odžaci, is located in the centre of the territory, while other settlements are radially positioned around the municipality centre.

The municipality Odžaci consists of nine cadastral municipalities: Odžaci, Bački Gračac, Bački Brestovac, Srpski Miletić, Bogojevo, Karavukovo, Deronje, Ratkovo and Lalić. According to the census from 2011, 30,154 residents live in the listed nine settlements, therewith that in the municipality centre – settlement Odžaci there are 29.22% of the municipality population. The average population density is 74 inhabitants per 1 km^2. The total number of households on the territory of the whole municipality is 11,073, while the average number of household members is 2.7 [1].

The settlements of the municipality Odžaci have the characteristics of typical settlements in Vojvodina with the elements of classical colonization and planned construction, adapted to the relief and terrain hydrography. Planning basis of the settlement has been preserved, which was also contributed by the creation of the adequate urbanism documentation [1].

3. MODEL CREATION BY MEANS OF THE SOFTWARE PACKAGE *VISUM*

The essence of this chapter is description of the arterials network on the level of municipality and definition of the basic elements of the model of transport offer (nodes, links, centroids, traffic zones and connectors), as well as description of the methods for the determination of inhabitants on the level of traffic zones. Today there is a series of software packages which enable a very reliable outcome of the planning process. Further in the text the basic characteristics will be defined, as well as the procedure of transport model forming within the software package *Visum*.

Visum is a software package which enables modelling of all types of private and public transport within one integrated model. The application of *Visum* software enables consistent management of the basic data which are given in transport and information systems, by means of the network editor. Unlike Geography Information System (GIS), this software allows keeping complex relationships within one or more transport models. A transport model consists of the demand model, network model based on the software package *Visum* and different influence models [2].

3.1 Description of the network and zone system of the munucipality Odžaci

Definition of the network model starts with the procedure of network description. In the practical sense it was necessary to put *Openstreet* map into the software package *Visum,* since this map contains a network of links and nodes, and its map coding has been previously conducted.

In the following step the check of links and nodes was conducted, concretely, checking the speed on arterials which go through populated places, as well as categorized nodes checking. It also means deleting certain links and nodes which were not necessary for this paper creation.

The links on the Openstreet map have already been categorized into 99 categories, while in the very paper links of 4 categories can be found: type 30, 40, 50 and 70. On the town arterials most commonly used links were the type 70 (speed 50km/h, capacity 400 veh/h). Arterials of a higher order go through populated places, where the speed had to be corrected in accordance with the speed limit in populated places (50km/h). The number of links was reduced to 1,178 at the end of this procedure. State roads of the class I and II intersect the territory of the municipality, that is, they connect Odžaci with Ratkovo, Srpski Miletić, Deronje, Lalić, then Srpski Miletić with Bogojevo, thus they were categorized as such. The roads Odžaci – Karavukovo – Bogojevo and Odžaci – Bački Gračac – Bački Brestovac are local roads, therefore they have been categorized as such.

The same procedure was also conducted for nodes. The four nodes were categorized as signalized intersections, while the other nodes were regulated by traffic signs. The number of nodes in the network is 430.

After the network checking, the following step was zone system defining. The basic idea when creating the network model of the municipality Odžaci was to divide the municipality area into traffic zones, so that each settlement (Ratkovo, Srpski Miletić, Karavukovo, Bogojevo, Lalić, Bački Gračac, Deronje and Bački Brestovac) represent a special traffic zone, while the settlement Odžaci, as the municipality centre, was divided into 20 traffic zones. The spatial plan of the municipality Odžaci did not define the division into traffic zones, which posed a great challenge when this article was done. Also, there were no adequate research studies of this area which would enable an appropriate information basis for further research. Therefore, in order to fulfill certain criteria necessary for creating the zone system, zone creating of the settlement Odžaci was conducted on the basis of Postal address codes. A postal address code can be defined as a numeric label of the address consisting of 6 digits. The aim of this method of zone creation is that each whole comprises a certain number of inhabitants. A free access to the internet portal *Pošta Srbije (The Post Office of Serbia)* enabled an insight into the map, borders and numeral label of each postal address code of a settlement. Zone borders were primarily created so that each zone has approximately a similar number and contains the whole number of postal address codes. On the basis of the data available on the internet portal *GEOSrbija*, according to the number of construction plots, it was established how many inhabitants there are in each postal address code.

The following form was used for calculating the number of inhabitants which comprises one postal address code:

$$BS_n = 2{,}7 \times BRp \ (stanovnika) \tag{1}$$

BS_n – number of inhabitants *n* of a postal address code area

n – ordinal number of the postal address code area

2.7 – average number of household members

BRp –number of construction plots of a postal address code area

During this procedure the attention was directed to the recognition of the types of housing in certain postal address code areas.

Since individual housing prevails in settlements, postal address code areas with multifamily housing were recognized. The original zone borders were then adapted to the housing type. The first created zones were those with multifamily housing. After that the borders of other zones were defined, taking into consideration the number of inhabitants, as well as the area covered by a postal address code.

Table 1. List of zones, postal address codes, number of inhabitants of each zone of the settlement Odžaci

ZONE	Number of postal address codes	Number of inhabitants	ZONE	Number of postal address codes	Number of inhabitants
1	12	535	**11**	14	443
2	4	135	**12**	15	589
3	3	1092	**13**	14	443
4	6	216	**14**	7	213
5	16	518	**15**	2	0
6	17	767	**16**	18	671
7	12	346	**17**	5	157
8	22	464	**18**	8	282
9	9	143	**19**	24	1376
10	7	246	**20**	4	175
TOTAL				214	8811
AVERAGE				441 inhabitants by a zone	

Table 2. List of zones – settlements, number of inhabitants of each zone

ZONE	The name of the settlement	The number of inhabitants
21	Srpski Miletić	3038
22	Bački Gračac	2286
23	Ratkovo	3411
24	Lalić	1343
25	Bogojevo	1744
26	Karavukovo	4215
27	Deronje	2487
28	Bački Brestovac	2819

With zone borders defined in this manner, the calculation of inhabitants of a certain zone was conducted. The number of inhabitants of each zone was calculated as the sum of inhabitants of each postal address code area which forms that zone. Table 1 shows the list of zones with the number of postal address codes which form the zones, as well as the number of inhabitants of each zone, while in Table 2 other zones (settlements) are shown, with their number of inhabitants.

Further in the text the results of the process of zone system creating will be shortly discussed. The original idea when defining zones borders was that all zones have approximately the same number of inhabitants. However, it was not possible due to different circumstances (e.g. type of housing in the zones, the area covered by a postal address code, etc.).

Considering all these, the form of the zone system was successfully defined in a different way. The largest number of zones has approximately the same number of inhabitants (labelled in green on the graph), ranging between 200 and 500 inhabitants. Then "extreme" (labelled in red on the graph), like the zones with significantly larger number of inhabitants (3 and 19) and the zones with no inhabitants (15). The other zones have a smaller or larger number of inhabitants in relation to the average value (labelled in blue on the graph). The previously described can be seen in the Figure 2.

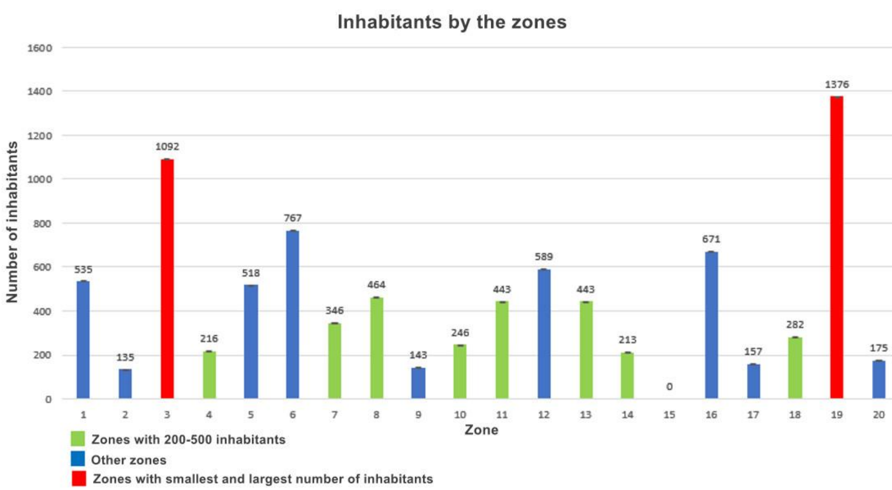

Figure 2. Display of inhabitants by the zones

Zone 3, which covers 3 postal address codes, differs from the other zones by population density. It is related to the area where there are exclusively the facilities for multifamily housing. Therefore, in relation to other zones a larger number of inhabitants resides in the given area.

Also, within the zone 19 it can be observed that there is a larger number of inhabitants due to the mixed type of housing in the zone. Zone 19 is also typical by the fact that postal address codes were defined in such a way that the whole could not be divided into two or more zones.

On the other hand, in the zones 4, 7, 8, 10, 11, 13, 14 and 18 it can be noticed that the number of inhabitants is between 200 and 500 inhabitants by a zone, which represents a slight deviation in relation to the mean. In a larger number of zones individual housing is present.

Zone 15 represents an area where there are work areas, warehouses and industrial plants, therefore the number of inhabitants there is equal to zero.

After defining traffic zones it is necessary to connect each centroid with nodes by means of a link which was categorized as a connector. *Visum* enables to check the created network by means of searching the shortest route, by which it was determined that nodes, links and connectors were properly defined.

Figure 3 shows the display of the zone system in the software package *Visum*, while the Figure 4 shows the zone distribution of the settlement Odžaci.

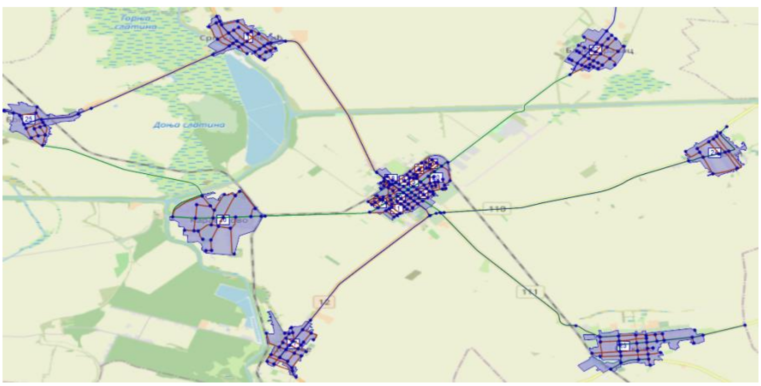

Figure 3. Zone system of the municipality Odžaci

Figure 4. Traffic zones in the settlement Odžaci

After creating the traffic zones and determining the number of inhabitants in each of them, the data on the number of inhabitants were put into the software package *Visum*. This step finalised the work on creating the network model.

4. CONCLUSION

This article describes the procedure for creating the network model of the municipality Odžaci, which means the description of the network and zone system formation. *Openstreet* map was used as the basis with the data on links and nodes networks. Zones were formed on the basis of the postal address codes and it was necessary that each zone covers the whole number of postal address codes. The software package *Visum* was used for the creation of the network model of the municipality Odžaci, with certain limited functions of the software package.

Observing the example of the municipality Odžaci, many advantages and benefits were noticed for the creation of the transport model. One of them is orthogonal street network, which is present in all settlements of the municipality Odžaci and it facilitated the creation of traffic zones.

As it has been previously stated at the beginning of this article, the specificity of this model is reflected in the use of the data of the postal operator in the creation of the zone system. In the existing system of the data we have found that it is one of the ways of creating a sufficiently reliable model. Definitely further research in all towns and municipalities should be directed to obtaining reliable socio-economic data which, apart from the number of inhabitants include a whole series of attributes which are used for describing and interrelating traffic demand and offer.

ACKNOWLEDGMENT

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REFERENCES

[1] Official Gazette of the municipality Odžaci, Spatial plan of the municipality Odžaci, Official Gazette of the municipality Odžaci, Odžaci, No 17/09, 2009

[2] Instructions for the software application: *PTV Visum Manual*, PTV group, Berlin, 2020.

[3] Information downloaded from the website *"Pošte Srbije"*: https://www.posta.rs/index-stanovnistvo-lat.aspx (accessed in May 2020).

[4] Information downloaded from the website *"GEOSrbija"*: https://a3.geosrbija.rs/ (accessed in May 2020).

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REDESIGNING THE FUNCTIONAL FRAMEWORK OF ROAD VEHICLES IN A SMART CITY

Key Words
Intelligent vehicle
Intelligent road
Digitization
Transport

Abstract

As smart vehicles begin to roam the streets, new possibilities will emerge for large-scale data acquisition tasks necessary for proactive smart cities applications. Unlike mobile devices, smart vehicles carry powerful sensors and are highly mobile; they can cover large areas and perform high quality sensing. The road infrastructure and the information and communication environment of the vehicle need to be adapted to take advantage of the capabilities of smart city functions. This requires a holistic approach to solving the problem of digitalization of transport in a smart city environment.

1. DATA COMMUNICATIONS IN SMART CITY INFRASTRUCTURE

Intelligent vehicle-based smart city system consists of three components: vehicles, roadside infrastructures, and a supporting data management system. The basic building block of a sustainable smart city infrastructure entails utilizing a vast amount of data from a wide variety of sources for different purposes. Data from different sources within a smart city proximity can be used for enhancement in many areas. Taking transportation as an example, supports for the day-to-day operation of the city include various pieces of connected infrastructural equipment, fleet management system, and critical automotive components that may have a substantial impact on traffic flow and road utilization efficiency. Further, generalized extensions to public transport systems that carry a significant proportion of commuters during peak hours would require data analysis of travel pattern. Data analytics therefore entails different types, like images that show the condition of real-time traffic (the overall picture entails analysis of video footage from an array of cameras that show vehicle movement in the area), pure numerical data about public transport usage, predefined routing of each and every bus operating in the area, and the most unpredictable movement of pedestrians that exhibits a high degree of randomness. To process such diverse types of data, a communication system must be able to carry data efficiently and securely irrespective of the type and intended destination.

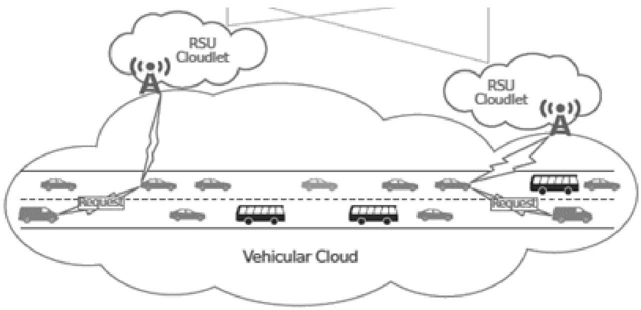

Figure 1. Vehicular cloud defined based on its network elements[6]

Moving into the smart city era, intelligent transportation systems entail far more than monitoring traffic flow on certain roads within a close proximity. The ITS architecture defines the framework for the development of the transport system in a small city*[3]*. Automation tasks such as electronic billing of road usage, collection of car parking fees, and electricity consumption of charging an electric vehicle (EV) should all be handled by a single payment platform. One of the key challenges is to assess data flow across the overall system, which has become a key part of smart transportation infrastructure development.

The major concerns are the ability to detect and identify events that are early warnings of traffic disruption, which could lead to eventual congestions. The ability to carry out an advance traffic assessment, data collection from multiple streams, integration and prognostication of multiple data streams for knowledge discovery, and decision-making will require a very sophisticated big data analysis platform. All of these outputs will ensure the reliability of the performance of the complex traffic analysis system.

2. VEHICLE COMMUNICATION NETWORK V2X

In the context of the smart city, interoperability with legacy networks and infrastructures is perhaps the greatest challenge that network planning has to deal with.This is significant as it entails more than full compliance with various networking standards. The legacy networks are not an issue by themselves, yet linking them with the smart city network backbone may entail validation of technology prior to network integration, and this may pose problems. When dealing with integration and interoperability, there is even more than integrating harmoniously between a smart city and the outside world. Smart city infrastructure should be designed such that vehicles ranging from the smallest personal mobility vehicle challenges in next generation transportation systems, several approaches and programs have recently been proposed, among them is the Intelligent Transportation Systems (ITS) concept*[7]*. Specifically, the latest ITS advances are promising to transform the system into a true Cyber Transportation System (CTS) with increased levels of connectivity among vehicles and the infrastructure (e.g., the Connected Vehicle (CV) initiative) and increased levels of vehicle automation (e.g., automated vehicles (AV) and ultimately self-driving cars). With the widespread adoption of V2X communication, smart cities are surrounded by various highly localized vehicular networks such as vehicle to vehicle (V2V), vehicle to home (V2H), and V2I. In the V2X context, the most important attribute of managing a network (or subnetwork) is constructing and maintaining network resources. Since momentous computational power is necessary to transmit and receive communication packets simultaneously, each vehicle in the V2X system may have certain limitations to share their resources by relaying packets destined for other nodes.

3. INTELLIGENT VEHICLE IN A SMART CITY

In the case of vehicle automation, it is possible that vehicles can safely follow each other more closely with faster reaction times while in traffic, thereby increasing the net capacity of the roadway (in terms of vehicles/hour/lane). However, it is very important to distinguish between autonomous vehicles and automated vehicles in the analysis. These two terms are often used interchangeably, however there is a significant difference when considering how vehicles interact in traffic and with associated congestion. An autonomous vehicle typically relies almost entirely on its on-board sensors to make driving decisions, just as humans do.

This is in contrast to automated vehicles, which in addition to on-board sensors, they can also take advantage of vehicle-to-vehicle communications, as well as infrastructure-to-vehicle communications. In the case of an autonomous vehicle, processing sensor information and making decisions solely on that information can sometimes take just as long as human drivers.

Automated driving is distinguished from driver assistance primarily through the role of the driver, and more specifically, through the involvement of the driver. Driver assistance systems including partially automated systems require the driver to constantly monitor the environment and to be instantaneously available to take back control from the vehicle. Automated driving systems will allow the driver to be completely out of the loop. If the driver is out of the loop, a significant amount of time may be required to return vehicle control to the driver. This challenge leads to relevant implications on the design of the automated driving system: the automated system has to make decisions in all situations and cannot rely on the driver to take back responsibility instantly. The interaction of the human driver with the automated system will be most relevant when it comes to the “handover” between manual driving and automated driving. The vehicle must monitor the driver’s position to take back control from the vehicle and must also ensure that the driver has taken back control. In case the driver fails to respond to a takeover request, the vehicle must be capable of bringing itself into a safe state. The execution of the safe state transition depends on the specific driving situation and may include changing to the emergency lane to come to a controlled stop or may result into a gradual slow down on the existing lane An automated driving vehicle needs to handle all situations within its functional scope. Driver assistance systems are typically designed and optimized for certain scenarios and often use rules to makes decision based on the detected scenarios. Automated vehicles must make reliable decisions in all scenarios Automated vehicles require combined lateral and longitudinal motion control to also ensure the desired position over time. Unlike the current generation of driver assistance systems, our control algorithms use coupled lateral and longitudinal control for improved performance. Automated Driving is a key enabling technology for increased efficiency, comfort and safety. More than 90 % of all accidents are at least partly caused by human error.

4. INTELLIGENT ROAD INFRASTRUCTURE OF A SMART CITY

There is a wide range of information that the infrastructure smart city can provide to connected and automated vehicles. By providing useful information about what is happening on the highways, infrastructure improves the functionality of automated vehicles and offers numerous benefits to the transportation system, including mobility, safety, and environmental benefits. These three areas are inextricably intertwined, and improvements in one area may result in benefits to the others*[6]* Congestion increases the risk of an incident occurring, which in turn leads to more congestion and fuel emissions. Similarly, where incidents occur, queues build up and may cause vehicles to stop suddenly, contributing to secondary crashes.

As noted above, connected infrastructure can provide information about impending congestion to an automated vehicle that can be used to make better route choices, dispersing traffic more efficiently across a network and improving mobility. Infrastructure can also support automation capabilities by providing managed lanes for truck platooning, which can improve the mobility of freight, thereby increasing national productivity. In addition to enriching the information environment, infrastructure may be a critical fail-safe when all other sources of information are unavailable. Connected infrastructure can contribute to safety by providing a redundant source of information that can be fused with sensors to increase the reliability of an automated vehicle. Any environment that relies upon highly sophisticated technology needs this redundancy so that if the primary system shuts down, backup systems are in place to ensure continuing functionality. Environmental benefits can also be realized through connected infrastructure. For example, the delivery of signal phase and timing information from traffic signals to automated vehicles can contribute to improved throughput and fuel savings by limiting the number of vehicles that idle at intersections waiting for lights to turn green.

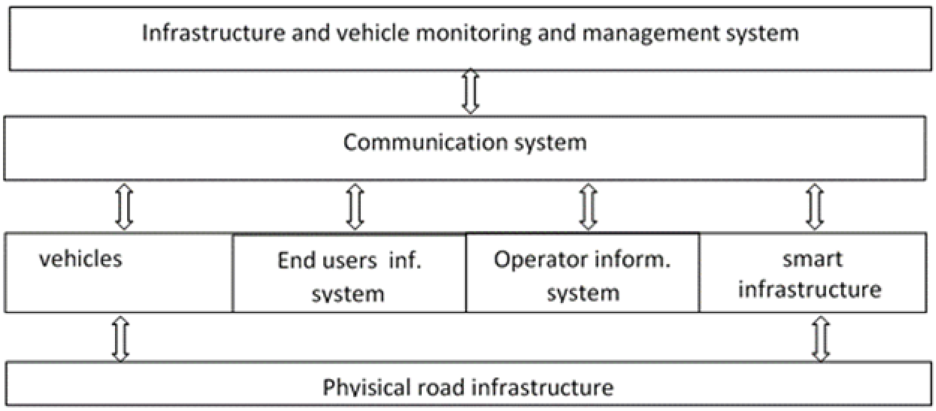

Figure 2. Functionalities of intelligent road infrastructure [1]

Timely infrastructure-provided information will enable new applications that are expected to be highly appealing to the buying public, thus benefitting all users of the transportation system. As intelligent infrastructure becomes increasingly deployed, automated vehicle purchases are expected to increase.

The installation of connected infrastructure may ultimately be the tipping point for revolutionary adoption of automated vehicles. Infrastructure and vehicle monitoring and management system, which automatically monitors all the other subsystems, manages the vehicle traffic and activates emergency procedures in case of malfunction. Infrastructure, whose role is to compensate the lack of performance on the onboard safety systems. End user information system, which allows end users to interact with the ARTS during normal and emergency operation. Operator information system, which allows a (human) fleet operator to remotely supervise the system operation and to intervene in case of need. Communication system, which must allow all the components communicate at all times. Automated vehicles, whose aim is to transport the passengers in a safe, secure and comfortable way from an origin station to a destination station

Our objective is to install a minimal number of RSUs on some road stretches such that every trajectory can be uniquely identified according to the received environmental evidences. More specifically, considering that some RSUs may use the same transmitting powers or time-dependent random numbers, here we focus on the distinguishability exclusively based on RSU identity numbers within the environmental evidences. Generally, the optimal placement of RSUs must guarantee three conditions. First, a minimal number of RSUs are deployed on certain road stretches. Second, the vehicles traveled along different routesmust be distinguishable according to their received environmental evidences' RSU identities. Last, considering that an adversary may intentionally drop certain RSUs' messages in order to create fake location claims, a flow's tag sequence cannot be the subsequence of any other flow's received tag sequence.

5. CONCLUSION

The development of the smart city requires a change in the environment of road vehicles, which includes intelligent roads and intelligent vehicles. This can be achieved by developing intelligent transport systems. The ITS architecture defines the framework for the development and implementation of ITS services. It is necessary to integrate the functions of the transport system and the intelligent city on a functional and physical level. This requires the inclusion of intelligent transport systems in all phases of smart city development from the planning, implementation implementation design and measurement of the effects of smart city functions on the transport system. In order to achieve the desired goals, it is necessary to transform the physical transport infrastructure into digitalization infrastructure. The digitized infrastructure will enable the interaction of road vehicles, drivers and transport users with the environment in a more efficient way, which will increase the efficiency of the transport system in the smart city.

REFERENCES

[1] Augusto,J,C.: Handbook of Smart Cities, Springer, 2021.

[2] Ezgeta,D.: Inteligentni transportni sustavi, Fakultet za saobraćaj i komunikacije Sarajevo,Sarajevo, 2018.

[3] Ezgeta, D., Mehanović,M.Ahmić.A: The role of ITS arhitecture in the digitalization of transport, 7th international conference „Toward City“, Novi Sad , 2019.

[4] Mehanović,M: Planiranje u saobraćaju , prijevozu i komunikacijama, Fakultet za saobraćaj i komunikacije Sarajevo,Sarajevo, 2017.

[5] Mehanovic,M: Public Transport of Passengers Main Resource of Sustainable Urban Mobility in Sarajevo,IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) 17 (2 Ser. IV)

[6] Meneguette,R.I, De Grande,R.E, Loureiro,A: Intelligent Transport System in Smart Cities, Springer,2018

[7] Song,M.,Srinivasan,R., Tamim Sookoor,T.: Smart city-foundations, principles and apllications, Wiley,2017.

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REORGANIZATION OF THE FOUR-LINE INTERSECTION IN VRANJE

Key Words

Intersection

Traffic flow

Regulation of traffic flow

Abstract

An intersection is a place on the traffic network where conflicts occur between traffic flows, which come in two or more different directions. As part of this research, an analysis of traffic conditions was conducted. After that, the forecast of traffic load at the four-line intersection in the city of Vranje is given. Based on the obtained data, adequate measures are proposed and then a functional evaluation of the proposed solutions is conducted in order to improve existing traffic conditions.

1. INTRODUCTION

In the field of traffic regulation and management, traffic conditions at intersections are often the most complex. An intersection can be defined as the place in the traffic network in which traffic conflicts occur between vehicles that arrive from two or more different directions. Therefore, the intersection represents a crossing of different traffic flows.

Traffic regulation at intersections depends on the intensity of traffic. When the intensity of traffic increases the capacity of the intersection decreases and therefore traffic regulation at intersections needs to be adjusted. These adjustments include the installation of vertical traffic signals, construction interventions, installation of traffic lights, etc.

In this paper, an analysis of traffic conditions at the four-lane intersection in the city of Vranje is presented. The four-lane intersection encompasses the following streets: Bora Stankovic Street, Maricka Street, Nemanjina Street, and Pariskih Komuna Street. The analysis is performed on Wednesday, the 23rd of June, 2021., between 7 AM and 7 PM. After that, the obtained results are analyzed and set of measures are proposed for the optimization of traffic. In this research the analysis of pedestrian flows at marked pedestrian crossing was not performed, because the mentioned four-lane intersection is mostly used by vehicles.

2. THE CHARACTERISTICS OF ANALYZED INTERSECTION

The analyzed four-lane intersection is located in the wider central zone of the city Vranje (Figure 1). The intersection is about 1 kilometer away from the city center.

Figure 1. Satellite image of analyzed intersection

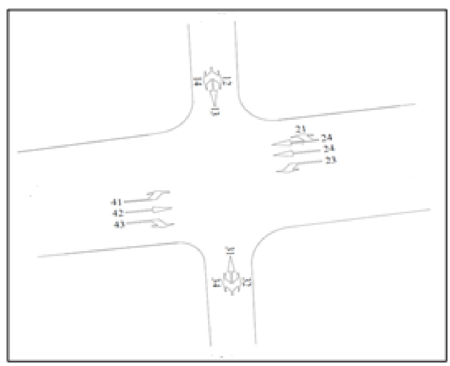

Figure 2. Inflow heads and directions of movement at the analyzed intersection

The four-lane intersection encompasses the following streets: Bora Stankovic Street, Maricka Street, Nemanjina Street, and Pariskih Komuna Street. At the analyzed intersection, traffic is allowed in both directions on all lanes. The traffic is regulated by light traffic signs. The directions of movement is shown in Figure 2.

The northern lane (Nemanjina Street) consists of an entry and departure lanes which are not separated by a median. The road lanes are separated by an unbroken dividing line, which has faded. The pedestrian crossing was partially marked, while the stop line was not marked, and other markings on the road are also faded. There is a vertical signalization which includes the sign - road with priority.

The eastern lane (Maricka Street) consists of an entry and departure lanes that are not separated by a median. The road lanes are separated by an unbroken dividing line, which has faded. The pedestrian crossing is partially marked, while the stop line is not marked. The traffic light is placed on the right edge of the road and there is also a vertical signalization that includes a sign - mandatory stop and a sign - pedestrian crossing.

The southern lane (Pariskih Komuna Street) consists of an entry and departure lanes which are separated by a median. The road lanes are separated by dividing line without defined priority. The pedestrian crossing is partially marked, while the stop line is not marked, and other markings on the road are faded. The traffic light is placed on the median between the traffic lanes. The traffic sign intended for pedestrian traffic is placed on both sides of the road.

The western lane (Bora Stankovic Street) consists of an entry and departure lanes which are separated by a median. The road lanes are separated by a dividing dashed line with defined priority. The pedestrian crossing is partially marked, while the stop line is not marked. In addition to the traffic light signs that are placed on the left edge of the right lane and on the median between the left and right traffic lanes, there is a vertical signalization that includes a sign - mandatory stop and a sign - pedestrian crossing.

At the entrances, the vertical and horizontal signalization is not positioned in accordance with the Rulebook on traffic signalization ("Official Gazette of RS", no.85/2017 and 14/2021).

3. THE TRAFFIC FLOW ANALYSIS

Traffic counting at the four-lane intersection was performed on Wednesday, the 23rd of June, 2021. Traffic counting was performed by the method of manual counting on the basis of a simple counting pattern, in the period from 7 am to 7 pm. The peak hour is chosen to be between 2 pm and 3 pm.

The obtained data show that the following vehicles participated in the traffic flow: passenger cars, buses, light, medium and heavy trucks, auto trains, motorcycles, bicycles, and tractors. Table 1 shows the structure of traffic flows by directions in the interval of 60 minutes. In the total sample, the number of passenger cars is incomparably the largest (see Table 1).

The most dominant category of vehicles in the sample in terms of number of vehicles is passenger cars (1146 veh/h or 84.8%). The following categories are: light trucks (88 veh/h or 6.5%), motorcycles (3.0%), medium-sized trucks (1.4%), buses (1.3%), cyclists (1.2%), heavy goods vehicles (1.1%), and motor vehicles (0.1%).

By converting the share of traffic load into PAJ, it is concluded that in the period after the noon peak load, the size of the traffic flow is most pronounced in the direction "31" when the flow rate is 279 PAJ/h, while it is least pronounced in the direction "14" when the flow rate is 14 PAJ/h. Also, the magnitude of the flow is most pronounced in Approach 3 (514 PAJ/h), while it is least pronounced in Approach 4 (227 PAJ/h), as shown in Figure 3.

Table 1. Traffic Flow Structure by Direction of Movement

Approach	Direction	BIC	MOT	WELL	THE BUS	CARGO VEHICLES			AV	Tractors	Total (veh/h)
						LT	ST	TT			
1	12	4	5	97	2	10	2	0	0	0	120
	13	0	2	151	2	24	1	0	0	2	182
	14	0	0	13	0	1	0	0	0	0	14
	Total	4	7	261	4	35	3	0	0	2	316
2	23	0	3	114	2	10	0	3	0	0	132
	24	0	2	78	4	4	0	0	0	2	90
	21	1	6	75	1	4	2	0	0	1	90
	Total	1	11	267	7	18	2	3	0	3	312
3	34	1	3	52	0	1	0	0	0	0	57
	31	6	11	241	3	14	3	1	0	0	279
	32	1	4	141	3	10	0	10	0	0	169
	Total	8	18	434	6	25	3	11	0	0	505
4	41	1	1	27	0	2	3	0	0	0	34
	42	0	2	87	0	6	1	0	0	0	96
	43	2	3	70	1	2	7	1	1	0	87
	Total	3	6	184	1	10	11	1	1	0	217
Total (veh/h)		16	42	1146	18	88	19	15	1	5	1350

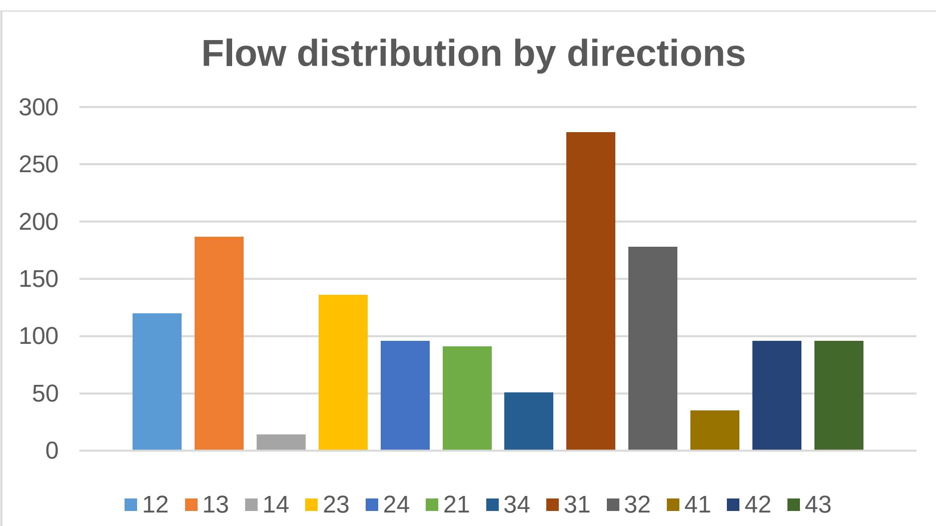

Figure 3. Graphical representation of flow distribution by directions

4. MEASURES FOR IMPROVING THE TRAFFIC AT THE ANALYZED INTERSECTION

Reorganization of the observed four-lane signalized intersection is reflected primarily in the change of the signaling timing plan, the geometry of the intersection, as well as in defining the purpose of traffic lanes.

Traffic lane 1. Three traffic lanes on the departure should be organized. The left traffic lane would be intended for left turns, the middle traffic lane would be intended for vehicles continuing their movement straight, and the right traffic lane would be intended for right turns. Vertical and horizontal traffic signalization should be installed (including the sign - road without priority). At least one traffic lane on the entry should be organized.

Traffic lane 2. Three traffic lanes on the departure should be organized. The left traffic lane would be intended for left turns, the middle traffic lane would be intended for vehicles continuing their movement straight, and the right traffic lane would be intended for right turns. At least one traffic lane on the entry should be organized.

Traffic lane 3. Three traffic lanes on the departure should be organized. The left traffic lane would be intended for left turns, the middle traffic lane would be intended for vehicles continuing their movement straight, and the right traffic lane would be intended for right turns. Vertical and horizontal traffic signalization should be installed (including the sign - road without priority). At least one traffic lane on the entry should be organized.

Traffic lane 4. Three traffic lanes on the departure should be organized. The left traffic lane would be intended for left turns, the middle traffic lane would be intended for vehicles continuing their movement straight, and the right traffic lane would be intended for right turns. Vertical and horizontal traffic signalization should be installed (including the sign - road without priority). At least one traffic lane on the entry should be organized.

All input data needed to determine the capacity and level of service and to propose the conceptual solution are obtained from traffic counting (Figure 4).

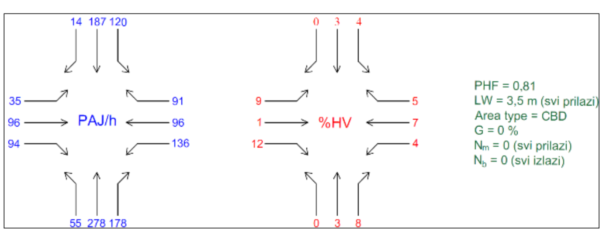

Figure 4. Display of input data in the conceptual solution

Application software – HCS was used to obtain the optimal cycle duration of 60 seconds. The mode of operation of the proposed variant would consist of two characteristic states, that is two phases. The duration of individual phases, with the period "all red" (protection times Δt_{12} and Δt_{21}), are shown in Figure 5.

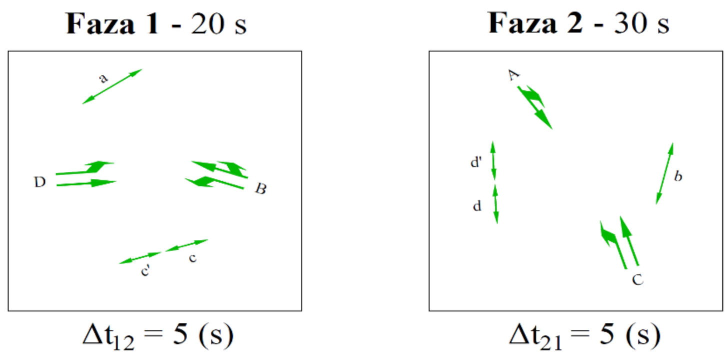

Figure 5. Phase plan for the proposed Variant

Based on the matrix of protection times and the phase plan, a timing plan for light signals is developed. The output results for the proposed variant are presented in Table 2.

Table 2. Display of output results for the proposed Variant

CAPACITY, TIME LOSSES AND LEVEL OF SERVICE										
Approaching	Western			Eastern		South			North	
Ribbon Groups	L	P	D	L	PD	L	P	D	IP	D
Capacity **c** (train/h)	270	474	1283	313	419	396	739	1331	543	1398
Saturation degree **X** (v/c)	0,16	0,25	0,09	0,54	0,55	0,17	0,46	0,17	0,70	0,01
Time losses **d** (s/train)	17,4	17,9	0,1	24,6	23,4	10,8	13,6	0,3	20,5	0,0
LOS	B	B	And	C	C	B	B	And	C	And
d in the driveway (s/train)	10,4			23,9		8,6			19,6	
LOS in the driveway	B			C		And			B	
d at the intersection (s/train)	**15,1**									
LOS at the crossroads	**B**									

As can be seen from the Table 2, in case of accepting the proposed variant of the solution traffic conditions in the four-lane intersection would be close to uninterrupted traffic flow (LOS=B) with a very favorable amount of time losses (15.1 s/car). The most favorable conditions would be on the southern lane, where the speed would be equal to the conditions of uninterrupted traffic flow (LOS=A), while on the northern and western lanes the speed would be close or equal to the conditions of uninterrupted traffic flow (LOS=B), and on the eastern lane conditions would be stable traffic flow (LOS=C).

5. DISCUSSION AND CONCLUSION

Traffic optimization on existing roads is not always a possible solution. In some cases, it is necessary to expand or build new roads. The presented example of the four-lane intersection referred to the improvement of traffic at the individual lanes in terms of geometry with the Rulebook on traffic signalization ("Official Gazette of RS", no. 85/2017 and 14/2021).

Based on the obtained data on the size of the traffic flow at the four-lane intersection the measures for improving the traffic are proposed. First, is is concluded that at the peak hour about 1350 veh /h pass, or when it is converted into PAJ about 1387 veh/h. The busiest lane is traffic lane 3 with about 505 veh/h, or when converted to PAJ 514 veh/h. The busiest route is the route from traffic lane 3 to traffic lane 1 with about 279 veh/h. As for the structure of the traffic flow, passenger cars dominate with a share of 84.4%. The main criteria during the search for the optimal solution for regulating the mentioned intersection is that the solution is functionally justified, as well as economically viable.

The adequate measures are proposed to regulate the traffic at the analyzed intersection. With the help of HCS application software, the optimal cycle duration of 60 seconds was obtained. Based on the matrix of protection times, the development of a plan for light signalization is proposed. After that, the evaluation of the proposed solution was performed and it is concluded that in the case of accepting the proposed solution, conditions close to uninterrupted traffic flow (LOS=B) would prevail in the intersection zone, with very favorable time losses (15,1 s/veh). The most favorable conditions are on the southern lane, where the vehicles' speed is projected to be equal to the conditions of uninterrupted traffic flow (LOS=A), while on the northern and western lane the vehicles' speed is projected to be close or equal to the conditions of uninterrupted traffic flow (LOS=B), and on the eastern lane conditions are projected to be stable traffic flow (LOS=C).

However, one should keep in mind that the network regulation and management of traffic flows need to be coordinate on the whole network and not only at single intersection. Inadequate regulation at a single point of a network can create traffic problems on the entire network. The future work could deal with the intelligent light signalization which is economically very favorable, especially over a longer prediction time interval.

As a potential solution to the problem, the traffic roundabout with appropriate geometry is also considered. However, based on the cost benefit analysis, this approach is unjustified from the economic point of view. In addition, the traffic roundabout brings the problem of limited vehicle flow capacity, limited pedestrian crossing, etc.

Last, but not the least, the budget funds are the funds of all citizens of the Republic of Serbia. Unintended spending of budget funds without consulting expert associates in the field of traffic planning is a large problem in the Republic of Serbia. This paper shows the possibility of saving funds with other more adequate solutions.

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REFERENCES

[1] Akçelik, R. (2011). *Roundabout Metering Signals: Capacity, Performance and Timing*. In Proc. 6th International Symposium on Highway Capacity and Quality of Service. Stockholm, Sweden, pp. 686-696.

[2] Akçelik, R. (2005). *Capacity and Performance Analysis of Roundabout Metering Signals*. In TRB National Roundabout Conference, Vail, Colorado, U.S.

[3] Azhar, A., Svante, B. (2011). *Signal Control of Roundabouts.* In Proc. 6th International Symposium on Highway Capacity and Quality of Service, Stockholm, Sweden, pp. 729-738.

[4] Bogdanović, V., Papić, Z., Ruškić, N., Dragic, D. (2016). *Regulating traffic at roundabouts.* Consulting with international participation on the topic: Traffic accidents, Zlatibor, pp. 189-196.

[5] Bogdanović, V. Excerpts from lectures in the subject Regulation and Traffic Management and Project Evaluation. University of Novi Sad, Faculty of Technical Sciences, Novi Sad.

[6] Brilon, W. &b Stuwe. (1993). *Capacity and Design of Traffic Circles in Germany.* In Transportation Research Record 1398, TRB, National Research Council, Washington, D.C., pp. 61-67.

[7] Cabarkapa, M., Vukanović, S. (2015). *Entry control eliminates vehicle conflict at the exit of the two-way roundabout.* Technique – Traffic 62, Belgrade, pp. 839-844.

[8] Regulation on conditions that must be met from the point of view of traffic safety by road facilities and other elements of the public road. (2011). "Official Gazette of RS", No. 50/2011, Belgrade.

[9] PTV (2018). Vistro 6 (Student) User Manual, Karlsruhe, Germany.

[10] Stevens, C. (2005). *Signals and Meters at Roundabouts.* Mid-Continent Transportation Research Symposium, Ames Iowa, United States.

[11] Tracz, M., Chodur, J. (2012). *Performance and Safety of Roundabouts with Traffic Signals*. In Proc. SIIV – 5th International Congress – Sustainability of Road Infrastructures, pp. 789-800.

8th INTERNATIONAL CONFERENCE
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New Mobility Challenges
Novi Sad 11th and 12th November 2021

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INFLUENCE OF THE SHARED RIGHT/THROUGH LANE ON SIGNALIZED INTERSECTION CAPACITY

Key Words

Signalized intersection

Shared right/through lane

Capacity

Abstract

At the signalized intersections, lanes are designed for use by the vehicles doing a different movement. Shared lanes increase the flexibility to fulfill different traffic volumes. However, a shared lane is not always beneficial. This paper compares two types of lane design at signalized intersections and their influence on the intersection capacity. An approach with a shared through/right lane with permitted Right Turn on Red (RTOR) is compared with an approach with the same lane layout but without permitted RTOR. This analysis showed whether the permitted RTOR is necessary at the intersection and how it affects intersection capacity.

1. INTRODUCTION

In some cases, more than one approach lane serves one directional flow due to large traffic demands. The exact number of lanes for through traffic is easy to calculate according to the volume.

The adjustment factors of the saturation flow rates at signalized intersections can also help determine the intersection's layout, including the exact number of lanes in each direction [1].

Turning movements have a determining effect on the safety and operations at the signalized intersections. Therefore, various treatments of turning movements have been the focus of attention of those involved in the design and operations of the intersection signal control. Right-turn movements at the signalized intersections are subjected to multiple treatments. Lower volume intersections typically involve a shared lane for the through and right-turning traffic. As traffic level increases, including the right-turning traffic, the need for providing an exclusive right also increases [2]. A traffic light is a common way of regulating traffic in places where flows collide because of the lack of capacity for some or all traffic flows appear unjustifiably large congestion or more serious deterioration of traffic safety. Traffic regulation is performed by applying appropriate light signaling systems. Unwarranted signals might cause some problems [3].

When right turn on red (RTOR) is permitted, the right-turn volume for analysis may be reduced by the volume of right-turning vehicles moving on the red phase. This reduction is generally made based on hourly volumes before the conversion to flow rates. The number of vehicles able to turn right on a red phase is a function of several factors, including

- Approach lane allocation (shared or exclusive right-turn lane),
- Demand for right-turn movements,
- Sight distance at the intersection approach,
- Degree of saturation of the conflicting through movement,
- Arrival patterns over the signal cycle,
- Left-turn signal phasing on the conflicting street, and
- Conflicts with pedestrians.

For an existing intersection, it is appropriate to consider the RTORs that occur. For both the shared lane and the exclusive right-turn lane conditions, the number of RTORs may be subtracted from the right-turn volume before analysis of lane group capacity or LOS. At the existing intersection, the number of RTORs should be determined by field observation. [4]

In this paper, an analysis of two signalized intersections was performed. At the first intersection, shared through/right lane that has permitted RTOR. At the second intersection, shared through/right lane that does not have permitted RTOR. According to conducted analyses, the influence of permitted RTOR on capacity was established.

2. METHODOLOGY

Traffic counting was performed on August 13, 2021, at two locations at Novi Sad. At the intersection Futoska ulica – Brace Ribnikara (Figure 1), the counting was performed in peak period from 08:00-09:00h, on approach that has an exclusive left lane, a through lane, and shared right / through lane on which there is a permitted RTOR. The cycle length on this intersection is 130s. Traffic lanes are separated by a median that is 1.30 m wide. The width of traffic lanes at all approaches is 3.0 m.

At the intersection Bulevar kralja Petra I - Rumenacka, traffic counting was performed on August 13, 2021, in a peak period from 15:00h-16:00h. The observed approach (Figure 2) consists of six traffic lanes. Traffic lanes are separated by a median that is 1.50 m wide. The cycle length on this intersection is 110s.

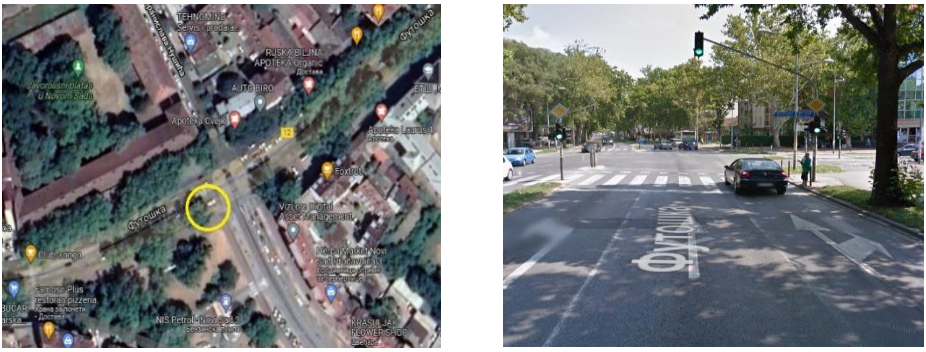


Figure 1. Analyzed approach at the intersection Futoska ulica - Brace Ribnikara

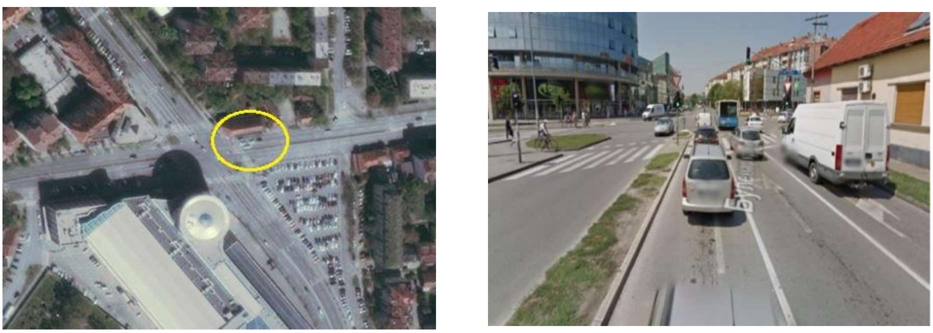


Figure 2. Analyzed approach at the intersection Bulevar kralja Petra I-Rumenacka

3. RESULTS

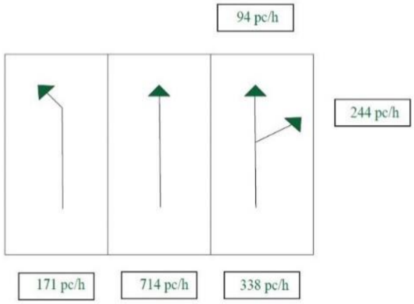
A capacitive analysis was performed based on the traffic counting, and the level of services for each lane on the observed approach was determined.

By counting the vehicles at the observed approach, at the intersection Futoska-Brace Ribnikar, distribution by lanes was obtained (Figure 3). Capacity analysis in the HCS 2000 (Highway Capacity Software) was performed. The output of this program is the capacity data of the individual lanes on this approach.

The number of the counted vehicles that are turning right is 244 pc/h. A total of 189 vehicles were blocked from turning right due to 94 vehicles in the same lane going through. That means that 51% of the vehicles that would turn right are blocked, which significantly affects the lane's capacity.

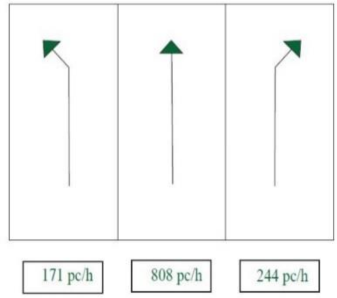
The existing level of service at the observed approach in all lanes D. If the right lane, which is shared right/through, would be converted to the exclusive right turn lane, it would have a different level of service, shown in Figure 4.

LOS is slightly lower in a through lane, downgraded from D to E using the new lane layout. On the other hand, LOS would be significantly better in the right turn lane. It would be improved from D to A.



LOS by lane D, D, and D, respectively.

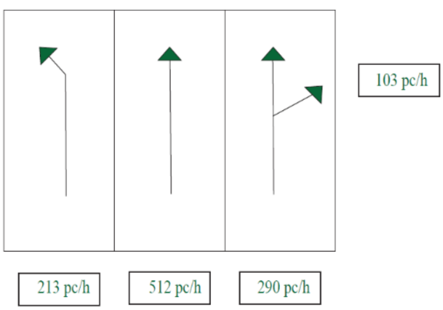
Figure 3. Traffic flow distribution by lanes and LOS at the observed approach



LOS by lane D, E, and A, respectively.

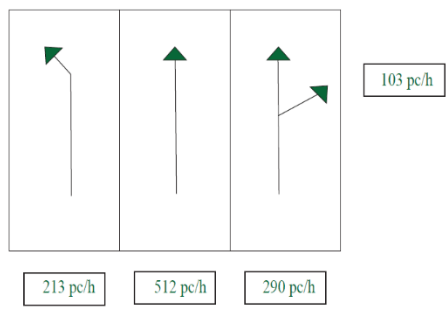
Figure 4. Traffic flow distribution by lane and LOS at the observed approach with a new lane layout

By counting the vehicles at the observed approach at the intersection of Bulevar kralja Petra I - Rumenacka, distribution by lanes was obtained. Capacity analysis results are shown in Figure 5.



LOS by lanes F, F, and C, respectively.

Figure 5. Traffic flow distribution by lanes and LOS at the observed approach



LOS by lanes F, F, and A, respectively.

Figure 6. Distribution by lanes and LOS on observed approach

At the shared right/through lane, RTOR is not permitted 290 pc/h vehicles that are going through during the cycle were blocked by 103 vehicles that are turning right. That means that 65% of vehicles that would go through are blocked.

If the shared right/through lane has permitted Right Turn on Red (RTOR), the level of service (shown in Figure 6) would be better.

4. CONCLUSION

In this paper, analysis of the intersection Futoska ulica-Brace Ribnikar and the intersection Bulevar kralja Petra I – Rumenacka, was performed. At the intersection Futoska ulica - Brace Ribnikar, an approach that has an exclusive left lane, a through lane, and a shared right/through lane on which there is permitted Right Turn on Red (RTOR) was analyzed. Another approach was also analyzed at the signalized intersection Bulevar kralja Petra - Rumenacka with the same lane layout, except that the shared right/through lane does not have a permitted RTOR.

In order to determine the traffic conditions at the analyzed intersection, an analysis of existing conditions was performed. For that purpose, traffic counting was made.

By analyzing the capacity using the HCS 2000, it was found that all the lanes at the intersection Futoska ulica - Brace Ribnikar have a level of service D. At this approach, in the shared through/right lane with permitted RTOR, 51% of right-turning vehicles were blocked by the vehicles that are going through. Regarding the existing level of service, if the shared right/through lane would be converted to an exclusive right turn lane, the level of service would be A.

At the intersection Bulevar kralja Petra I – Rumenacka in shared through/right lane with no permitted RTOR, 65% of through vehicles were blocked by the right-turning vehicles. At this lane, the calculated LOS is C. If we introduce permitted RTOR for this lane, LOS would be A.

Traffic conditions at the signalized intersections are influenced mainly by traffic signal phasing design and the green light duration. Minor corrections, as well as very cheap measures, can significantly affect the level of service. This paper showed how the soft measures (change of lane designation or addition of green light arrow) could improve traffic conditions and level of service at the signalized intersection.

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REFERENCES

[1] Qi, H.; Wang, D.; Chen, P.; Bie, Y. Simulation of departure flow profile at stop lines for signal approach spillover. Transp. Res. Part C Emerg. Technol. 2013, 33, 88–106.

[2] Wang, Y.; Rong, J.; Zhou, C.; Chang, X.; Liu, S. An Analysis of the Interactions between Adjustment Factors of Saturation Flow Rates at Signalized Intersections. Sustainability 2020, 12, 665.

[3] Lj. Kuzović: Kapacitet i nivo usluge drumskih saobraćajnica. Beograd, 2000.

[4] Highway Capacity manual, 2016.

[5] Highway Capacity manual, Transportation Research Board, Nationl Research Council. Washington D.C., 2010.

8th INTERNATIONAL CONFERENCE
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IS ROUNDABOUT BETTER SOLUTION THAN A SIGNALIZED INTERSECTION?

Key Words

Traffic simulation

Signalized intersection

Roundabout intersection

Simulation software

Abstract

Roundabouts have become a common model of traffic control in urban areas in Serbia. This type of intersection is increasingly used as an alternative solution to signalized intersections. But is that always a good solution, regarding traffic capacity and level of service? This paper gives insight into the comparative analysis of capacity and level of service on 3 signalized intersections and 3 roundabouts in the City of Novi Sad, Serbia. The main goal is to compare the traffic conditions in the existing state and proposed state (roundabouts to signalized intersections and vice versa). All analyses were performed in a simulated environment.

1. INTRODUCTION

The most common way of traffic control at intersections with high traffic volume is the use of signalized intersections or roundabouts.

At the signalized intersections, the priority is defined by traffic signals. Advantages of this way of control are flexible control, possibility to adapt green time to traffic volume which can enlarge approach capacity and improve the level of service. Traffic lights are a common way of control at the intersections where traffic flow exceeds unsignalized intersection capacity. Disadvantages of traffic lights are higher vehicle speeds in the center of the intersections, more conflict points than a roundabout, as well as pedestrians passing crosswalks during right or left turns.

In recent days, roundabouts became very common on street and road networks. The advantages of roundabouts are lower vehicle speeds and fewer points of conflict compared to signalized intersections, which makes them generally safer than signalized intersections. Average vehicle delay during peak periods can be lower at roundabouts than at signalized or two-way stop-controlled intersections. Disadvantages of roundabouts are high construction costs, unsignalized pedestrian crosswalks and inability to face a potential increase in traffic demands.

In this paper, an analysis of traffic control change was made. Three signalized intersections and three roundabouts were selected as a subject of potential traffic control change. The proposed solution changed control at the roundabout to a signalized intersection and vice versa. Analyses of capacity and level of service were made for all six intersections.

2. PREVIOUS RESEARCH

Traffic conditions are analyzed by many researchers. According to HCM, traffic conditions are observed through delays [1].

There are various papers regarding both types of analyzed intersections (roundabouts and signalized intersections). Many of those papers focused on the idea of changing traffic control at the intersection, either roundabout into a signalized intersection or vice versa. Rune Elvik [2] analyzed the safety effects caused by changing a signalized intersection into a roundabout. He defined advantages of such solutions.

Evaluation of benefits of changing roundabouts into signalized intersections, to get better capacity and level of service, has been analyzed by Mahmoud Owais, Omar Abulwafa, and Youssef Ali Abbas [3]. In their paper, two roundabouts from the cities of Jeddah and Al-Madinah were analyzed using Sidra and Synchro software. The results of this research showed the benefits of reconstruction of the roundabout into a signalized intersection.

Ibrahim Khliefat, Mohammad Naser, Fadi Alhomaidat, and Shadi Hanandeh [4] analyzed the existing traffic condition at the roundabout by using VISSIM and C++ software. They concluded that signalized intersections offer a higher level of service, as well as a significant decrease in delays.

Jithender Jatoth, Nawal Kishor Singh, and Arpan Mehar [5] analyzed two signalized intersections. Their paper showed that the usage of the countdown timer showed a better level of service and higher capacity values.

According to Aleksandr Novikov, Ivan Novikov, and Anastasia Shevtsova, the capacity on signalized intersections has been decreased in the wintertime and when the road is wet, and the changes in signal schedule resulted in a capacity increase [6].

In their paper A. Polus, S. Shumeli [7], H. R. Al-Masaeid, and M. Z. Faddah [8] had focused on the influence of the roundabout's geometry on its capacity and level of service both in Germany and Jordan. They had used various models to analyze several roundabouts with different dimensions and concluded that the size of the central island influenced capacity increase.

Roundabout's advantages have been analyzed by Marc T. Johnson and William A. Hange [9]. They conducted 4 independent studies and analyzed several intersections. Their paper showed that the roundabouts provide better results in both level of service and higher capacity.

3. METHODOLOGY

For this paper, a 24-hrs traffic recording was conducted. Video recordings were used for acquiring data of the traffic flow and traffic distribution by directions on the intersections. The obtained values of peak hour flow are given in Table 1.

Table 1. Peak hour flow (veh/h)

	Approach 1	Approach 2	Approach 3	Approach 4	Total
Bul. Oslobođenja - Futoška St. - Jevrejska St. (I1)	1451	928	1472	779	**4630**
Futoški put - Bul. patrijarha Pavla - Bul. kneza Miloša (I2)	907	1345	785	934	**3971**
Bul. Oslobođenja - Bul. Cara Lazara (I3)	1404	1333	980	1285	**5002**
Rumenački put - Bul.Evrope - Rumenačka St. (R1)	954	589	954	1185	**3682**
K. Stankovića St. - Bul.Evrope - Bul. vojvode Stepe (R2)	905	916	733	924	**3478**
Bul. Evrope - Bul. Cara Lazara - Bul. patrijarha Pavla (R3)	828	1615	112	883	**3438**

The obtained data were used to determine the capacity and level of service in the existing state. In the proposed state, it was presumed that traffic control is changed at the intersections (roundabout to signalized intersection, and vice versa). In that case, the capacity and level of service had been determined. Models used in this research were HCM [10, 11, 12].

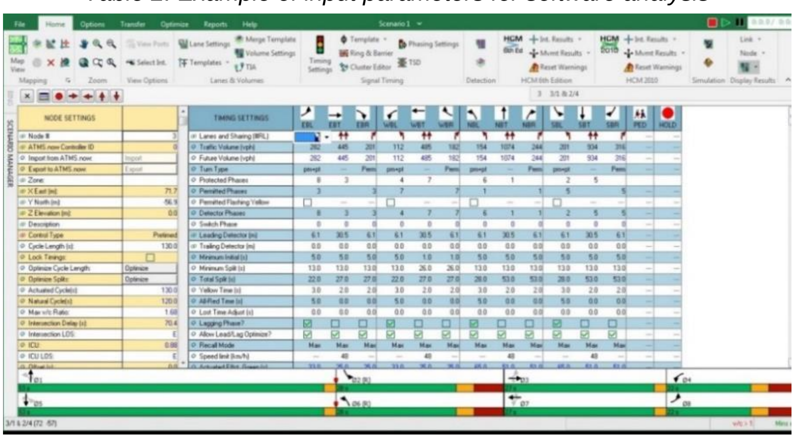
All analyses were made using Synchro software. Every analyzed intersection was modeled in the existing state and proposed state. The intersection model in the existing state and its traffic volume is shown in Figure 1, while the proposed state is shown in Figure 2.

Figure 1. Model of the signalized intersection in Synchro software

Figure 2. Model of the roundabout in Synchro software

An example of input data is given in Table 2.

Table 2. Example of input parameters for software analysis



The results are presented in the next Chapter.

4. RESULTS

Six intersections were chosen for the study, three of them are signalized while three are roundabouts. Every intersection has a different traffic volume. All intersections are chosen by traffic flow parameters to get different traffic conditions for all analyzed cases. Positions of the intersections at the street network of Novi Sad are shown in Figure 3.

Figure 3. Position of intersections at the street network of Novi Sad

For this paper, the following steps are made:

Step 1: The level of service at the intersections in the existing state was analyzed.

Step 2: Traffic control was proposed to be changed. Roundabouts became signalized intersections and vice versa.

Step 3: The level of service in the proposed conditions was analyzed.

Step 4: The comparative analysis in the level of service at existing and proposed conditions was determined. Results of all previous steps are shown in Table 3.

Table 3. Level of service – existing and proposed state

Intersection	Rush hour peak (veh/h)		Existing state LOS			Proposed state LOS	
Bul. Oslobođenja - Futoška St. - Jevrejska St. (I1)	4630	**Signalized int.**	E	(70,4)	**Roundabout**	F	(227,7)
Futoški put - Bul. patrijarha Pavla - Bul. kneza Miloša (I2)	3971		E	(79,2)		F	(80,8)
Bul. Oslobođenja - Bul. Cara Lazara (I3)	5002		F	(107,9)		F	(207,7)
			Existing state LOS			**Proposed state LOS**	
Rumenački put - Bul.Evrope - Rumenačka St. (R1)	3682	**Roundabout**	F	(245,3)	**Signalized int.**	D	(35,6)
K. Stankovića St. - Bul.Evrope - Bul. vojvode Stepe (R2)	3478		F	(148,7)		D	(45,0)
Bul. Evrope - Bul. Cara Lazara - Bul. patrijarha Pavla (R3)	3438		C	(16,6)		C	(21,9)

Results of changing way of control showed:

- At the intersection **R1** (roundabout), the determined level of service is **F** (**d = 245,3 s/veh**). After changing traffic control into signalized, the level of service has been improved to **D** (**d = 35,6 s/veh**).

- At the intersection **R2** (roundabout), the determined level of service is **F** (**d = 148,7 s/veh**). After changing traffic control into signalized, the level of service has been increased at **D** (**d = 45,0 s/veh**).

- At the intersection **R3** (roundabout) level of service in the existing state is **C** (**d = 16,6 s/veh**). After changing traffic control, roundabout into the signalized intersection, level of service remains **C**, while the delays of the intersection have been increased to **21,9 s/veh**.

- For the roundabout, change of control into signalized intersection leads to the level of service improvement in case if traffic volume exceeds 3500 veh/h. On the other hand, if the traffic volume is less than 3500, the level of service remains the same or getting worse.

- Intersection **I1 (signalized)** has level of service **E** (**d = 70,4 s/veh**). After changing traffic control into the roundabout, the level of service getting worse - **F** (**d = 227,7 s/veh**).

- Intersection **I2 (signalized)** has level of service **E** (**d = 79,2 s/veh**). After changing traffic control into the roundabout, the level of service has slightly lower - **F** (**d = 80,8 s/veh**).

- The same case is for the **I3 (signalized)**. This intersection has the level of service **F** (**d = 107,9 s/veh**) in existing conditions. After changing traffic control to a roundabout, the level of service remains F, while the intersection delays have been increased to **207,7 s/veh**.

- For signalized intersections, change of traffic control to roundabout always degrade the level of service for high traffic volume (more than 3500 veh/h).

The results shown in this paper indicated that the method of turning roundabout into signalized intersection could be applicable at intersections with a traffic volume higher than 3500 veh/h. Other analyzed studies did not determine the exact volume when the roundabout should be changed to signalized intersection.

5. CONCLUSION

In many cities, it is a typical case to change a signalized intersection into a roundabout. However, that is not always a good solution. By changing traffic control to a roundabout, the level of service can become worse than at the signalized intersections. This paper shows an analysis of three signalized intersections and three roundabouts in Novi Sad, with a traffic volume of more than 3000 veh/h.

The analysis results show that the signalized intersections will have a lower level of service if they are converted into roundabouts. According to the results, in cases when traffic volume exceeds 3000 veh/h (3500 veh/h at most), changing signalized intersection into a roundabout is not a good solution.

On the other hand, the level of service at the analyzed roundabouts is improved after changing traffic control into a signalized intersection. For high traffic volume (over 3500 veh/h), changing the roundabout into a signalized intersection proved as a better solution. In two cases, the results showed a significantly better level of service (from F to D) and much smaller delays.

The limit of 3500 veh/h determined in this paper is subject to adjustment. If the number of circulating lanes reduces from two to one, the capacity of a roundabout will be lower. Increased percent of heavy vehicles and left-turn volume can lead to LOS deterioration, reducing the limit of 3500 veh/h. As a general conclusion, whenever LOS is F on all approaches, a change of roundabout to a signalized intersection should be considered.

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REFERENCES

[1] G. Šenica, D. Milošević, "*Savremene raskrsnice sa kružnim tokom - proces planiranja,* " Institute for Roads, Belgrade, Institute for Design "Trasa"

[2] E. Rune, "Effects on Road Safety of Converting Intersections to Roundabouts, Review of Evidence from Non - U.S. Studies, " *Transp. Res. Record,* vol. 1847, Paper No. 03-2106, pp. 1-10, Jan. 2003.

[3] M. Owais, O. Abulwafa, and Y. A. Abbas, "When to Decide to Convert a Roundabout to a Signalized Intersection: Simulation Approach for Case Studies in Jeddah and Al-Madinah," *Arabian Journal for Science and Engineering,* vol. 45, pp. 7897-7914, Oct. 2020.

[4] I.Khliefat, M. Naser, F. Alhomaidat, and S. Hanandeh, "Improving the Capacity and Level of Service at the Sixth Circle in Jordan by Using Traffic Signals and Roundabout Metering Approach," *The Open Transp. Journal,* vol. 5, pp 69-80, Feb. 2021.

[5] J. Jatoth, N. K. Singh, and A. Mehar, "Evaluating the Performance of Signalized Intersection with Signal Countdown Timer," *Int.Journal of ITS. Res.,* vol.19, pp. 182-190, Jan. 2020.

[6] A. Novikov, I. Novikov, and A. Shevtsova, "Study of the impact of type and condition of the road surface on parameters of signalized intersection," *Transp. Res. Procedia*, vol. 36, pp. 548-555, 2018.

[7] A.Polus, and S. Shmueli, "Analysis and Evaluation of the Capacity of Roundabouts," *Transp. Res. Record*, vol. 1572, Paper No. 970115, pp 99-104, Jan. 1997.

[8] H. R. Al-Masaeid, and M. Z. Faddah, "Capacity of Roundabouts in Jordan," *Transp. Res. Record,* vol. 1572, Paper No. 970348, pp 76-85, Jan. 1997.

[9] M.T. Johnson, and W. A. Hange, "*Modern Roundabout Intersections: When To Use Them? A Comparison With Signalized Intersections," ITE 2003 Technical Conference and Exhibit: Transportation's Role in Successful Communities,* Mar. 2003.

[10] HCM 2000, "*Highway Capacity Manual (2000)*," Washington D.C.: Transportation Research Board, 2000.

[11] HCM 2010, "*Highway Capacity Manual (2010)*," Washington D.C.: Transportation Research Board, 2010.

[12] HCM 2016, "*Highway Capacity Manual (2016)*," Washington D.C.: Transportation Research Board, 2016.

Group of Articles 4
Urban logistics and parking management

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SOLVING THE PROBLEM OF VEHICLE PARKING DURING POSTAL DELIVERY

Key Words
Postal delivery
Parking spots
Focal point
zone

Abstract

An increase in the number of packages and express mails generated based on electronic trade, as well as user requests for the delivery of those mails, have additionally made the delivery vehicle parking problems more complex in urban areas. Some studies point to the fact that the delivery vehicle spends 15% to 74% of the total transportation time on parking [1]. In the paper, a proposal is made for solving the problem of the illegal parking of delivery vehicles using reserved parking spots and a methodology was proposed for determining the optimal location for delivery vehicle stopping and parking.

1. INTRODUCTION

The postal operators' delivery vehicle parking problem is one of the burning issues in today's cities. When speaking about postal operators, there is an increase in fuel consumption, paying illegal parking fees, an increased stress in the deliverer that may also result in a lower quality of the service rendered. On the other hand, social communities also suffer due to the mentioned problems, which reflects in the additional greenhouse gas emission and an irrational use of the existing infrastructure and available resources.

This paper is aimed at perceiving the number of delivery vehicle stops and reducing the number of stops based on the developed methodology, and also at increasing the probability of finding a free parking spot. By perceiving the problem, it is noticed that there are significant optimization resources (the deliverer spends even more than one whole hour during the working time on moving a vehicle along the itinerary so as to evade parking recording and tolling systems). Pursuant to that, a methodology is developed after defining the issue and an example of the application of the methodology and finding out a solution is given for one delivery region on the territory of the City of Novi Sad. The leading idea is to provide the optimal number of reserved parking spots on public parking lots for postal delivery vehicles to park, because those vehicles participate in public traffic transportation.

2. PROBLEM DEFINING

With respect to postal mail deliveries, there is a special challenge connected with central city zones and high-level gravitational regions (focal points) as well. It can be said that there is ever more pronounced incompatibility between the increase in the number of cars and the needed parking areas. It can also be noticed that the competition among postal operators has become ever more pronounced, too, in urban areas, which leads to the even greater complexity of this issue.

The need for parking most frequently goes beyond available capacities with respect to the traffic infrastructure. According to some authors, the cause for that lies in free-of-charge parking, so that an adequate toll parking system can achieve a balance between parking demand and the offer [2]. Different parking management systems have been developed. Most frequently, that requires the use of different sensors as the integral parts of the available infrastructure. Some solutions propose installing a sensor on each parking spot, which is quite expensive [3]. On the other hand, a possible solution implies that citizens should be included in the identification of available parking spots [4, 5].

Parking management encompasses different policies and programs aimed at the more rational use of parking resources, in which manner significant economic and social results can be ensured and negative influences on the environment can be reduced. Problems related to parking in cities and urban areas are becoming ever more important and are one of the topics being paid the most attention to [6]. In the era of the Internet of Things and smart cities and smart parking, there is a necessity for appropriate innovative solutions towards the implementation of sustainable cities [7]. The elements considered with the aim of achieving an optimal solution to parking are vehicles, the available road infrastructure and users as well [8]. Contemporary technologies have ever increasingly been present in solving the parking problem [9, 10].

In order to reach a balance with respect to the needs for parking spots and their availability, there is the need for gaining control of parking demands and managing available parking spots. From the point of view of postal traffic, an optimal parking spot needs to be found so as to properly make a delivery in the observed area. Therefore, parking demands are, on the one hand, defined by postal service users (as postal mail destination places), and by postal operators on the other, defining delivery regions. From the point of view of deliverers, a limited parking space can be said to be one of the key factors whose consequence reflects in the deliverer's longer mileage, which on its part reflects on the service quality, even financial penalties such as parking fines [11]. On the other hand, deficient parking spots for making a delivery has as consequences an irrational dissipation of resources, a negative influence on the environment, and the influence of stress on the deliverer as well if the deliverer is making a delivery in the case of illegal parking.

Search for a free parking spot and an optimal parking location is one of the basic problems in research studies dedicated to delivery vehicle parking. While looking for a parking spot, there is the unnecessary blocking of the traffic infrastructure by the vehicle, additional fuel consumption, a greater emission of greenhouse gases and an increase in the deliverer's nonproductive work, which is a consequence of passing the additional distance on foot in order to come to the ultimate destination. If there is no parking spot in the vicinity, the deliverer may illegally park the vehicle (double-park), which may significantly reflect on the amount of parking fees [12]. A lack of parking spots is especially present in rush hours along urban arteries [13]. Postal mail delivery is one of the main challenges postal operators are faced with, where failure to make it is one of the basic problems.

3. METHODOLOGY

As the first step in developing the methodology, available parking spots on the area of observation where a mail delivery is made need to be perceived. After that, the area which the deliverer can cover by occupying a certain parking spot needs to be defined. In that direction, the significant input variables are the deliverer's working time measured in norm-minutes for service performance, as well as the average number of the mails delivered by the deliverer during the day. With respect to the norm-minutes available to the deliverer, for example 400 norm minutes available to the deliverer for an eight-hour working time. This number of the norm minutes is obtained when the time the deliverer spends on preparing the workplace and daily rest during the day is subtracted from 480 minutes of such eight-hour working time.

Perceiving different postal operators, the conclusion is that on average the deliverer delivers mails at 60 destinations (stops) per day. Given the fact that 3.5 mails on average should be delivered at 60 stops within the available 400 norm minutes, the conclusion is that one stop requires the delivery time (the distance travelled and mail deliveries) of around 6 minutes. In Figure 1, the places where one delivery vehicle has stopped or is parked in the Center – Novi Sad City region. The number of the stoppings is either equal to or greater than the number of the stops. This is for the reason of avoiding paying for parking or illegal stopping. The implementation of the delivery process can be said to consist of the mileage (the distance travelled) and the mail delivery. The distance travelled contains driving the transportation vehicle to the car parking place and a walk from the vehicle to the mail delivery destination. The envisaged mail delivery time (according to the operator's statistical norms) is 2 minutes, so that that walk takes the deliverer up to 4 minutes. Taking into account the fact that the speed the deliverer moves at is 1.5 m/s in the open and inside a building, he can deliver mails at the address (stop) 180 m away from the vehicle in 4 minutes (2 minutes to go to the address and 2 minutes to return to the vehicle).

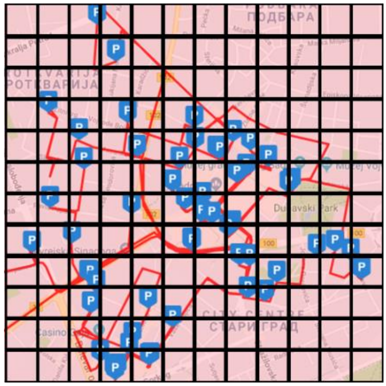

Figure 1. Vehicle parking in the delivery area Center Novi Sad–the use of over 100 parking spots

The input variables having been defined, the set covering location problem (SCLP) method for finding optimal parking spots will be applied while making a delivery. The applied method has the task to find the minimum number of the parking spots that the deliverer will use, thus including the maximum delivery points with a defined cover radius. Taking into consideration the potential parking spots and demands for mail delivery, an appropriate cover matrix is developed. The cover matrix $[p(i,j)]$ is obtained upon the following condition [14]:

$$p(i,j) = \begin{cases} 1 \; for \; d_{i,j} < d^*_{i,j} \\ 0 \; for \; other \end{cases} \tag{1}$$

where $p(i,j)$ is the element of the cover matrix $[p(i,j)]$, $d(i,j)$ is the given distance, and $d^*_{i,j}$ is the maximum acceptable distance. The aim is to reduce the number of the rows in the cover matrix to as few as possible in a way that each column of the reduced matrix contains at least one element equal to 1.

4. SOLUTION PROPOSAL

Depending on the requirements in terms of the gravitational areas and the allowed maximum distance of the service nodes from the demand nodes (180m), the parking spot locations and the total minimum number of parking spots as well are determined. The settlement areas are divided into the 180m-diagonal N zone squares, whereas the radius of the circumscribed circle encompasses the four square-shaped zones (Figure 2). The Euclidean distance formula is used. In Figure 2, the lattice structure is shown.

STEP 1. The lattice structure of the settlement is organized as follows–the vertical and horizontal lines are swiped through the focal point, which generates the most gatherings; then, the grid is “stretched” to left/right and up/down from the focal point (in Figure 2, the focal point is 18), so that it covers the entire settlement area. According to the previously defined pattern, the place with the most content is taken as the starting point if the focal point cannot be in the settlement. This is how the network G (N, A) is obtained, where N is the number of the nodes, A is the number of the square zones for which d=180m, covering the surface of the settlement. In the concrete case in the nodes 15, 16, 20, 21 and 25, there is no demand for the service, nor is there any possibility whatsoever to park a vehicle, because the deliverer would have to cross the communication with several lanes.

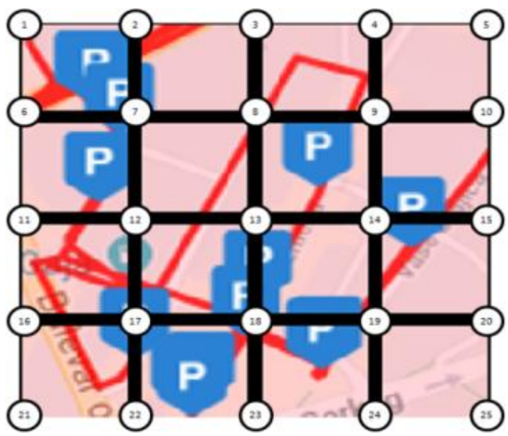

Figure 2. Part of the Center Novi Sad zone

STEP 2. The values “0” or “1” are assigned to the obtained square zones, depending on the urban attributes of the observed zones and the requirements for a coverage radius, i.e. the maximum acceptable distance between the parking spot and the point where demand is generated (stop delivery)(“0” for the maximum distance up to 180 m and “1” for the maximum distance up to 360m). the zones without housing buildings or those whose percentage of the already constructed housing buildings does not exceed 20% of the total area are not taken into consideration for setting up the demand and service nodes. The requirement to determine the gravitational area radius is based on the truth of the following statements: A: The shape of the settlement/zone is an axial shape; B: In the settlement/zone, there is a well-maintained infrastructure (bicycle and pedestrian paths); C: The construction in the settlement/zone is indented; D: The settlement/zone is predominantly single-family residential, and E: The settlement/zone has a high housing density. By establishing the logical structure between the pieces of evidence, more complex evidence is obtained. Based on this, the conclusion is made about the value of the gravitational radius of the zone. The truth value of this complex expression will indicate the need to define the GP radius as a value 360m;otherwise, the value of the radius will be 180m.

STEP 3. The zones are compressed into the mega-zones of a 360m radius and a radius 180m <r <360m.

STEP 4. In each node in the network G` (N´, A´), anode is set which generates a service request. There are N´ nodes. When the nodes requiring a service level and the nodes candidates for the allocation of parking spots were defined, the task was further solved as alocational problem with requirements.

The application of the proposed methodology determined the position and number of the parking spots with a complete service level (Figure 3).

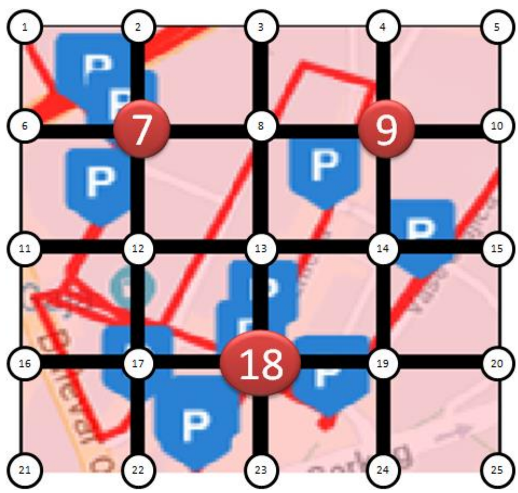

Figure 3. The permanent parking spot location

5. CONCLUSION

When considering the implementation of the proposed model for determining the minimum number of parking spots an example of the Novi Sad –Center settlement was subjected to consideration. Currently, there are seven parking spots for postal couriers to use them in the settlement. The application of the proposed methodology determined the position and number of the permanent parking spots (Figure 4). The example shows that the determination of the minimum number of the parking spots has not decreased the service quality level. On the contrary, this example is a demonstration of an increase in the postal service rendering level. Significant progress was made, given the fact that it was realized that only 3 out of 10 stoppings were needed in the places that would be reserved for postal operators, where the mentioned aggravating circumstances during the delivery of postal mails would be avoided in that way.

ACKNOWLEDGMENT

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REFERENCES

[1] R.C. Hampshire and D. Shoup, What share of traffic is cruising for parking?. Journal of Transport Economics and Policy (JTEP), 52(3), 184-201,2018.

[2] D. C. Shoup, “The high cost of free parking,” Journal of Planning Education and Research, vol. 17, no. 1, pp. 3–20, 1997.

[3] W.J. Park, B.S. Kim, D.S. Kim and K.H. Lee, Parking space detection using ultrasonic sensor in parking assistance system. In: proc. of the IEEE Intelligent Vehicles Symposium, IEEE (2008) 1039-1044.

[4] J. Hildenbrand, Google releases open spot for android find and share parking (July 10 2010), 2010.

[5] L. Stenneth, O. Wolfson, B. Xu and P.S. Yu, Phone Park, Street parking using mobile phones. In: Proceedings of the 13th IEEE International Conference on Mobile Data Management (MDM '12), IEEE (2012) 278-279.

[6] I.Hossam El-Din, Car Parking Problem in Urban Areas, Causes and Solutions (November 25, 2017). 1st International Conference on Towards a Better Quality of Life, 2017.

[7] Al-Turjman and A. Malekloo, Smart parking in IoT-enabled cities: A survey. Sustainable Cities and Society, 49, 101608, 2019.

[8] M. Gohar, M. Muzammal and A. U. Rahman, SMART TSS: Defining transportation system behavior using big data analytics in smart cities. Sustainable cities and society, 41, 114-119, 2018.

[9] M. Abujubbeh, F. Al-Turjman and M. Fahrioglu, Software-defined wireless sensor networks in smart grids: An overview. Sustainable Cities and Society, 51, 101754, 2019.

[10] T. Lin, H. Rivano and F. Le Mouël, A survey of smart parking solutions. IEEE Transactions on Intelligent Transportation Systems, 18(12), 3229-3253., 2017.

[11] J. Allen, M. Piecyk and M. Piotrowska, An Analysis of Online Shopping and Home Delivery in the UK, 2017.

[12] M. Figliozzi and C. Tipagornwong, Impact of last mile parking availability on commercial vehicle costs and operations. In Supply Chain Forum: An International Journal (Vol. 18, No. 2, pp. 60-68). Taylor & Francis, 2017.

[13] A. Wenneman, K. Habib and M. Roorda, “Disaggregate Analysis of Relationships between Commercial Vehicle Parking Citations, Parking

Supply, and Parking Demand."Transportation Research Record: Journal of the Transportation Research Board 2478: 28–34, 2015.

[14] D. Šarac, M. Kopić, K. Mostarac, M. Kujačić and B. Jovanović, Application of set covering location problem for organizing the public postal network. PROMET-Traffic & Transportation, 28(4), 403-413., 2016.

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A CONTRINUTION OF PARKING POLICY TO SUSTAINABLE URBAN MOBILITY

Key Words

Sustainable urban mobility

Parking policy

Parking charge

Parking enforcement

Abstract

The increased awareness towards quality of life and environmental standards along with high costs and limited spatial possibilities for traffic infrastructure expansion, have led to the transport planning paradigm shift. Instead of construction, new concept insists on a better use of existing infrastructure through the management of transport demand, primarily through modal shift from a car to alternative transport options. In this sense, parking demand management policy is increasingly seen as a powerful tool which can largely contribute to the realization of new concept. Parking policy becomes an integrated part of transport policy and it is more integrated with the general aims of the city in terms of mobility, urban planning and environmental quality.

Nevertheless, even though the new concept of parking management has been adopted and parking is regulated in central areas of most Serbian cities and towns, the impression is that parking is poorly managed, hence above mentioned impacts are missing. According to our experience, the main reason lies in inadequate measures as well as in poor parking enforcement.

This paper aims to demonstrate, on the example of one Serbian city, how proper parking management can solve parking problems, but also contribute to the realisation of sustainable urban mobility goals. Likewise, this paper intend to encourage

transport policy makers in the region to implement parking policy within the sustainable urban mobility framework and to share their best practices in order to show tangible accomplishments, and to encourage researchers to engage in promoting this topic so as to gain its deserved place.

1. INTRODUCTION

Excessive reliance on passenger cars as a primary mean of people mobility and the infrastructure planning that primarily supports this mode of transport have led to numerous environmental, social and spatial problems. The inability to follow the increase in the number of cars by constructing areas where cars travel (roads and streets) and areas where they are parked (parking lots) has caused an imbalance between supply and demand which is reflected in traffic and parking congestion. The awareness of limited energy resources, environmental protection and aesthetic appearance of cities has influenced the abandonment of the traditional approach in planning and problem-solving strategies which meant adapting a city to traffic. At the same time, the idea of a sustainable transport system which would enable mobility in a way that would not impair the quality of life has risen. These changes have led to the development of sustainable urban mobility concept.

Unlike the traditional approach which relied on the traffic supply expansion, the sustainable urban mobility concept emphasizes the quality of life in a city, whereas its main objectives are to provide mobility and information services and better connectivity of the existing network [12]. Sustainable urban mobility is based on mobility management, which means the application of various measures aiming to use the existing transport resources as efficiently as possible. It sets priority on the movement of people and goods rather than just motor vehicles. This actually means limiting the car use, as it was identified as the root cause of the problem. This is achieved, on the one hand, through the improvement and promotion of alternative transport modes, and on the other, by discouraging the car use through the implementation of various measures among which parking measures play a significant role.

Sustainable planning implies comprehensiveness, therefore parking management has become an integral part of urban transport policy. In this way, parking policy should solve parking problems, while contributing, at the same time, to the achievement of a sustainable transport system.

Parking management in central and other areas of high attractiveness typically starts with the implementation of an adequate parking regime. The aim of this policy is to increase parking turnover through the discouragement of long-term parkers and thus to balance limited parking supply with qualified demand. Regulated parking duration regime is commonly in use, within which parking charge has stood out as a very effective measure due to the high price sensitivity of users [4, 11]. Possible driver responses to parking regimes (parking charge and time limitation) are complex and varied. These include a change in the parking type, parking location, transport mode, car occupancy, destination, travel frequency, travel time (with possible consequences on the parking duration) and route (Feeney, 1989). This mechanism of influence allows the parking regime to be used to achieve objectives beyond this subsystem.

Even though most cities in Serbia (82%) have accepted the idea of a modern parking management concept and introduced some of the restrictive parking regimes in their central areas, the impression is that the desired management effects have not been sufficiently achieved. This is confirmed by the research which was conducted in 11 Serbian cities and towns in 2018. The results show that central areas of all surveyed cities experience illegal parking during peak periods (67% of them "to a large extent") while at the same time in 44% of the surveyed cities parking spaces are underused [9]. This may be due to the inadequate measures (in just 22% of cities the implemented measures are the result of the Parking study) and/or due to poor control of implemented measures, i.e. poor parking enforcement. One of the reasons for inadequate measures is often irrational attitude of public towards parking (users believe that parking should be unlimited and free) and towards parking measures that are restrictive by nature [7]. This prevents decision makers (politicians) from supporting the adoption of parking measures because they doubt the measures would be accepted by the general public (electorate).

This paper aims to demonstrate how proper parking management can solve parking problems using an example of one Serbian city, and how it can contribute to the realisation of sustainable urban mobility goals. Also, this paper intends to encourage transport policy makers in the region to implement a parking policy within the sustainable urban mobility framework and to share their best practices in order to show tangible accomplishments, and to encourage researchers to engage in the promotion of this topic so that it can gain its deserved place.

2. PARKING STATE IN PIROT

This paper uses data collected within the Parking system improvement study for Pirot, which was done by the Faculty of Transport and Traffic Engineering, Belgrade, for the need of Standing Conference of Towns and Municipalities in the period of 2019-2020 [10]. The study is realized within the project “Sustainable Urban Mobility in Towns and Municipalities of Serbia”, which is a part of wider initiative – regional project “Sustainable Urban Mobility in Southeast European Cities - Phase II” (SUMSEEC 2) funded by the German Technical Cooperation within the Open Regional Energy Efficiency Fund (GIZ ORF EE). The motive for this parking study was the assessment of SUMP work group that parking is the main traffic problem in the city. The assessment was done on the basis of transport subsystems indicator values and data collected by the survey of citizens.

According to Census 2011, the Municipality of Pirot has population of 57,928, whereby 65% of them is urban population[3]. Despite the fact that number of

[3]Source: https://www.pirot.rs/images/foto-galerija/demografski_podaci.pdf. Access: 16.07.2021

population constantly decreases (by 17% in the last 40 years); the number of motor vehicles increased by 35% in the last 15 years[4]. Accordingly, trips are mainly realised by private car: users make 34% of trips as a driver or as a passenger, so private car is the second place in modal split, right behind the walking (42% of trips).

Parking problem is the most notable in the inner central area, which is therefore chosen to be the subject area of this study. In this area a restrictive parking regime has been implemented in 2008. Parking regime is valid every workday in the period from 7 a.m. to 9 p.m. and at Saturdays from 7 a.m. to 2 p.m.

In this area there are 1,002 on-street parking spaces and only 103 parking spaces at off-street parking lots. The area is split into 3 parking zones which vary in regime attributes. In Extra and Red zones, parking duration is limited to 2 hours and parking price is 45.00 and 35.00 RSD/h, respectively. Green zone doesn't have time limitation and parking price is 30.00 RSD/h. In addition, parking in Red and Green zones can be paid per day, whereby the price is equal to the cost of 4 hours of parking when paying per hour.

Beside "visitor" category to which all above-mentioned measures relate, tariff system also defines "priority users". In the Extra zone, this category includes only residents while in other zones it includes other private and business users too. In other words, in Red and Green zones anyone can buy monthly parking permit at a very reasonable price (from 1,100.00 to 1,700.00 RSD). Parking space can also be reserved.The compliance with the prescribed regime on regulated parking places is controlled by PC "Komunalac" staff while parking control on the places where parking is prohibited is done by Traffic Police.

The study presents the current state analysis based on the data collected from official documentation provided by institutions which are in charge of parking management or operation, as well as the data collected by field survey. In the survey area all parking spaces were recorded as well as minimal (morning) and maximal (noon) parking accumulation, while other relevant parameters were recorded based on representative sample of on-street and off-street parking spaces using methods of independent and dependent survey (i.e. counting and interviewing).

The main conclusion of the analysis was that parking state in the area was poor, i.e. that parking was poorly managed. This can be seen primarily through the large number of vehicles parked at places where parking is not allowed, although at the same time there are enough regulated spaces where all users could park. To illustrate this, at noon when the area is maximally occupied by parked vehicles, 30% of parking spaces are vacant, while 29% of vehicles are parked illegally. Even worse situation is early in the morning (at minimal accumulation) when only 58% of regulated spaces are used, while 23% of residents' vehicles are parked illegally. Users choose to park illegally because they know that the probability of being sanctioned for it is very small: a fine is issued only for every 500th violation.

[4]Source: https://publikacije.stat.gov.rs/G2019/Pdf/G201913046.pdf. Access: 16.07.2021

On the other hand, users who park at regulated parking spaces mainly do not pay for parking – in fact, 51% of residents and 58%[5] of visitors do not pay for parking and/or do not comply with the prescribed time limitation. A penalty is issued only for every 150th violation of this kind.

In addition to the above documented poor parking enforcement, the implemented poorly-defined parking measures also contribute to the poor parking state. The applied tariff system is inadequate in the sense that it contains contradictory measures (in the Red Zone there is a time limitation but also the daily ticket that defeats it) and measures that are contrary to the parking management objectives (monthly tickets for individuals, which encourage parking of users with the "work" purpose). That is why it is not surprising that there is a significant share of visitors with the "work" purpose: 16% of all parking activities during the day and 55% at noon. Due to the long parking duration, the purpose "work" is the basic purpose that "should not" be realized in attractive zones where a restrictive parking regime applies. It can never be completely abolished, but we must not stimulate it by pricing scheme.

It is interesting to note that users are car dependent. This can be supported by the following data: the car is also used for short-distance travel. Namely, more than half of the users come from the urban part of the city, with 11% of them driving less than 400 m to the central area, and 34% driving between 400 m and 800 m. These are distances that could be easily travelled by walking or by bicycle. The average drive length of the citizens of Pirot is 1.2 km. The fact that the most important parameter for the quality of parking service is “vicinity of the final trip destination” speaks in favour of user car dependency. This is the reason why, although a vacant parking space can always be found, 27% of users drive additionally to find a parking space that is as close as possible to the destination.

3. PROPOSED MEASURES

In accordance with the parking state analysis and assessment, measures that should lead to its improvement have been defined. The measures proposed to solve/mitigate the parking problem are aimed indirectly at improving the quality of life of citizens, through their impact on urban mobility. Arranging parking in a way that will enable the parking demand management will affect the increase of parking service quality, but also the quality of other transport subsystems operation, especially the quality of pedestrian, bicycle and dynamic traffic.

The part of the measure set, which is important for the topic of this paper, includes:

Improvement of parking enforcement system, both the part in charge of the Traffic Police and the part in charge of PC Komunalac.

Redefining the tariff system: abolishing the daily ticket as well as the monthly ticket for private users, and keeping the number of monthly ticket for legal entities and

[5] Of this number of visitors, 53% have a parking duration of less than 15 minutes, which is tolerated by the controller of PE Komunalac, although there has long been no legal obligation to do so.

users of reserved parking spaces under control. In addition, it is possible to increase parking prices if there is a need to (additionally) contribute to the realization of urban mobility management objectives.

It should be noted that the **communication with users**, citizens of Pirot, was envisaged as one of the so-called parallel activities - which is in line with the concept of sustainable mobility. Communication is necessary to create a positive image and raise public awareness that parking management is necessary as a concept of managing their quality of life through mobility management.

4. EXPECTED IMPACT OF PROPOSED MEASURES

In accordance with the defined measures, the effects are forecasted taking into account the following:

- All users park at regular parking spaces: those who currently park illegally will either move to regulated parking space or give up parking (depanding on their price sensitivity).
- All users who park in the area pay for parking in one of the prescribed ways, with all residents possess resident parking permit.
- The number of reserved parking spaces and monthly tickets for legal entities remains unchanged.
- Users who currently pay for parking with a monthly ticket for private users or a daily ticket will either change the type of ticket or will give up parking in the zone (depending on their price sensitivity).

In addition to the above, the number of visitors who are willing to pay for parking per hour at current prices was calculated based on the price sensitivity of visitors, which was obtained by a survey, using the stated preferences technique. The results show that visitors are very sensitive to parking price: only 19% stated that they would never give up parking regardless of the parking price. Users who would give up were asked how they would come to the zone in that case.

In this way, it was obtained that the parking volume in the area would be reduced by 1,256, i.e, 15%: 22% in the Extra Zone, 14% in the Red Zone and 13% in the Green Zone.

Visitors who would give up parking in the area would not give up coming to the area (which is a positive finding in terms of maintaining its attractiveness and economic vitality), but they would change the travel mode. Over 500 visitors would switch from a car to a non-motorized mode: they would come to the area on footh (316) or by bicycle (209), which is in line with short travel distances of most users, and is essential for the development of sustainable urban mobility. Others would switch to public transport, taxi and so on.

By increasing parking price, the number of visitors who would come to the area by alternative transport mode instead of a car would also increase, Figure 1. This means that if parking pricing was implemented and properly controlled, the parking price could be an effective tool not only for managing parking demand but also urban mobility.

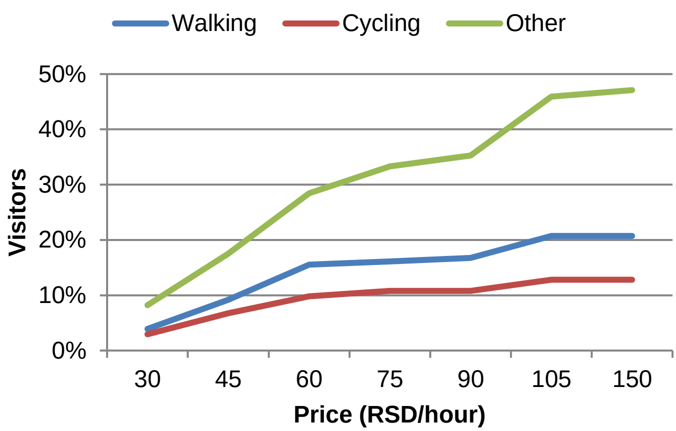

Figure 1. Distribution of visitors according to alternative modes of transport depending on the applied parking price

Similar to the parking volume forecast, the forecast of the maximum parking accumulation was made, Figure 2. In doing so, distribution of visitors parked at the maximum accumulation by parking purposes and price sensitivity of visitors of different purposes were taken into account.

The maximal accumulation in the area would be reduced by 11%, whereby illegal parking would be eliminated and already existing spaces would be used more efficiently. This is a positive finding not only for the parking subsystem, but also for other subsystems (dynamic, pedestrian, cycling…) due to the negative impact of on-street parking (especially illegal one) on their exploitation and safety. By reducing the parking accumulation, the parking adjustment factor also decreases (which is especially pronounced in Pirot as there is usually 1 lane per direction and parking turnover is high), i.e. the road capacity increases and thus their level of service too [1]. Based on the predicted maximal accumulation, the maximal parking occupancy was calculated, Figure 3.

By implementing the proposed measures, it is predicted that the maximal parking occupancy would be 87%, which is close to the 85% which is typically taken as a targeted value in the literature, because it is considered that then there is practically no parking search [8]. A slightly higher value of occupancy would be realized only in the Extra Zone, so the parking search within it would not be eliminated, but it would be reduced.

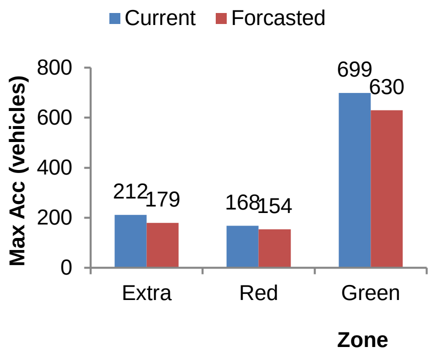

Figure 2. Forecasted maximal parking accumulation

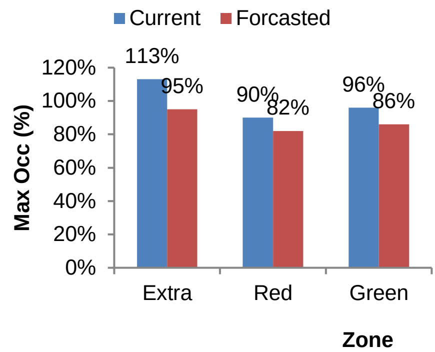

Figure 3. Forecasted maximal parking occupancy

If the average parking search times in Red and Green Zones are taken into account (0.59 and 1.67, respectively), as well as the number of entrances to these zones during the day (2,181 and 3,899, respectively), it can be concluded that in current state users spend 130 hours a day cruising for a vacant parking space. By bringing the parking occupancy to the desired level, this additional driving would be eliminated, which would, in addition to users' time and money savings, also contribute to significant energy and environmental effects. Using a model for the evaluation of energy and environmental effects of cruising for parking [2], it was calculated that cruising for parking in the area consumes 81 litres of fuel per day and emits 316 kg of CO_2[6]. In this analysis, only users looking for a parking space were included, while the impacts of this search on other users were not quantified. Additional driving due to parking search increases traffic volume [8], searching vehicles move at a lower speed and often stop, thus lowering the level of service on the street network and contributing to traffic congestion.

Finally, given that parking pricing generates revenue, the financial effects of the proposed measures were also forecasted. The analysis refers to the revenue from parking pricing, while the revenue from parking fines was not taken into account. Also, the revenue from reserved parking spaces was not taken into account, but due to the recommendation that the number of these parking spaces should be "frozen", it is expected that it will remain unchanged.

For the existing revenue, the accomplished revenue from parking charging on the day of the survey was taken. The forecast of revenue which could be realized if the proposed measures were implemented (Section 3) was made on the basis of the forecasted operational effects of these measures (volume and distribution of users by type of ticket), average parking duration of visitors who would pay for parking per hour (expressed in the average number of commenced hours) and the price by types

[6] The distribution of the passenger car fleet in the Republic of Serbia according to the fuel (Manojlović et al., 2020) was taken into account, as well as the average consumption according to the fuel (Mellios et al., 2011).

of parking tickets. The analysis showed that in this way the parking revenue could increase by as much as 460%.

As it was pointed out, the precondition for achieving these effects is the good functioning of the parking enforcement, both the part which is in charge of PC “Komunalac” and the part in charge of the Traffic Police. However, in practice, for objective and subjective reasons, the projected regulatory measures are almost never fully implemented. However, further analysis showed that if 80% of users obeyed the parking regime, the parking revenue would increase by 357%.

Finally, it should be noted that the proposed measures would cause major changes in user behaviour, and that the effects are forecasted based on user statements about the change in their behaviour. Although this way of forecasting is considered valid, the predicted effects should not be taken as a precise value, but they indicate well enough the changes that can be expected.

5. CONCLUSION

This paper demonstrates how proper parking management solves not only parking problems but also improves the transport system in general, i.e., contributes to the realization of sustainable urban mobility goals. On the example of one Serbian city (Pirot), we showed that adequate parking measures and their implementation could lead to the realization of following effects:

- **They contribute to the realization of targeted car share in the modal split**, because some users switch from a car to alternative (primarily non-motorized) transport modes due to restrictive parking measures.
- **The attractiveness and economic efficiency of the central area is not impaired**, as the total number of trips to the area is not reduced, which is probably due to the fact that central area of “smaller-size” cities have no adequate alternative.
- **The negative impact of parking on other transport subsystems** (dynamic, pedestrian, cycling) **is reduced** through the reduction of illegal parking and the reduction of parking search time.
- **The negative environmental impact of traffic is reduced** through reduced fuel consumption due to fewer car trips as well as less cruising for parking.
- Finally, **the revenue is generated** that can be partly used for parking and transport system improvement programs, as well as to invest in local community development programs that contribute to the creation of more liveable cities.

These findings should be an incentive for policy makers to boldly use parking policy as a powerful tool within the sustainable urban mobility framework.

REFERENCES

[1] Transportation research board & National research council (US) (2010). *HCM 2010 : Highway capacity manual.* Washington D.C. USA

[2] Čuljković, V. (2018). Influence of parking price on reducing energy consumption and co2 emissions. *Sustainable Cities and Society*, *41*, 706–710.

[3] Feeney, B. P. (1989). A review of the impact of parking policy measures on travel demand. *Transportation Planning and Technology*, *13*(4), 229–244.

[4] Golias, J., Yannis, G., & Harvatis, M. (2002). Off-street parking choice sensitivity. *Transportation Planning and Technology*, *25*(4), 333–348.

[5] Manojlović, A., Momčilović, V., Milović, M., Trifunović, J., Kaplanović, S., & Milosavljević, I. (2020). Study on the assessment of emissions of pollutants into the atmosphere from traffic on state roads of the order I and II for the period 2016-2018 [*Studija o proceni emisija zagadjujucih materija u atmosferu od saobracaja na drzavnim putevima I i II reda za period 2016-2018*]. University of Belgrade – Faculty of Transport and Traffic Engineering.

[6] Mellios, G., Hausberger, S., Keller, M., Samaras, C., Ntziachristos, L., Hausberger, S., Samaras, C., Mellios, G., & Nziachristos, L. (2011). Parameterisation of fuel consumption and CO2 emissions of passenger cars and light commercial vehicles for modelling purposes. *JRC*, 116.

[7] Mingardo, G., van Wee, B., & Rye, T. (2015). Urban parking policy in Europe: A conceptualization of past and possible future trends. *Transportation Research Part A: Policy and Practice*, *74*, 268–281.

[8] Shoup, D. C. (2006). Cruising for parking. *Transport Policy*, *13*(6), 479–486.

[9] Simićević, J. (2018). Parking state in Republic of Serbia cities and towns [Stanje parkiranja u gradovima i naseljenim mestima u Republici Srbiji]. *Proceeding in* XII Conference on Traffic Engineering Techniques (*TESi) 2018*, 315–320.

[10] Simićević, J., Milosavljević, N., & Čuljković, V. (2020). Study on the improvement of the parking system in Pirot [*Studija o unapređenju sistema parkiranja u Pirotu*]. University of Belgrade – Faculty of Transport and Traffic Engineering.

[11] Simićević, J., Milosavljević, N., Maletić, G., Kaplanović, S. (2012). Defining parking price based on users' attitudes. *Transport Policy*, *23*, 70–78.

[12] Tafidis, P., Sdoukopoulos, A., & Pitsiava-Latinopoulou, M. (2017). Sustainable urban mobility indicators: Policy versus practice in the case of Greek cities. *Transportation Research Procedia*, *24*(2016), 304–312.

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MANAGING THE SUSTAINABILITY OF ROAD FREIGHT TRANSPORT: OVE HUMAN INDICATOR

Key Words

Fleet
Sustainable
Environmental
Efficiency

Abstract

An advanced and responsible community shall raise awareness on the need for its own sustainability and create impacts through formulation of ethical principles and adoption of legal guidelines. Transport needs to strive towards sustainability that is defined inter alia, through efficient use of renewable energy resources. In order to reach transport process sustainability objective, one needs to establish a methodology and to define, determine, adapt and apply indicators and methods for transport industry management.

This paper presents an application methodology for a sustainability management indicator and method, and proposes a cycle to be applied when developing the method and the overall indicator of overall transport process effectiveness in freight transport and sustainable transport in general. The paper deals with the development cycle, while the indicator itself and the calculations were presented in previous papers by the listed authors.

1. INTRODUCTION

There are two main determinants arising from transport process sustainability. The first is to determine an indicator for overall transport process effectiveness, and the second is to define a method to improve the overall transport process effectiveness in general. Through application of indicators and methods one is able to manage the transport process effectiveness, to make decisions in accordance with the set objectives and to take actions towards their implementation through effective use of available resources. The subject of this paper is to define a methodology for calculation of indicators and methods which serve to manage the transport process and sustainable transport in general. The goal of the paper is to present a cycle that needs to be applied when defining methods and indicators, and that is integral part of the Total Productive Maintenance methodology. The paper demonstrates the importance of a sustainable transport process and describes the applied methodology. Furthermore, the paper lays out a cycle how to develop an overall transport effectiveness improvement indicator and method in freight transport, as it goes through the stages of defining the objectives, as-is analysis and indicator selection, measurements, definition and implementation of improvement programs and finally, performance measurement and evaluation.

2. SUSTAINABLE TRANSPORT PROCESS

Sustainable transport process is an aspect of global sustainability. It can be defined as „transportation that does not endanger public health or ecosystems and meets needs for access consistent with use of renewable resources at below their rates of regeneration and use of non-renewable resources at below the rates of development of renewable substitutes“ [1].

According to the given definitions, transport needs to strive towards sustainability, which is defined, inter alia, by efficient use of renewable energy resources. Even though this objective is not yet achievable, transport development guidelines reflect energy efficiency, environmental protection, use of renewable energy sources, etc. [2].

Transport demand created by the society in the above manner has been set out only when the industry and the society reached the current level of development, and the current degree of awareness of the importance of sustainability. A developed and responsible community builds awareness of the need to be sustainable and exerts influence through formulation of ethical principles and adoption of legal guidelines. There is a tendency to develop a rational transport process which meets achievable criteria imposed by both the community and the industry in parallel. This is exactly one of the challenges within the HORIZON 2020 Program (Smart, Green and Integrated Transport). A sustainable transport process developed in this way may stimulate: improvement of vehicle fleet energy efficiency, more efficient utilization of resources used for transport process realization, reduced share of transport costs in the product price, improved traffic safety, reduced dependency upon non-renewable energy sources, increase in gross domestic product rates, better living surroundings, a cleaner and healthier environment and a safer future for new generations.

On the other hand, transport process in the given settings needs to be managed and improved in line with the objectives of sustainability. Managing a transport process comprises adaptation to modern and future technological demands in terms of: manufacturing and packing of goods, manufacturing and procurement of means of transport, vehicle operation and maintenance, transport service, infrastructure, etc.

Achieving a sustainable transport process is a goal that can be realized through mutual interaction between relevant stakeholders, in particular:

- the government, i.e. the community,
- the academic, professional and scientific community, and
- vehicle fleet owners.

The state, as a socio-political community, creates the most favourable solution for its citizenry based on the current internal state of affairs, but in interaction with the surroundings. Moreover, the authorities establish transport policies, guidelines, deadlines for their application, define limitations, degree of freedom and the settings for sustainable transport realization. The task of the academic, professional and scientific community is to indicate the consequences of the upcoming development, which will enable the state to amend the transport policies and make sound decisions. Practical application of results from different scientific and professional research efforts and analyses how to adopt and implement transport policies represent a transport policy challenge. Majority of research results at universities and research institutes do not have sufficient practical influence on transport policy decisions. Numerous research results are exchanged mostly only inside the academic community and are neglected by executive authorities for various reasons. Vehicle fleet owners provide road transport services to commercial activities in order to meet demand on the market. The authorities do not determine what services are to be rendered, where nor at what time. These are commercial decisions that are made by vehicle fleet owners in cooperation with their users. The main goal for vehicle fleet owners is to increase the benefits, i.e. to increase the profits. They adjust their performance to the settings defined and seek higher profits through rationalization.

Transport process management pursuant to sustainable development criteria was first defined at the 1992 summit in Rio under the sustainable development plan for XXI century, called Agenda 21. In the Republic of Serbia, *The First Action Plan for Energy Efficiency of the Republic of Serbia for the period from 2010 to 2012* (adopted at the Serbian Government session held on July 29th, 2010) is of major importance for sustainable transport process. For the first time, the Plan has introduced European energy efficiency standards, promoted eco-driving, introduced transport process effectiveness management, energy management, made provisions for incentives to replace existing fleets, etc.

3. SUSTAINABILITY MANAGEMENT

In order to achieve the objective of transport process sustainability, it is required to establish a methodology and to define, determine, adapt and apply indicators and methods used for managing the transport industry. In the Republic of Serbia, no indicators or methods conducive to sustainable transport process management are applied, and there are no road transport-oriented models available. It is important to develop, to scientifically and professional justify and verify indicators and methods in this area, because of the effects that may be exerted onto this economic activity. The following has been used as a starting point to develop the methodology:

- No indicators for road freight transport effectiveness monitoring have been defined;
- It is evident that there is a need to ensure a harmonized, interactive and simple indicator, easy to understand, applicable in all parts of the transport process, defined so as to accurately evaluate the ratio between the activities that add value to the transport process and those that do not;
- No methods for transport process effectiveness measuring are applied,
- It is possible to develop a method to improve the overall effectiveness so as to make decisions sustainable for the transport process;
- Decision at certain management levels are made ad hoc, based on available but mostly imprecise and incomplete parameters, and
- Evaluation of effects brought on by the applied measures is mostly just formal, and its vertical and horizontal integration, as well as integration into the decision-making process, is negligible.

The methodology is based on the Total Productive Maintenance (hereinafter: TPM), i.e. the TPM approach, modified in the function of studying and analysing the directions and impacts of the indicators upon the improvement of the transport process in general. This methodology covers a cycle comprised of: definition of objectives, as-if analysis and selection of indicators, measuring, defining and implementation of improvement programs and evaluation of outcomes.

The result of such a comprehensive approach is reflected in the fact that indicators and methods for managing a sustainable transport process, i.e. transport sustainability, are hereby defined.

The OVE Human method (OVE - *Overall Vehicle Effectiveness,* hereinafter: OVE) is applied in companies dealing with road freight transport [2]. The objective is to improve the effectiveness of resources and existing capacities. The objective needs to be achieved without considerable additional investments, but rather through better organisation of operation, systematisation, reorganisation of jobs, the technological process, sustainable procurements, etc. The objective can be achieved through the following tasks: improve fleet and driver effectiveness, improve energy efficiency and improve service quality.

Through application of the TPM approach and its benefits, the OVE Human indicator of the overall transport process effectiveness needs to go through the development stages in the identical way as the OVE indicator when Simons and authors of [3] and

[4] were developing this indicator based on the OEE - *Overall Equipment Effectiveness* (hereinafter: OEE) indicator, viz.:

- A method was developed by considering possible applications in local settings, using the knowledge and experience of vehicle fleet managers for the territory of the Republic of Serbia. A concept for an overall vehicle fleet operation efficiency indicator was presented and it was investigated whether the indicator could been applied in companies managed by these fleet managers. Review of the relevant literature, interviews with vehicle fleet managers and the analysis of current indicator application revealed details how data collection was organized. Data which were difficult to collect were defined. For some, a different collection method was defined, while others were excluded from further consideration.
- Findings obtained in the first stage were used to improve and to modify the overall transport process effectiveness indicator. Indicators that comprise this particular indicator were specified, together with respective data collection methods. The indicator of overall transport process effectiveness was titled OVE Human, because its calculation included evaluation of the availability, performance and quality of staff operation. OVE Human was then presented at the 2016 Transport Congress, and the congress participants underscored the importance of investigating the impacts of energy efficiency and staff performance quality indicators upon the transport process itself.
- Finally, at the end of the research, several vehicle fleet indicators were analysed, managers, heads and dispatchers were interviewed and also vehicle fleet data bases were analysed.

Indicators or data comprising complex indicators need to be accessible (available), measurable (precise for quantification purposes), easily verified (valid) and sensitive in the local settings. A disadvantage of indicators presented by authors of [5] and [6] is that they are limited only to studies for which they were defined, developed and applied. Each of the indicators given in [6] has one or more disadvantages in terms of availability of data required for calculation, accuracy of the data collection method and validity with regard to whether it is possible to verify the value of a resulting data or indicator.

In order to further use data used for OVE Human calculation in the same form as presented or proposed, it is required to consider their sensitivity to the disadvantages observed. Availability, accuracy and validity of data and indicators used for calculation of indicators were presented in [6].

3.1. As-is analysis

In order to apply the method for overall transport process effectiveness improvement it is required to analyse the current situation. Such as-if analysis needs to be carried out based on available data. If data required for the as-if analysis are not available, then it is required to collect historic data on vehicle fleet and driver operation. An as-if analysis determines the functioning of the transport process and identifies areas for improvements and future care. An as-if analysis comprises the following steps: criticality assessment, current assessment, renewal and future care about the transport process.

Criticality assessment serves to assess the state of vehicle fleet operation and to establish relative criticality for each vehicle, organisational part and all activities in the transport process, which then further enables forecasting of priorities for renewal, future vehicle care, changes in the operation organisation i.e. improvement of elements that affect the overall fleet effectiveness most. Moreover, special attention needs to be given to the management mechanisms and operating methods. Dispatchers, drivers, maintenance crews and other employees (operators, process stakeholders) need to be involved in the identification of the most critical activities in the transport process from their own perspective. Each vehicle and each activity are evaluated against the following criteria: suitability for implementation of the activity, reliability from the operators' point of view, impact of failures or implementation problems upon quality of operation, losses due to failure, safety, environment and costs.

Current assessment is an assessment of critical activities that affect the transport process state. Current assessment is made per activities in the transport process. Hereby, current functionality of the transport process activities is determined and activities are identified and ranked according to priorities for improvement.

Current assessment is used as the basis for renewal plans in order to establish such transport process state where maximum effectiveness would be achieved. The purpose of renewal is to abide by the instructions from the previous step.

Future care about the transport process follows the renewal. It is required to anticipate future care measures, plans and programs for implementation of activities, funds, operators and vehicles, which will ensure that the transport process is realized as foreseen.

In order to define deviations, monitoring activities need to be determined. Best monitoring practices are ensured when the operator of an activity is allowed to inform the operator of another, related activity at the moment when the process starts to degrade, but before it becomes critical.

3.2. Measuring the effectiveness

Measuring provides a value that denotes the effectiveness of vehicles, drivers and the quality of service. Measuring is done after the as-is analysis and it needs to be repeated after the improvement program has been implemented. It is important that each subsequent transport process effectiveness measurement results in higher OVE Human indicator values, which would indicate that the effectiveness has been improved. Measuring serves to assess the current value of transport process effectiveness and to set a reference baseline for future improvement measurements. In order to perform a successful measurement, a sound information base is required, as well as an extensive indicator for overall transport process effectiveness improvement. Data needed to perform the measurement, i.e. historic vehicle and driver operation data, comprise the information base. These data are included in electronic data bases of operating hours, vehicle monitoring, procurements, storage, book-keeping, etc. Such data can be retrieved directly from travel orders, work schedules, log books, maintenance work orders, records made by supervisors, etc.

3.3. Improvement program and possible effects

Transport process improvements need to be constant in terms of scope and period of time. Application of the kaizen approach implies small yet constant improvements. Improvements realized in this way yield best results - resistance by the surroundings is the lowest, results inevitably come, and employees are satisfied to contribute to a measurable quality.

Improvement programs comprise the following: definition of the improvement program, implementation of the improvement program, and best practise examples and knowledge base.

Application of this overall transport process effectiveness improvement method is expected to increase the value of the developed OVE Human indicator [5], and to improve the transport process in general. It revaluates and establishes potential losses and applies various improvement measures in order to influence the achieved values of the OVE Human indicator. Application of the method developed is expected to yield positive effects in the transport process, i.e. improvement of all measured parameters.

These effects should enable planned transport process and fleet activities to be realized with as low overall costs as possible in the given period. If an organization decides to fully and consistently apply this overall transport process effectiveness improvement method, it can be expected that the organization will define a world class effectiveness that it will strive to achieve. Hereby, the set OVE Human indicator application goal – improvement of the transport process effectiveness - would be achieved. For manufacturing organizations, the literature [7] and [8] specifies that the world class score corresponds to the overall effectiveness value of 0.85.

According to many researchers, one of the more prominent measures that improves vehicle fleet energy efficiency is improved cargo hold utilization in vehicles, [2] and [6]. Furthermore, the manner in which drivers operate vehicles has a strong impact upon energy efficiency. Building awareness with drivers, providing relevant trainings on economical and eco-driving and monitoring drivers' performance may increase the energy efficiency of the vehicle fleet. Outcomes are evaluated using values calculated for individual indicators and the extensive indicator of the overall transport process effectiveness, OVE Human [2].

4. CONCLUSION

The paper presents a methodology for application of sustainability management indicators and methods, and the development cycle of a method and an extensive indicator for overall transport process effectiveness improvement in freight transport, and sustainable transport in general. The paper describes the development process, while the indicator itself and the calculation are given in other papers by the same authors. The calculation is based on the determination of vehicle and driver availability utilization rate, vehicle and driver performance rate, quality of the service rendered from the perspective of the user, energy efficiency and the operator [6]. Moreover, the paper specifies an adapted procedure and a cycle to be operated in order to achieve the desired effects and to improve the overall transport process effectiveness. Consistent application of methods and indicators requires certain investment, both in terms of time and funds. The methodology shown in this paper has been adapted to the setting of the Republic of Serbia and it proved to be suitable for overall transport process effectiveness improvement and improvement of sustainability of transport in general. Results of the application of this methodology are given in papers by the same group of authors, [2, 5, 6].

REFERENCES

[1] OECD, “Environmental criteria for sustainable transport”, Document OECD/GD(96)136, OECD Environment Directorate’s Task Force on Transport, 1996.

[2] D. Radosavljević, A. Manojlović, O. Medar, N. Bojović, “Vehicle fleet energy efficiency: influence on overall vehicle effectiveness”, Thermal science, vol. 22, no. 3, pp. 1537-1548, 2018.

[3] D.Simons, R.Mason and B.Gardner, “Overall Vehicle Effectiveness”, International Journal of Logistics: Research and Applications, Vol. 7, pp. 119-135, 2004.

[4] D.Simon, I.Iliana, M.Hans, H. Jos Van, „Transportation performances measures and metrics: Overall Transportation Effectiveness (OTE)“ 46th Hawaii International Conference on System Sciences, Hawai, 2013, pp. 4186-4195.

[5] D. Radosavljević, A. Manojlović, O. Medar, N. Bojović, „Ocena ukupne efektivnosti transportnog procesa“, Tehnika, Vol. 5/17, pp. 717-724, 2017.

[6] D. Radosavljević, A. Manojlović, O. Medar, N. Bojović, D.Bogićević, „Managing the effectiveness of road freight transport“, 6th International Conference „Towards a Humane City“, Novi Sad, Serbia, 2017,pp. 717-724.

[7] Willmott P., Total Productive Maintenance: The Western way. Butterworth-Heinemann Ltd, Oxford, UK, 1994

[8] Willmott P., McCarthy D., Total Productive Maintenance: A Route to World-Class Performance, Butterworth-Heinemann Ltd, Oxford, UK,2001.

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THE IMPACT OF THE SARS-COV-2 PANDEMIC ON PARKING CHARACTERISTICS IN THE CENTRAL ZONE OF THE CITY OF NOVI SAD

Key Words

Parking characteristics

SARS-CoV-2

Abstract

With the increase in the number of registered vehicles and the degree of motorization in Novi Sad, the requirements for parking have significantly increased. Research conducted in 2017 and 2019 determined the basic characteristics of parking in the central zone of the city of Novi Sad, and certain measures were given to improve the parking system. In the central zone of the city, it has been determined that the requests for parking exceed the capacities of the parking lot and in certain parts of the day they reach the value of up to 140% of the capacity. However, during the state of emergency caused by the SARS-CoV-2 virus pandemic, parking requirements were drastically reduced. Limited working hours of catering facilities, reduced scope of work of administrative centers, failure to hold sports and other events have led to the average occupancy of parking spaces on a daily basis being reduced to below the value of parking capacity (less than 100%).

1. INTRODUCTION

With the increase in the degree of motorization and individual motor traffic, Novi Sad has faced increasing traffic problems. Problems related to vehicle parking are among the most significant, given to lead to a number of negative effects, such as a reduction in the capacity of city roads conditioned by the slow movement of the vehicle and maneuvering in the process of parking, occupation of the intended areas movement of pedestrians and cyclists, irrational use of available areas, noise and exhaust emissions, dissatisfaction of citizens and users of parking lots, etc. The need to park vehicles in central city zones arises as a consequence of numerous factors, whereas parking requirements are random value. Constant increase in the number of direct parking requests is a consequence of:

- concentration of numerous activities in central urban areas;
- lifestyle changes;
- an increased mobility of the population;
- high representation of individual car traffic in the total traffic structure of mechanized modes of movement [1].

The SARS-CoV-2 virus pandemic has an impact (directly or indirectly) on all aspects of society. A large number of jobs and obligations are solved online, without direct contact between people. Visits to numerous administrative centers have been reduced to a minimum. A large number of smaller entrepreneurs were forced to stop their work, while catering facilities were partially or completely closed at certain times. Matches and sports events were held without the presence of the audience or with a drastically reduced number of people in relation to the capacity of the facilities. All decisions to prevent the spread of the virus have also reduced travel requirements, in other words reduced the need for people to leave their homes. The reduced demand for travel has the direct consequence of reducing the need for parking passenger cars in certain parts of the city, which in the previous period were characterized by great attractiveness and the need for free parking space. One of such zones is certainly the central part of the city of Novi Sad. This paper will present a comparative analysis of parking requirements in the central zone of the city, before and after the appearance of the SARS-CoV-2 virus.

2. FIELD OF RESEARCH

The research was conducted in the central zone of the city of Novi Sad, where based on previous research it has been shown that there are the highest requirements for parking [2]. Based on previous research, the idea came to the idea that these streets are in the extra zone in the tariff parking system, in the zone where parking time would be limited to one hour, and the use of parking spaces charged at the highest tariff [3].

The survey covered the following streets:

- Mihajlo Pupin Boulevard (section between the intersection with Narodnih heroja Street and Žarko Zrenjanin Street) - on both sides of the road,

- Modena Street,
- Ilija Ognjanovića Street (the part of the street with dead end to the intersection with Modena Street),
- Street of People's Heroes (Figure 1).

In the observed area, parking lots are organized as a street, with direct access to the road. Modena Street is in one short part one-way, while the road of other streets is intended for two-way traffic.

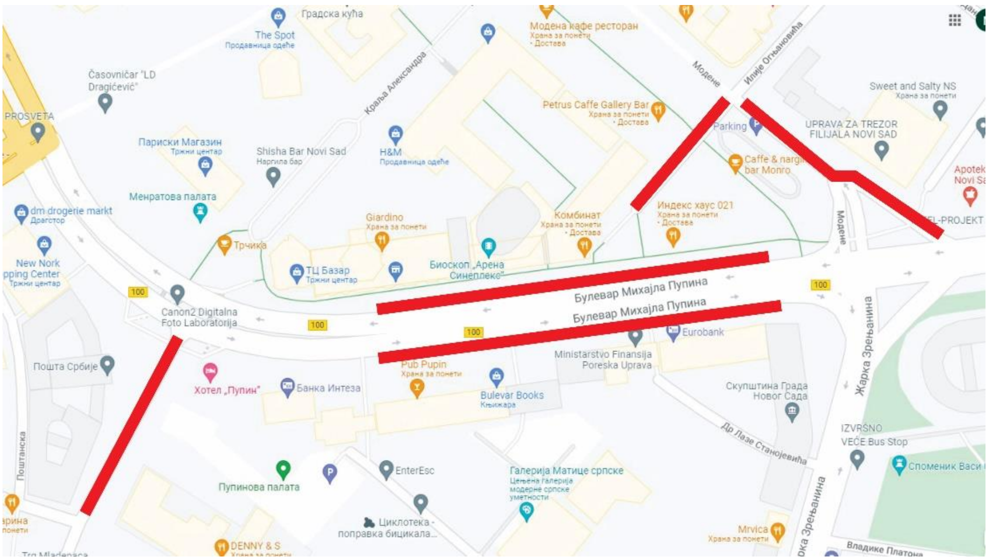

Figure 1. Overview of the research area

The original research was conducted in 2017, within the Smart Plan project, which was ordered by the City of Novi Sad. The second research was conducted in 2019, as a control counting and verification of requests, in order to start forming an extra zone in the parking system. However, with the appearance of the SARS-CoV-2 virus, from March 2020, the requirements have drastically decreased. So, the third research was conducted in October of the previous year, in order to determine the requirements in the period when there was a pandemic in the society. During the research, a full-day count of vehicles was performed in the parking lots, from 07:00 to 21:00, in the period when parking is charged in Novi Sad. The research, which was conducted in 2020, was conducted until 5:00 p.m. The reasons for the shortened research time are the measures to prevent the spread of the SARS-CoV-2 virus, which were currently in force. Namely, from 5:00 pm, all trade and catering facilities were closed. And as the administrative centers also worked part-time, after 17:00 in this part of the city there were no large requests for parking.

3. CHARACTERISTICS OF PARKING IN THE OBSERVED AREA WITHIN THE CENTRAL PART OF THE CITY OF NOVI SAD

The basic characteristics of parking, which can be determined by counting in the field, are: turnover, accumulation and durability of parking [1]. Table 1 shows the parking turnover by year. It can be concluded that the value of parking turnover was similar in 2017 and 2019. During the research conducted during the pandemic with the SARS-CoV-2 virus, a turnover of 6.89 vehicles per one parking space determined. It should be noted that in 2020, the research was conducted until 17:00, due to measures to combat the spread of the virus, which were currently in force. However, if the survey had been conducted by 9pm, as was done in 2017 and 2019, the value of the parking turnover would not have been much higher. This can also be seen on the basis of the accumulation, the occupancy of the parking space, which is shown in the following figure (Figure 2).

Table 1. Parking turnover

Year	2017	2019	2020
Parking turnover (veh./p.s.)	11,74	11,13	6,89

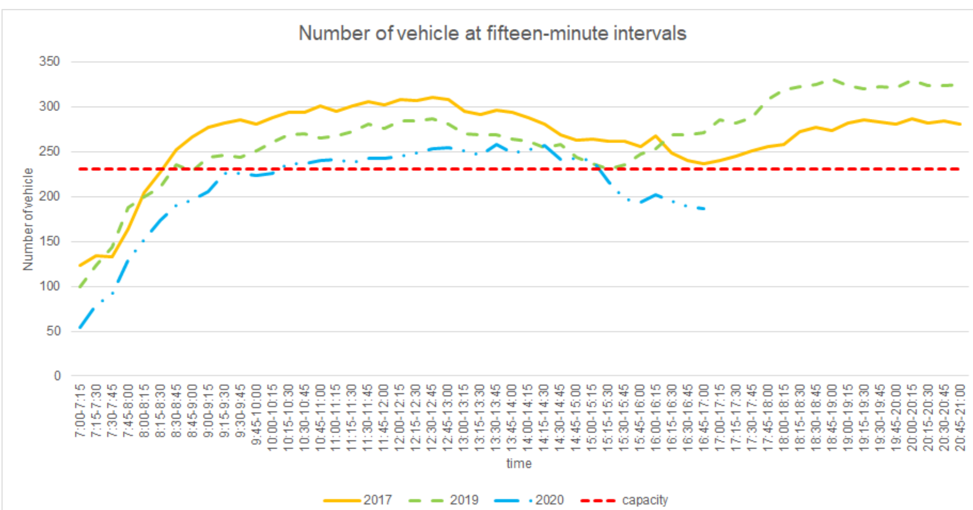

Figure 2. Occupancy of parking spaces at fifteen minute intervals

The diagram of the accumulation (Figure 2) clearly shows the classic display of parking space occupancy in the central zone of the city. There is a gradual increase in the number of vehicles in the morning and early morning hours to the maximum value, which is reached around 10: 00-11: 00 h. After that, the parking spaces are approximately constantly occupied until 14:00, and then there is a slight decrease in the number of vehicles in the parking spaces. In the late afternoon, the demand for parking increases again until the end of the day. The morning accumulation of vehicles happens due to solving private obligations - going to administrative centers (tax administration, City Assembly, etc.), post office, banks, etc. Afternoon and evening accumulation of vehicles happens due to leisure and visits to catering facilities.

But when looking at the capacity of the observed area, in the first two surveys the utilization was greater than 100% during most of the day. The average capacity utilization in 2017 and 2019 was 115%, while the 2020 count determined an average utilization of 92%. Figure 2 clearly shows that the occupancy of parking spaces in 2020 was much lower in each part of the day than in the previous two surveys.

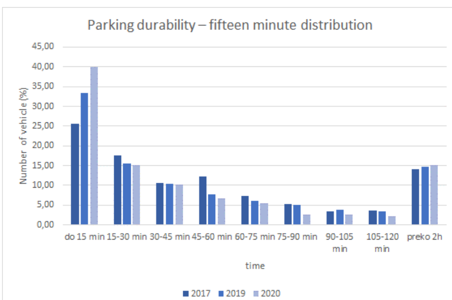

Figure 3. Parking durability – fifteen minute distribution

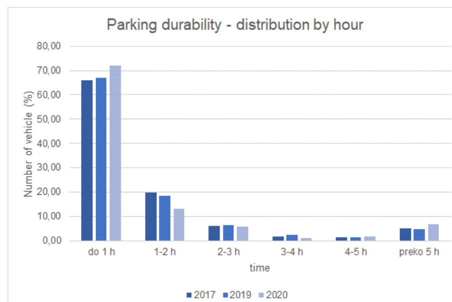

Figure 4. Parking durability - distribution by hour

If we are looking at the durability of parking, only one change can be observed during the 2020 survey compared to previous surveys. Namely, it can be seen that the share of short-term parking, parking up to 15 minutes, has increased. While in all other durability categories, the percentage of vehicles is approximately the same in all three surveys.

4. CONCLUSION

Problems related to vehicle parking are among the most significant problems in the field of traffic, which have arisen with increasing levels of motorization and individual motor traffic.

The emergence of the SARS-CoV-2 virus has an impact on all aspects of society. One of the direct impacts is the reduction of travel requirements, which has the direct consequence of reducing the need to park passenger vehicles in certain parts of the city, which in the previous period were characterized by great attractiveness. In order to show the influence of the appearance of the virus on parking requests, a research was done in the central zone of the city of Novi Sad.

The results of the research, which was conducted in the period before the emergence of the SARS-CoV-2 virus, during 2017 and 2019 and after the appearance of the virus in Novi Sad, were compared. As the basic characteristics of the parking requirements, the following were determined: durability of parking, turnover and occupancy of the parking space.

When we look at the parking turnover, it is clear that in 2020, this value dropped drastically. This indicates the fact that one parking space was used by fewer vehicles during the observed period.

If the accumulation is observed, it can be concluded that during the entire observed period during the day, the number of vehicles in the parking lot was significantly lower than when the survey was conducted in 2017 and 2019. And during the appearance of the virus, in certain periods during the day, the occupancy of parking spaces exceeded 100%. This means that users leave their vehicles in places that are not intended for parking, which creates the problem of using other free designated areas (passages, green areas, etc.). At the same time, this confirms the conclusions from previous research that the observed area should be transferred to the extra zone in the tariff system of parking fees in Novi Sad. The research from 2017 and 2019 determined the average occupancy of parking spaces of 115%, while in 2020 it was 92%. This percentage is still high, so it is necessary to implement measures, defined within the Smart Plan project, in order to improve the parking system in the central zone of the city of Novi Sad.

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REFERENCES

[1] S. Kostić i B. Davidović, *Parkiranje i javne garaže*. Fakultet tehničkih nauka Novi Sad, 2012.

[2] Smart Plan – Prikupljanje podataka „prva faza“, Grad Novi Sad, 2018.

[3] Smart Plan – druga faza, Grad Novi Sad, 2019.

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CROWDSOURCED DELIVERY SYSTEMS – COMPANIES EXPERIENCES AND APPLICATION POSSIBILITIES

Key Words

Crowdsourced systems

Delivery

Experiences

Abstract

Fast and successful delivery for companies that provide delivery services is the core of the business and is of great importance for competitiveness in the market. In urban areas, various factors make it difficult to deliver shipments to users, so companies often experiment with technical and organizational improvements to mitigate or eliminate the effects of these factors. Crowdsourced delivery has emerged as one of the solutions. This paper will present the experiences of companies dealing with this type of delivery, as well as point out the possibilities of applying this delivery in the territory of Serbia.

1. INTRODUCTION

In the process of transferring shipments, last-mile delivery is the most time-consuming step, especially in rural areas due to long distances, difficult traffic, and low speed. For these reasons, it is not surprising that there are many innovations related to the optimization of this final, the most expensive, but extremely important step in the shipment transfer process. These innovations have a technical and organizational character. Technical is reflected in: the installation of collection or mailboxes and self-service machines from which end users can pick up their packages at appropriate places; delivery by drones or autonomous delivery vehicles.

Its organizational character is reflected in the software applications for delivery through which it is possible to better coordinate the delivery time with the wishes and needs of end-users. In this sense, the need for solutions to delivery problems in urban areas that can eliminate (or at least control) the factors that hinder delivery and lead to financial losses is particularly pronounced. At the same time, it is necessary to reduce the negative effects on the natural environment that are a direct consequence of the increased volume of motor traffic. These effects are by no means negligible and there is a multitude of national and international initiatives to mitigate, or ideally, to eliminate harmful gases.

2. CROWDSOURCED DELIVERY

Crowdsourcing as a term is derived from the English words crowd and outsourcing and as such came to live relatively recently (2005) [1]. This approach is a type of participatory activity in which an institution or company proposes to a group of individuals, through a flexible open call, to perform tasks voluntarily (often for a particular type of reward). Crowdsourced delivery is a business model that is currently expanding and with which many companies are experimenting. Due to its inherent complexity and the participation of many ”external” participants, ultimate cost-effectiveness and efficiency can depend to a large extent on many factors that are not under the direct control of the organization.

To successfully apply the crowdsourced model, in any sphere of business, it is necessary to have effective and efficient information systems. That can connect supply and demand in a timely and optimal manner (or at least to prevent imbalance between them). Such systems are complex and rely on a variety of algorithms and predictive models to solve the many operational problems inherent in crowdsourced business models. They have become an indispensable tool, especially in courier services, because in the dynamic operating environment of postal and courier services, new customer orders can interfere with the optimal delivery plan that was originally defined [2]. In addition, they are an indispensable component through which participants in crowdsourced systems communicate, and it is often possible to access them through a dedicated application that is installed on a mobile device, or an appropriate website.

To fully define the concept of crowdsourced delivery, it is necessary to first explain the concept of sharing economy and show globally popular successful examples of its use, such as ride-sharing and ride-hailing.

Sharing economy as a concept is not completely new, but innovations in this area have recently been a direct consequence of the development and application of modern information technologies. Terms used as synonyms for sharing economy or to describe similar concepts are also “crowd-based capitalism“ [3] and “platform economy” [4].

One of the most famous examples of the sharing economy lately is ride-sharing, which is realized by companies like Uber and Lyft. Ride-sharing is a synonym for group transportation organized between individuals, that is, a process where passengers share a vehicle with other passengers. In contrast, ride-hailing is a service where the passenger hires a personal driver to take him to the required destination.

3. EXPERIENCES OF COMPANIES

According to a report by Zebra technologies [5], 45% of shipments find their way to end consumers through postal, courier, or commodity companies, while 42% of shipments are sent through logistics providers. Considering that total revenue from online sales of physical goods in the United States alone reached over $ 343 billion in 2019, and is expected to grow to $ 476 billion in 2024 [6], no one should be surprised by the global trend of increasing investment in start-up companies engaged in delivery. This trend is particularly noticeable in China and Asian countries, where crowdsourced delivery has not yet come to full expression due to issues such as security, regulatory irregularities, and the responsibilities of process participants.

Leaders and larger retail companies are also experimenting with new delivery models. Same-day delivery is extensively tested by Amazon, eBay [7], and Google [8]. Walmart, which is one of the leading retail chains in the United States, provides an opportunity for a customer at the checkout when paying for goods to say where he lives, and deliver a package to another customer who ordered some goods online and lives on his way home. In case the user accepts this offer, Walmart offers him a discount on the purchase invoice which covers the fuel costs for the delivery of the downloaded package. The company runs several projects such as *Walmart to Go* (in partnership with FedEx) for same-day delivery [9], but also a program with Waymo in Chandler (USA) where an autonomous vehicle picks up a customer who orders groceries online, brings it to the store and then returns it to its original location [10]. Amazon is working on a project called *On my way* [11], which deals with urban retailers who pay small delivery fees to interested individuals. Under it, users can download their package and in doing so download packages ordered by users online.

In September 2013, DHL launched the *MyWays* platform [12], which facilitates the delivery of shipments to end-users in Stockholm via crowdsourcing. The platform allows individuals requesting flexible delivery to connect with those who travel for minimal fees and agree to deliver packages whose delivery address is within their usual daily route. After registering on the My Ways platform, the user is allowed to specify the time and place of delivery of the shipment, as well as the fee he is willing to pay for delivery. The specificity of this platform is that it focuses primarily on people who pass by DHL service points as part of other daily activities (e.g., going to and from work) and who do not consider multiple tours as a source of additional income.

Crowdsourced delivery companies are developing rapidly, including recognizable companies such as DoorDash, Postmates, Kanga, Hitch, UberEats, Roadie, Nimber, UberFreight, Truxx. Most of them provide services at the local level (usually the city or suburban level). Some of them, such as Deliv, Postmates, Roadie, and Kanga, deliver all shipments except a shortlist of prohibited shipments. Other companies such as UberEats and DoorDash focus mainly on food delivery. UberEats, for example, has partnered with local restaurants and provides delivery of their meals, while DoorDash provides delivery from any restaurant as well as grocery delivery. Shipt and Instacart provide grocery delivery and require independent contractors who not only do delivery to customers but also make purchases for them at a nearby grocery store. Kanga and Hitch, unlike UberEats and DoorDash companies, primarily focus on delivering from and to individuals more than on delivering goods provided by other companies, i.e. connect people who want to send and receive a package or shipment with a driver who is willing to make the delivery.

Compensation for the performed delivery can be generally divided into three types:

- Compensation per hour where the main advantage is predictability in compensation schemes and which is attractive to drivers who prefer a secure inflow of funds during planned hours;
- Compensation per delivery which is the most commonly used type of compensation in crowdsourced delivery systems, where the fee is calculated using pre-defined formulas;
- The deliverer and the buyer determine the compensation where the deliverer and the buyer directly agree on the delivery prices and the platform for their connection takes an intermediary commission.

Archetti et al. [13] consider a situation in which a company that sells and delivers products online in addition to its fleet may hire occasional drivers who are willing to perform a single delivery using their vehicle in exchange for minimum compensation if the delivery location is not too far from their destination. They were the first to model the problem of crowdsourced drivers in logistics networks, by modelling the problem of vehicle routing with occasional drivers.

Crowdsourced delivery systems in the area of parcel delivery have not been implemented on the territory of Serbia. In the future, this can be expected having in mind the trends described in developed countries. These trends are certainly closely related to environmental protection strategies and reducing emissions. However, in contrast to the absence of crowdsourced delivery in Serbia, in the last few years there has been an expansion of companies that provide ride hailing services such as Bla Bla Car. Such a system connects drivers who have free seats in vehicles with people who need transportation on the same route. Another example of a similar system is Car Go, which allows drivers of this system to earn extra income, by driving in this system. The ways in which these systems work are similar to those in developed countries. Positive examples of these two companies will certainly influence the emergence of one of the crowdsoruced delivery systems in the territory of Serbia, which has as its main focus the delivery of goods, parcels, etc.

4. CONCLUSION

Crowdsourcing as a model of relocating business processes is becoming increasingly popular in modern times (since technical-technological development has greatly simplified the connection of participants on the side of supply and demand) and that many leading world organizations in the field of retail are experimenting with its use. This trend, coupled with global efforts to reduce greenhouse gas emissions, promotes a healthy lifestyle that involves more physical activity.

On the territory of Serbia, it would be interesting to consider the use of bicycles by suppliers in the postal systems of urban areas. This can help reduce overall shipping costs. Since the costs of depreciation, use, and maintenance of bicycles are significantly lower than for cars (there is no cost of fuel, maintenance is cheaper, no payment of often expensive parking in central city zones is required) it is realistic to expect lower delivery costs.

In addition, especially in areas with developed cycling infrastructure, more efficient delivery of shipments on time (just in time) can be expected, which should lead to greater trust of end-users and growth of the customer base. From a supplier's perspective, crowdsourced delivery can be a great source of additional or even basic revenue.

From the aspect of countries within which such systems are implemented, EU member states directly contribute to the fulfilment of created strategies by enabling employment growth and job creation (EU Cycling Strategy envisages growth of jobs in the cycling economy from 650,000 in 2017 to 875,000 by the year of 2030 [14]).

Last but not the least, the positive impact on the environment of bicycle-based delivery systems, which are inherently in line with initiatives to reduce CO_2 emissions as well as those related to the cessation of the sale of fossil fuel vehicles by 2030 in some countries, should not be overlooked [15].

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REFERENCES

[1] J. Howe, “The rise of crowdsourcing,” Wired magazine, vol. 14, no. 6, pp. 1–4, 2006.

[2] C. Lin, K. L. Choy, G. T. Ho, H. Lam, G. K. Pang, and K.-S. Chin, “A decision support system for optimizing dynamic courier routing operations,” Expert Systems with Applications, vol. 41, no. 15, pp. 6917–6933, 2014.

[3] A. Sundararajan, The sharing economy: The end of employment and the rise of crowd-based capitalism. Mit Press, 2016.

[4] M. Dufva, R. Koivisto, L. Ilmola-Sheppard, and S. Junno, “Anticipating alternative futuresfortheplatformeconomy,”TechnologyInnovationManagementReview ,vol.7, no. 9, pp. 6–16, 2017.

[5] https://www.zebra.com/content/dam/zebra_new_ia/en-us/solutions-verticals/ vertical-solutions/retail/vision-study/fulfillment-vision-study-report-en-us.pdf.

[6] https://www. statista.com/statistics/272391/us-retail-e-commerce-sales-forecast/.

[7] https://clark. com/technology/amazon-ebay-testing-same-day-delivery/.

[8] https://phys.org/news/ 2013-03-google-same-day-delivery.html.

[9] https://www.ksat.com/tech/2019/02/28/ fedex-testing-robots-that-will-deliver-goods-from-walmart-target-and-pizza-hut/.

[10] https://www.freightwaves.com/news/technology/last-mile-delivery-in-search-of-solutions.

[11] https://www.businessinsider.com/ amazon-on-my-way-delivery-service-could-crowdsource-deliveries-2015-6/.

[12] https://www.dhl.com/en/press/releases/releases_2013/logistics/dhl_crowd _ sources_deliveries_in_stockholm_with_myways.html#.XokB13KxWUl.

[13] C. Archetti, M. Savelsbergh, and M. G. Speranza, “The vehicle routing problem with occasional drivers,” European Journal of Operational Research, vol. 254, no. 2, pp. 472–480, 2016.

[14] E. C. Federation, Recommendations for Delivering Green Growth and an Effective Mobility System in 2030., 2018, https://ecf.com/sites/ecf.com/ files/EUCS_Summary_small_file.pdf.

[15] https://www.thelocal.dk/20181004/ stop-selling-new-petrol-and-diesel-fuelled-cars-by-2030-danish-government.

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THE IMPACT AND PERSPECTIVE OF BUSINESS INTELLIGENCE IN URBAN LOGISTICS

Key Words

Business intelligence
Big data
Big data analysis
Urban logistics
Sustainability

Abstract

Effective and efficient decision making based on business intelligence (BI) is essential to ensure competitiveness for sustainable growth in urban logistics. The rapid development of information and communication technology has made collection and analysis of big data essential, resulting in a considerable increase interesting for academic studies on big data and urban logistics. However, many of these studies are not linked to BI concept in an integrated manner. Therefore, the goal of this research is twofold. First, a substantial amount of research has been devoted to establishing and developing theories concerning big data, big data analysis (BDA) and BI to address this need. Second, the BI, big data, and BDA are not analyzed as separate methods but as integrated decision support systems. Operational staff is able to use these tools themselves and access timely and relevant data and information to make effective decisions as sustainable urban logistics practices.

1. INTRODUCTION

Sustainability has become an important objective of urban logistics management. The urban logistics deals with the physical distribution of goods to the final destination at urban areas, with respect to a set of objectives such as effective services, cost-effectiveness, and sustainable development [1]. Much more precisely, urban logistics mainly deals with two major physical flows: forward and reverse flows [2].

The main objective of urban logistics is to improve the effectiveness and efficiency for shippers, service providers, and customers. Since the last decade, sustainable development has become a contemporary and significant objective to urban logistics stakeholders. Under the paradigm of sustainability, the goal is to reduce the negative externalities of logistic activities, while ensuring service coverage and improving quality of life of all inhabitants at the city level. The latter mainly deals with waste and collection of recycled materials and returns of goods.

Both forward and reverse flows must be effectively and efficiently managed, despite the complexity in the operational processes [3]. The former e-commerce objectives, in the highest level of abstraction, could be shown as: Business-to-Business (B-to-B) flows from a supplier's site to a retailer' site; Business-to-Consumer (B-to-C) flows from a seller's site to a consumer's location; and Consumer-to-Consumer (C-to-C) flows between individual consumers. All the highest level of abstraction could be managed with effective and efficient decision making software tools. These concepts were developed in different ways, and software vendor companies have also great influence on these developments and deployments [4].

Effective and efficient decision making based on business intelligence (BI) is essential to ensure competitiveness for sustainable growth in complex urban logistics. The rapid development of information and communication technology has made collection and analysis of big data essential, resulting in a considerable increase in academic studies on big data and urban logistics. However, many of these studies are not linked to business intelligence, as companies do not understand and utilize the concepts in an integrated way. Therefore, the goal of this research is twofold. First, the business intelligence, big data, and big data analysis (BDA) are not reviewed as separate methods but as integrated decision support systems. Second, a substantial amount of research has been devoted to establishing and developing theories concerning big data, BDA and BI to address this need, though it is still challenging for a company to find, understand, integrate, and use the findings of these studies, which are often conducted independently and cover only select aspects of the business subject. Although BI and BDA are generally studied independently, it is challenging and often unnecessary to distinguish between the two concepts when performing business tasks. Recent research has found that BI plays an important role in implementing and monitoring strategies such as sustainable urban logistics practices. Operational staff is able to use these tools themselves and access timely and relevant data and information to make effective decisions.

2. BUSINESS INTELLIGENCE, BIG DATA AND BIG DATA ANALYSIS

At the beginning of 1990s, the concept of data warehouse (DW) was introduced for strategic decision support. Independently, W. H. Inmon [5] and R. Kimball [6] created two very similar approaches based on multidimensional databases. The basic and simplified data warehouse architecture proposed by R. Kimbal is presented in Fig 1 [6]. These concepts were developed in different ways, and software vendor companies had also great influence on these developments and deployments.

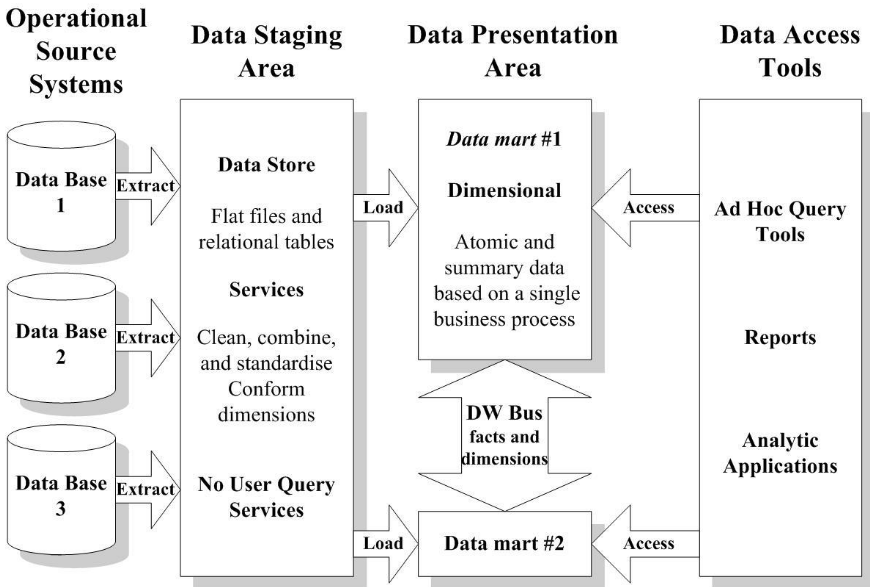

Figure 1. Simplified data warehouse architecture (Adapted from [6])

At the beginning of the 21st century, software vendors offered customers a new terminology and software tools they called business intelligence, which presented nearly the same concept as DW. Business Intelligence is a set of technologies and processes that allow business managers at all levels of an organization to access and analyze data. BI meets the requirements of business systems because it can get information quickly, reliably and in an appropriate form.

The development of information technology – IT has enabled the development of modern platforms to help work with large amounts of data – big data. On one hand, the volume of data being generated and stored in business systems is constantly growing, and on the other hand, there is an increasing number of users and their needs for high-quality information and new knowledge.

Big data can also simply refer to a huge amount of complex data, but their type, characteristics, scale, quality, and depth vary depending on the capabilities and purpose of each company. Previous studies generally agree on three main properties that define big data, namely: *V*olume, *V*elocity, and *V*ariety, or the "*3Vs*" [7], which have recently been expanded to "*5Vs*" with the addition of *V*eracity/*V*erification and *V*alue [8].

BDA refers to the overall process of applying advanced analytic skills, such as data mining, statistical analysis, and predictive analysis, to identify patterns, correlations, trends, and other useful techniques [9]. BDA contributes to increasing the operational efficiency and business profits, and is becoming essential to businesses as big data spreads and grows rapidly.

3. BUSINESS INTELLIGENCE, BIG DATA AND URBAN LOGISTICS MANAGEMENT

The role of urban logistics is enhanced by the recent rapid growth of e-commerce sales and, especially, the new business environment of omni channel retailing which stresses both online and offline channels [10]. To advance the competitiveness of services, retailers and logistics service providers have devoted significant efforts to deploy express fulfillment services, e.g., same-day or next-day delivery. This results in new logistics challenges, such as fragmented and downsized shipments, higher delivery frequency, shorter delivery time, highly fluctuant and uncertain demands, and returns. Such challenges are particularly impacting parcel markets. On the one hand, this is a huge challenge to the flexibility and agility in product distribution and delivery. On the other hand, this will also challenge the capacity and cost-effectiveness of the reserve logistics systems. Collecting and recycling the packaging materials (cardboard boxes, plastic packaging) is another sustainable issue of importance [11].

There are numerous multi-dimensional methods for choosing how much data to gather and how to analyze and utilize the data. In brief, the methodology for extracting valuable information and taking full advantage of it could be more important than the data's quality and quantity. A substantial amount of research has been devoted to establishing and developing theories concerning big data, BDA, and BI to address this need, but it is still challenging for a company to find, understand, integrate, and use the findings of these studies, which are often conducted independently and cover only selected aspects of the subject.

Some areas of BI and BDA, such as data analysis and data mining, overlap. This is to be expected, as the raw data in BI have recently expanded to become big data in volume and scope. This has necessitated reorganization of the field and concepts of BI to provide business insights and enable better decision making based on BDA [12]. Although BI and BDA are generally studied independently, it is challenging and often unnecessary to distinguish between the two concepts when performing business tasks.

4. PRACTICAL URBAN LOGISTICS BUSINESS APPLICATION AND BUSINESS INTELLIGENCE

Traditionally, logistics was considered a support industry for manufacturing and consumption and was mainly perceived as a cost. However, manufacturing corporations with supply expansion based on ICT meet consumers' demands as a key growth strategy, and the courier service industry has shown remarkable increase in the need for parcel transportation.

A courier service is generally defined as comprising the entire process of transportation, from receiving a parcel to packaging, transporting, and delivering the parcel to the final destination. Courier service companies are normally large operational organizations that deal with large amounts of cargo, hub terminals, general information systems, and a wide range of transportation vehicles and consist of a complicated network of labor and equipment.

Given consumers' increasing focus on personal service and convenience in consumer products, as well as global economic development, the manufacturing sector is converting from mass production of limited items to multi-item, small-scale production. This is rapidly increasing the volume and sales of courier services as more consumers buy online purchases.

CJ Logistics company is the largest logistics service provider in Korea with the highest market share and sales revenue of KRW 7110.3 billion in 2017 [13]. This company examines the sorting process, especially regarding decisions about loading/unloading docks and hub terminals, which are at the core of courier services. In order to improve business effectiveness and efficiencies in every level of decision-making big data, big data analyses through BI are used. In addition, the company is an innovation leader in the logistics industry. It is traditionally considered a 3D business that uses BI based on high-tech automation-oriented technology, engineering, and solution, while actively and rapidly adopting big data/BDA at the same time.

This company is a market leader equipped with cutting-edge logistics technologies, including real time tracking of freight, an integrated courier and freight tracking system that enables users to view customer information and requirements, satellite vehicle tracking, and temperature control systems. With five hub terminals, more than 270 sub-terminals, and more than 16,000 vehicles, the company processes more than 5.3 million packages per day [13]. Its mega hub terminal in Gwangju with an investment of more than KRW 400 billion, will utilize convergence technologies such as big data, robots, and Internet of Things (IoT) to expand its services for the convenience of its customers across Korea. This will include same-day delivery, same-day return, and scheduled delivery services.

This is a very brief example on urban logistics company, though in general some conclusions can be made. Business activities that are believed to be sufficiently empirical and productive to ensure efficiency can benefit from different perspectives and breakthroughs upon acquiring and analyzing big data, and can be realized through business intelligent system. The value of big data depends on the types of data extracted and how they are utilized. The crucial factor, however, is the method of turning raw data into valuable information, and not the quality or quantity of the data. Therefore, it is vital to identify the type and scope of data to be collected according to their purpose and focus area.

The efficient use of big data may provide an opportunity to a small or medium enterprise to become a large corporation or market leader by taking advantage of meaningful information, and for a large corporation to maintain its market share and ensure sustainable growth and competitiveness. Many studies have been conducted on BI, big data, and BDA so far; nevertheless, for enterprises to implement changes, it is necessary for them to understand intuitively that BI, big data, and BDA cannot be separated, but should rather be integrated and utilized in the management decision support system as a whole. As the brief case of CJ Logistics shows, the process of collecting and analyzing big data and applying it through business intelligence is separated neither individually nor progressively.

5. CONCLUSION AND FUTURE WORK

Business organizations today are the part of global and dynamic business environments characterized by continuous competition and change, uncertainty and customer needs, as well as radical advances in technology development. The goals of this paper are: (1) the business intelligence, big data, and big data analysis are not separate methods but integrated decision support system; (2) it is still challenging for a company to find, understand, integrate, and use these technologies which are often conducted independently and cover only selected aspects. The brief description of one Korean's logistics company is a good example for an enterprise which implemented changes necessary to understand that BI, big data, and BDA cannot be used separately in corporate decision making.

Future research will focus on experience and practical knowledge by collecting and sharing similar experiences in companies in Serbia including: volume management through production of boxes for each customer, as well as the classification of customers based on volume densities, which are established on practical business applications in order to build integrated knowledge.

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REFERENCES

[1] M. Savelsbergh, T. Van Woensel, "50th anniversary invited article – city logistics: Challenges and opportunities", Transportation Science 50, pp. 579-590, 2016.

[2] T. Bektaş, T.G. Crainic, T. Van Woensel, "From managing urban freight to smart city logistics networks, in: Network Design and Optimization for Smart Cities", Series on Computers and Operations Research. World Scientific, pp. 143-188, 2016.

[3] J. Holguín-Veras, J. Amaya Leal, I. Sánchez-Diaz, M. Browne, J. Wojtowicz, "State of the art and practice of urban freight management: Part I: Infrastructure, vehicle-related, and traffic operations", Transportation Research Part A: Policy and Practice 137, pp. 360-382, 2020.

[4] D. Simić, J.L Calvo-Rolle, J.R Villar, V. Ilin, S.D. Simić, S. Simić, "A new information infrastructure approach for end-to-end supply chain management", Advances in Intelligent Systems and Computing 1401, pp. 314-323, 2021.

[5] W. H. Inmon, “Building the Data Warehouse” (3rd edition), Wiley, 2008.

[6] R. Kimball, M. Ross, “The Data Warehouse Toolkit: The Complete Guide to Dimensional Modeling”. Wiley, 2002.

[7] Y. Wang, L. Kung, W.Y.C. Wang, C.G. Cegielski, “An integrated big data analytics-enabled transformation model: Application to health care”. Information & Management 55(1), pp. 64-79, 2018.

[8] B. Roßmann, A. Canzaniello, H. Von der Gracht, E. Hartmann, “The future and social impact of big data analytics in supply chain management: Results from a Delphi study”, Technological Forecasting and Social Change 130, pp. 135-149, 2018.

[9] S. Tiwari, H.M. Wee, Y. Daryanto, “Big data analytics in supply chain management between 2010 and 2016: Insights to industries”, Computers & Industrial Engineering 115, pp. 319-330, 2018.

[10] Giannikas, V., McFarlane, D., “Examining the value of flexible logistics offerings”, European Journal of Operational Research 290, pp. 968-981, 2021.

[11] Escursell, S., Llorach-Massana, P., Roncero, M.B., “Sustainability in e-commerce packaging: A review”, Journal of Cleaner Production 280, 124314. 2021.

[12] Fan, S.; Raymond, Y.K.; Lau, J.; Zhaob, L., “Demystifying big data analytics for business intelligence through the lens of marketing mix”, Big Data Res. 2, pp. 28-32, 2015.

[13] CJ Group, “Data Analysis, Retrieval, and Transfer System (DART) of Financial Supervisory Service; Understanding of CJ and Logistics Industry”, Seoul, Korea, 2018.

8th INTERNATIONAL CONFERENCE
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COMPUTATIONAL INTELLIGENCE METHODS IN TRAFFIC MANAGEMENT

Key Words

Computational intelligence

Neural networks

Fuzzy systems

Evolutionary computation

Traffic management

Abstract

Computational intelligence (CI) is becoming increasingly important in traffic management design, application, and monitoring. CI is often deployed for managing traffic, that is for reducing mileage, congestion, the use of fuels, and environmental impact. The purpose of this paper is to present the three main subjects in a CI approach, namely neural networks, fuzzy logic systems, and evolutionary computation and to emphasize their impact on various traffic management domains, including traffic flow forecasting, traffic light control, traffic fatalities prediction, traffic sign detection, and optimization of transportation networks.

1. INTRODUCTION

Due to the constant increase in the degree of motorization and individual motor traffic, cities are exposed to growing traffic problems and hence there is an increased need for the well-organized traffic management system. Traffic management can be defined as the organization, arrangement, guidance, and control of both stationary and moving traffic, including pedestrians, bicyclists and all types of vehicles [1]. Nowadays, to achieve efficient and effective traffic management system the use of information and communication technologies (ICT) and intelligent transportation systems (ITS) is required.

ITS are often deployed for collecting and interpreting traffic data in order to improve traffic flows. As an example, Internet of Things (IoT) devices can be used for collecting and analyzing the traffic data. However, in order to manage traffic data, that is to transform raw data on input towards meaningful information on output a middleware is required. For that purpose, various nature-inspired algorithms are implemented as part of software solutions that acts as a bridge between input and output in the ITS specialized for traffic management. In general, the use of algorithms in traffic management has multiple advantages for the organization, arrangement, guidance, and control of both stationary and moving traffic. These advantages include decrease of mileage, decrease of traffic congestion, decrease of the use of fuels, decrease of noise, etc. In that sense, computational intelligence (CI) is becoming increasingly important in traffic management design, application, and monitoring. CI belongs to the class of nature-inspired techniques used to solve complex and multi-criteria problems in real-world environments. In traffic and transportation environment, CI is often deployed for managing traffic and reducing congestion. Here we adopt the classification that differs three main subjects in a CI approach, namely (1) neural networks (NN) inspired from human brain modeling and is a trainable system along with pattern recognition abilities, (2) fuzzy logic systems involve techniques and methods for reasoning under imprecision or uncertainty conditions, and (3) evolutionary computation is a type of stochastic optimization search and consists of swarm intelligence and evolutionary algorithms [2].

The rest of the paper is organized as follows. First, various applications of neural networks in traffic management are presented. After that, fuzzy logic systems and traffic management are discussed. Finally, evolutionary computation is introduced and some frequently used methods in traffic management are explained. The paper concludes with a discussion of the key findings and implications for future research.

2. NEURAL NETWORKS AND TRAFFIC MANAGEMENT

An artificial neural network (ANN) is a technique that mimics the function of biological neurons of brain as well as their interconnections. ANN belongs to the class of nonparametric technique, together with support vector machines, K-nearest neighbors' regression, etc. The ANN ability to reproduce non-linear relationships between variables describing object's behavior and the ability to develop effective configurations is conducive to traffic management applications [3].

ANN are often used for traffic prediction, which is an important aspect in all ITS models. Traffic prediction refers to the possibility to forecast future state of traffic variables, such as flow or speed based on historical or captured traffic data. Traffic prediction usually encompasses numerous characteristics of the traffic, such as different measurement intervals, time scale of prediction, etc. In the literature, most of the ANN models used for traffic prediction fall into one of the following types: multilayer feedforward neural networks (MLFNN), time-delay neural networks (TDNN), recurrent neural networks (RNN), convolution neural networks (CNN), deep belief networks (DBN), radial basis function neural networks (RBFNN), wavelet neural networks (WNN), and fuzzy neural networks (FNN) [4]. Of these methods, CNN have the greatest application in traffic management. For example, CNN are used for recognizing highway traffic congestion in surveillance camera images, for intelligent traffic management for emergency vehicles, and for real time automatic urban traffic management [5, 6]. Images generated by highway surveillance cameras usually have much more extensive range of perspective and thus larger area of background, including rich variance of scenes and road configurations [5]. Therefore, CNN have a task to classify such images, without any special previous processing such as segmentation of objective roads. In the case of traffic management for emergency vehicles CNN model is deployed to accept the video from the traffic road and take quick decision to allow the emergency vehicles. Automatic urban traffic management includes monitoring and control of the traffic environment. The system is mostly designed for large cities in which traffic congestions need to be monitored and regulated. In [6], authors propose CNN to differently classify non-motorized traffic participants (pedestrians, bikes, and kick scooters) and motorized vehicles (light vehicles, trucks, and motorbikes).

In some cases, ANN are combined with some other methods to increase efficiency of the hybridized model. For example, deep neural networks are hybridized with bat algorithm (BA) to provide a dynamic form of traffic control in vehicular ad-hoc networks [7]. The proposed model has shown precise traffic flow predictions in real-time conditions and, as a result, the main traffic parameters are improved, including decrease in delay, fuel consumption, and emissions.

3. FUZZY LOGIC SYSTEMS AND TRAFFIC MANAGEMENT

A fuzzy logic system (FLS) is a technique suitable to represent incomplete data and uncertain information by fuzzy sets instead of crisp set theory. An important advantage of FLS is to include expert’s knowledge in their design which can be decisive feature in traffic management, e.g., in managing vehicles routes, traffic signals, creating new traffic management systems, etc. [8].

With changing demand and traffic conditions over time, dynamic management is a requirement [9], that is real-time traffic management. One example of real-time traffic management is the use of autonomous vehicles equipped with various sensors and decision-making systems that enable increased traffic safety and decreased negative impact on the environment. Another example is allocation of sensors throughout the road network. There are usually obstacles to deploy sensors on the whole road network and in such situation new technologies, particularly FLS, can be used to estimate the missing information. Deveci et al. [10] used four main criteria, namely economic, public and political, environmental, and traffic safety, and 13 sub-criteria using fuzzy multi-criteria decision making to prioritize the advantages of six different real-time traffic management methods, which are dynamic speed limits, lane control systems, variable message signs, ramp metering, traffic diversion, and integrating autonomous vehicles into other traffic management systems. Their results imply that the real-time traffic control integration with autonomous vehicles has the highest priority, while variable massage signs as a traffic management method is the least advantageous.

FLS can also be used to propose new traffic management systems. In [11], a smart barricade system is proposed. This smart system is intended to localize nature-based barriers and barriers based on the intensity of traffic. The FLS is used to decide where to place the barriers and an algorithm, called, Modified Grasshopper Optimization Algorithm is used to find optimal membership limits. Besides for road traffic management, FLS is used for creating new railway traffic management systems [12] and air traffic management systems [13].

4. EVOLUTIONARY COMPUTATION AND TRAFFIC MANAGEMENT

Evolutionary computation (EC) is a technique that mimics phenomena from nature, such as natural evolution of life. EC belongs to the class of heuristic searching mechanism to find optimal or near-optimal solutions in different optimization problems. In traffic management, EC has been often deployed for managing traffic and dealing with routing and scheduling problems. EC algorithms include evolutionary algorithms (genetic algorithms (GA), genetic programming (GP), learning classifier system (LCS), and so on), swarm intelligence (ant colony optimization (ACO), artificial bee colony (ABC), particle swarm optimization (PSO), and so on), and hybrid algorithms [14]. Among them, GA, ACO, ABC, and PSO are widely used for dealing with traffic management problems.

The GA is a metaheuristic search algorithm based on the biological evolutionary process of “the survival of the fittest” – the principle proposed by Charles Darwin. The purpose of using a GA is to find the individual from the search space with the best “genetic material”. The quality of an individual is measured with a fitness function and the part of the search space to be examined is called the population. In traffic management, GA is deployed for optimizing traffic signals [15], prediction of severity of traffic accidents [16], travelling salesman problem [17], and so on.

The ABC is a metaheuristic search algorithm inspired by the foraging habits of bees. The colony of artificial bees in ABC contains three groups of bees: employed bees associated with specific food sources, onlooker bees watching the dance of employed bees within the hive to choose a food source, and scout bees searching for food sources randomly. In ABC, the position of a food source represents a possible solution to the problem and the nectar amount of a food source corresponds to the quality (fitness) of the associated solution. In traffic management, ABC is deployed for traffic sign detection [18], traffic signal timings [19], vehicle routing problem [20], and so on.

The ACO is a metaheuristic search algorithm inspired by the foraging behavior of ants, which use pheromones as a communication medium to determine the best path from the food source to their nest. The pheromone trails are represented with numerical values and during the search those numerical values are adjusted. In traffic management, ACO is deployed for dynamic traffic routing and signal-free intersection traffic control for connected vehicles [21], intelligent traffic control systems [22], traffic lights optimization [23], and so on.

The PSO is a metaheuristic search algorithm that simulates swarm of particles. The basic idea of the PSO algorithm is to mimics social behavior of bird flocks and fish schools searching for food. In comparison to previously mentioned methods, the PSO is relatively easy to implement, it has a less tendency to be trapped in a local optimum, and it requires less memory and CPU time. In traffic management, PSO is deployed for traffic flow forecasting [24], traffic light optimization [25], traffic fatalities prediction [26], and so on.

5. CONCLUSION AND FUTURE WORK

In this paper we have shown the importance of CI in traffic management design, application, and monitoring. The three main subjects in a CI approach, namely neural networks, fuzzy logic systems, and evolutionary computation are explained and their applications in various traffic management domains are presented. Among them, evolutionary computation algorithms are particularly emphasized and their applications in traffic flow forecasting, traffic light control, traffic fatalities prediction, traffic sign detection, and optimization of transportation networks are highlighted.

Future work could focus on extending the research on other CI subjects, such as reinforcement learning and Q-learning. Potential research could also include the thorough analysis of one selected CI method and investigation of its applications in various traffic management domains. Likewise, the researchers could choose one traffic management domain and investigate which CI methods are adequate to be applied.

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REFERENCES

[1] R.T. Underwood, “Traffic management: an introduction”, Hargreen Publishing, pp. 1-222, 1990.

[2] D. Karaboga, B. Gorkemli, C. Ozturk, N. Karaboga, “A comprehensive survey: artificial bee colony (abc) algorithm and applications”, Artificial Intelligence Review, vol. 42(1), pp. 21-57, 2014.

[3] A. Brzozowska, D. Bubel, A. Kalinichenko, “Analysis of the road traffic management system in the neural network development perspective”, Eastern-European Journal of Enterprise Technologies, vol. 2(3-98), pp. 16-24, 2019.

[4] L.N.N. Do, N. Taherifar, H.L. Vu, “Survey of neural network-based models for short-term traffic state prediction”, WIREs: Data Mining and Knowledge Discovery, vol. 9(1), pp. 1-24, 2019.

[5] H. Cui, G. Yuan, N. Liu, M. Xu, H. Song, “Convolutional neural network for recognizing highway traffic congestion”, Journal of Intelligent Transportation Systems: Technology, Planning, and Operations, vol. 24(3), pp. 279-289, 2020.

[6] A. Meicler, A. Sanogo, N. Shvai, A. Llanza, A. Hasnat, et al. “Real time automatic urban traffic management framework based on convolutional neural network under limited resources constraint”, in *Proceedings of the Lecture Notes in Computer Science,* pp. 95-106, 2020.

[7] S. Kannan, G. Dhiman, Y. Natarajan, A. Sharma, S.N. Mohanty, “Ubiquitous vehicular ad-hoc network computing using deep neural network with iot-based bat agents for traffic management”, Electronics, vol. 10(7), pp. 1-16, 2021.

[8] A. Engelbrecht, “Computational Intelligence: An Introduction”, Wiley, New York, pp. 1-632, 2007.

[9] Z.H. Khattak, M.D. Fontaine, “A Bayesian modeling framework for crash severity effects of active traffic management systems”, Accident Analysis and Prevention, vol. 145, 2020.

[10] M. Deveci, D. Pamucar, I. Gokasar, “Fuzzy Power Heronian function based CoCoSo method for the advantage prioritization of autonomous vehicles in real-time traffic management”, Sustainable Cities and Society, vol. 69, 2021.

[11] C. Raskar, S, Nema, “Modified Fuzzy-Based Smart Barricade Movement for Traffic Management System”, Wireless Personal Communications, vol. 116(4), pp. 3351-3370, 2021.

[12] A. Blagojević, S. Kasalica, Ž. Stević, G. Tričković, V. Pavelkić, “Evaluation of Safety Degree at Railway Crossings in Order to Achieve Sustainable Traffic Management: A Novel Integrated Fuzzy MCDM Model”, Sustainability, vol. 13(2), pp. 1-20, 2021.

[13] P. Wei-jun, R. Jie, W. Run-Dong, “Air Traffic Management Process Quality Assessment Model Based on Improved Fuzzy Matter Element Analysis”, Journal of Physics: Conference Series, vol. 1187(5), pp. 1-10, 2019.

[14] Y. Hu, K, Liu, X, Zhang, L. Su, E.W.T, Ngai, et al., “Application of evolutionary computation for rule discovery in stock algorithmic trading: A literature review”, Applied Soft Computing Journal, vol. 36, pp. 534-551, 2015.

[15] N.A. Al-Madi, A.A. Hnaif, “Optimizing traffic signals in smart cities based on genetic algorithm”, Computer Systems Science and Engineering, vol. 40(1), pp. 65-74, 2021.

[16] H. Ospina-Mateus, L.A. Quintana Jiménez, F.J. Lopez-Valdes, S. Berrio Garcia, L.H. Barrero, et al., “Extraction of decision rules using genetic algorithms and simulated annealing for prediction of severity of traffic accidents by motorcyclists”, Journal of Ambient Intelligence and Humanized Computing, vol. 12(11), pp. 10051-10072, 2021.

[17] V, Ilin, D. Simić, S.D. Simić, S. Simić, “Hybrid Genetic Algorithms and Tour Construction and Improvement Algorithms Used for Optimizing the Traveling Salesman Problem”, in *15th International Conference on Soft Computing Models in Industrial and Environmental Applications (SOCO 2020)*, vol. 1268, Springer, Cham, pp. 530–539, 2020.

[18] A. Banharnsakun, “Multiple traffic sign detection based on the artificial bee colony method”, Evolving Systems, vol. 9(3), pp. 255-264, 2018.

[19] M. Dell’Orco, Ö. Başkan, M. Marinelli, “Artificial bee colony-based algorithm for optimising traffic signal timings”, Advances in Intelligent Systems and Computing, vol. 223, pp. 327-337, 2014.

[20] K.K.H. Ng, C.K.M. Lee, S.Z. Zhang, K. Wu, W. Ho, “A multiple colonies artificial bee colony algorithm for a capacitated vehicle routing problem and re-routing strategies under time-dependent traffic congestion”, Computers and Industrial Engineering, vol. 109, pp. 151-168, 2017.

[21] T.-H. Nguyen, J.J. Jung, “Ant colony optimization-based traffic routing with intersection negotiation for connected vehicles”, Applied Soft Computing, vol. 112, 2021.

[22] P.M. Kumar, U. Devi G, G. Manogaran, R. Sundarasekar, N. Chilamkurti, et al., “Ant colony optimization algorithm with Internet of Vehicles for intelligent traffic control system”, Computer Networks, vol. 144, pp. 154-162, 2018.

[23] M. Elgarej, M. Khalifa, M. Youssfi, “Traffic lights optimization with distributed ant colony optimization based on multi-agent system”, in Networked Systems. NETYS 2016, vol. 9944, Springer, Cham, 2016.

[24] H.Q. Zhang, C.H. Wang, “Traffic flow forecasting method based on improved particle swarm optimization algorithm”, Advances in Transportation Studies, vol. 3(Issue Special Issue 2018), pp. 109-116, 2018.

[25] W. Hu, H. Wang, Z. Qiu, C. Nie, L. Yan, “A quantum particle swarm optimization driven urban traffic light scheduling model”, Neural Computing and Applications, vol. 29(3), pp. 901-911, 2018.

[26] X. Gu, T. Li, Y. Wang, L. Zhang, Y. Wang, “Traffic fatalities prediction using support vector machine with hybrid particle swarm optimization”, Journal of Algorithms and Computational Technology, vol. 12(1), pp. 20-29, 2018.

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THE CATEGORIZATION OF URBAN CONSOLIDATION CENTRE CONCEPTS

Key Words

City logistics
UCC concepts
Urban freight transport
External effects
Systematic literature review

Abstract

The purpose of this paper is to provide structured information on urban consolidation centre concepts regarding their impacts on urban freight transport external effects. The aim is to provide a framework for future research focused on urban consolidation centre impact modelling. A systematic literature review was performed to identify journal articles focused on urban consolidation centres and related impacts of such facilities on urban freight transport externalities. According to the reviewed concepts and included city logistics initiatives, we proposed a categorization of urban consolidation centre concepts. The categorization can be useful for researchers to allow and shape modelling efforts and for practitioners to guide them in the decision-making process.

1. INTRODUCTION

Urban consolidation centers (UCC) have a central role in many solution **concepts** to reduce the impact of urban freight transport (UFT) (in [1] according to [2, 3]). Also, numerous additional city logistics (CL) initiatives are used to improve UCC impacts.

Individual implementation of CL initiatives does not create a sustainable and competitive CL system [4]. Therefore, the implementation of the UCC is not a guarantee that all the problems and challenges generated by the UFT will be solved. Especially because in practice it has been shown that the UCC initiative is often unsuccessful [5]. However, the UCC enables more efficient implementation of many other CL initiatives and vice versa. Therefore, the UCC is rarely implemented without additional CL initiative, whether it has already been implemented at the time of the UCC introduction, or its implementation is planned together with the UCC. For example, regulatory and restrictive measures are often applied in urban areas to reduce the negative effects of UFT, which could be beneficial to the UCC [1]. Also, the UCC fleet can gain a competitive advantage, compared to conventional trucks used by carriers, by using environmentally friendly vehicles for local freight transport [1]. Therefore, when we speak about the implementation of the UCC initiative and its results, we often refer to the results of the combined implementation of the UCC and other UL initiatives, i.e. UCC concepts.

The decision of an initiative or concept implementation to decrease external effects of UFT is not an easy task. High number of alternative UCC concepts further increases complexity of decision making process. The need to identify and categorize effective UCC concepts for UFT externalities reduction is essential for both efficient urban logistics policy and future research. Such categorization should create a framework to facilitate and guide practitioners in decision making process and inspire future research related to presented concepts. Therefore, here presented research aimed to identify and classify UCC concepts by a systematic literature review of journal articles content.

The paper is structured as follows. The process of systematic literature review is presented in Chapter 2. Further, the results of the content analysis are shown in Chapter 3. Finally, Chapter 4 shows the conclusions of the research.

2. METHOD

A systematic literature review was conducted in order to categorize the UCC concepts that are most often applied in practice.

Firstly, journals dedicated to discuss CL themes, and particularly themes regarding UCC implementation, are identified. The most influential and highly ranked scientific journals with high impact factors are considered as sources of reliable information: *Transport Reviews (IF[7] = 9.34), Transportation Research Part A: Policy and Practice (IF = 6.10)*, *Transportation* (*IF* = 4.99), *International Journal of Sustainable Transportation (IF = 4.17), Transportation Research Procedia (IF = 1.85)*. Also, one journal dedicated to publish proceedings of the most influential conferences (*Procedia - Social and Behavioral Sciences*) is used to cover papers published at conferences and a few Thesis [2, 6, 7] are used as a comprehensive source of useful information considering the aim and purpose of this research. The review process in this paper is not limited but rather focused to sources listed in this paragraph.

Secondly, as the different terms with similar or even the same meaning are used in the scientific literature, especially in the young research fields such as CL, the keywords to search for the useful papers are defined and listed in Table 1. The keywords were divided into three levels. The first level terms are used to identify the UCC-related papers. Second level keywords intend to focus the literature review on relationship between UCC and freight transport flows in urban areas. Finally, the

[7] IF = Impact Factor

third level terms are used to filter the papers that describe the impacts of UCC on performance of UFT, e.g. vehicle-kilometers or GHG emission before and after UCC introduction.

Table 1. Keywords used to search for literature sources

	First level	Second level	Third level
Keywords	city/urban logistics initiative city/urban logistics measure city/urban logistics scheme city/urban consolidation centre city/urban transshipment terminal	urban freight transport city goods distribution last mile delivery	initiative impact transport externalities external effects external costs

The first level keywords singled out 4183 papers. By introduction of second and third level keywords the number of relevant papers is reduced to 1798. Further, a manual search exported 117 papers from this list to perform a content analysis. The content analysis of the research papers was conducted in order to identify initiatives used to form a UCC concept and to perform a categorization of the UCC concepts.

3. RESULTS

We analyzed all the papers collected by using first level keywords in order to identify CL initiatives planned or applied in the combination with the UCC. Further, results of the papers filtered by second and third level keywords brought information on external impact of UFT by introduction of such concepts. Consequently, the most frequently used additional CL initiatives are identified by their external impacts and grouped by their common characteristics in five classes:

- alternative means of UFT;
- delivery windows;
- restrictive and regulative measures;
- incentives and other mechanisms for funding CL initiatives, and
- other CL initiatives (reverse goods flows collection; satellite terminals; operational optimization; added-value services, application of contemporary IT solutions)

The groups of additional CL initiatives are used to define five categories of UCC concepts. Table 2 shows categorization of the identified UCC concepts significant for reduction of UFT external effects. The detailed UCC concept structure is also shown, according to specific additional CL initiative found in the literature sources. Due to limited length of this paper, from 117 analyzed sources only representatives are cited in Table 2, as the UCC concepts and the initiatives combinations repeat in other papers.

Table 2. UCC concepts categorization

UCC concept	Additional CL initiatives	Source
UCC + Alternative means of UFT	Electric delivery vehicles	[8, 9, 10, 11, 12]
	Cargo bikes and tricycles including electric	[13, 14]
	Switch to smaller road vehicles	[12, 6]
	Cargo trams	[3]
	Other alternative means of UFT	[3, 15]
UCC + Delivery windows	Off-hour delivery	[1, 8, 15, 7, 16]
	Night delivery	[6, 7]
UCC + Restrictive and regulative measures	Zone-based restrictions on access for freight vehicles	[3, 1, 8, 6, 17]
	Type-based restrictions on access for freight vehicles	[15, 17, 18, 19]
	Time-based restrictions on access for freight vehicles	[17, 18, 20]
	Access restrictions based on load factor of freight vehicles	[5]
	Regulations for loading and unloading freight vehicles	[3]
	Congestion charging	[20]
	Development of off-street loading/unloading bays	[3]
UCC + Incentives	Incentives for UCC operator	[1, 21]
	Incentives for carriers	[1, 8, 20]
	Incentives for receivers	[1]
UCC + Other CL initiatives	Reverse flows collection to improve vehicle utilization	[22]
	Satellite terminals	[10, 23]
	Operational optimization	[24]
	Added-value services	[22]
	Application of contemporary IT solutions	[3]

4. FINAL REMARKS AND CONCLUSION

The systematic literature review included 6 scientific journals from which 117 papers are identified as UCC-based papers and which discussed relationship with UFT flows and consequential effects.

Five different categories of UCC concepts were identified by content analysis (UCC + Alternative means of UFT; UCC + Delivery windows; UCC + Restrictive and regulative measures; UCC + Incentives; UCC + Other CL initiatives). The most attention in UCC concepts is given to combination of UCCs and eco-friendly (mostly electric) delivery vehicles. This is the consequence of the basic aim of the UCC to target the challenge of negative environmental and social impacts from freight delivery vehicles in urban areas. Also, the restrictions are broadly discussed because those are common measures of urban freight transport management, despite UCC application and a considerable attention is given to incentives, because a lot of UCC concepts in practice failed due to financial problems. Other initiatives are less discussed in analyzed literature. However, this does not mean that they are less important for the success of the UCC concept.

The categorization should be beneficial to researchers as well as practitioners. Researchers should gain benefits for the impact models development process because the classification makes it possible to simplify the model structure and reduce the number of variables. Practitioners may use the categorization as the guide in the decision making process related to UCC implementation.

There are some limitations in the research presented in the paper. The systematic literature review is focused on scientific journal articles on SCI list. Although such sources are the most reliable and highly valued in the scientific community, there are doubts that something is missed by the research because other sources were not considered (other journals, conference proceedings, project reports and studies, etc.). Also, the content analysis results are guided by model development motives. This means that UCC concepts categorization aims rather to facilitate the urban freight transport modelling process and indicate solutions in policy decision-making, then to provide a comprehensive and strict UCC concepts list. Policy makers and stakeholders have to include more in-depth analysis and other concepts variations to develop the most suitable and sustainable city logistics solution in particular case.

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REFERENCES

[1] W. van Heeswijk, R. Larsen and A. Larsen, "An Urban Consolidation Center in the City of Copenhagen: A Simulation Study," International Journal of Sustainable Transportation, vol. 13, no. 9, p. 675–691, 2019.

[2] H. Quak, "Sustainability of Urban Freight Transport - Retail Distribution and Local Regulations in Cities," Erasmus University Rotterdam, Rotterdam,Netherlands, 2008.

[3] MDS Transmodal, "DG MOVE European Commission: Study on Urban Freight Transport," MDS Transmodal Limited, Chester, United Kingdom, 2012.

[4] J. Gonzalez-Feliu, "Sustainable Urban Logistics," ISTE, London, United Kingdom, 2018.

[5] J. Allen, M. Browne, A. Woodburn and J. Leonardi, "The Role of Urban Consolidation Centres in Sustainable Freight Transport," Transport Reviews, vol. 32, no. 4, p. 473–490, 2012.

[6] M. Janjevic, "Urban Freight Consolidation Platforms as a Means of Decreasing Costs and Enhancing Performance of Urban Logistics Chains within the Framework of a Market Economy – Application to Brussels-Capital," Ecole Polytechnique de Bruxelles, Université Libre de Bruxelles, Bruxelles, Belgium, 2016.

[7] H. Johansson, "Urban Consolidation Centres: On Relationships Between Customer Needs and Services in City Logistics," Linköping University, Linköping, Sweden, 2018.

[8] M. Björklund, M. Abrahamsson and H. Johansson, "Critical factors for viable business models for urban consolidation centres," Research in Transportation Economics, vol. 64, p. 36–47, 2017.

[9] M. Browne, J. Allen and J. Leonardi, "Evaluating the use of an urban consolidation centre and electric vehicles in central London," IATSS Research, vol. 35, no. 1, pp. 1-6, 2011.

[10] V. Correia, L. Oliveira and A. Guerra, "Economical and Environmental Analysis of an Urban Consolidation Center for Belo Horizonte City (Brazil)," Procedia - Social and Behavioral Sciences, vol. 39, p. 770–782, 2012.

[11] L. Faure, P. Burlat and G. Marquès, "Evaluate the Viability of Urban Consolidation Centre with Regards to Urban Morphology," Transportation Research Procedia, vol. 12, p. 348–356, 2016.

[12] J. van Duin, H. Quak and J. Muñuzuri, "New Challenges for Urban Consolidation Centres: A Case Study in The Hague," Procedia - Social and Behavioral Sciences, vol. 2, no. 3, p. 6177–6188, 2010.

[13] J. Leonardi, M. Browne and J. Allen, "Before-After Assessment of a Logistics Trial with Clean Urban Freight Vehicles: A Case Study in London," Procedia - Social and Behavioral Sciences, vol. 39, p. 146–157, 2012.

[14] P. Ormond and J. Telhada, "Using Urban Consolidation Centre with Cyclocargos Support to Increase the Performance and Sustainability of Urban Logistics: A Literature Review and a Case Study in the City of São Paulo," in 3rd International Conference on Energy and Environment: Bringing Together Engineering and Economics, Porto, Portugal, 2017.

[15] E. Taniguchi, "City Logistics for Sustainable and Liveable Cities," in Green Logistics and Transportation: A Sustainable Supply Chain Perspective, B. Fahimnia, M. Bell, D. Hensher and J. Sarkis, Eds., Springer International Publishing AG Switzerland, 2015, p. 49–60.

[16] E. Marcucci and V. Gatta, "Investigating the Potential for Off-Hour Deliveries in the City of Rome: Retailers' Perceptions and Stated Reactions," Transportation Research Part A: Policy and Practice, vol. 102, p. 142–156, 2017.

[17] R. Elbert and C. Friedrich, "Simulation-Based Evaluation of Urban Consolidation Centers Considering Urban Access Regulations," in Proceedings of the 2018 Winter Simulation Conference, R. M., J. A.A., M. N., S. A., J. S. and J. B., Eds., IEEE, 2018, p. 2827–2838.

[18] J. Allen, M. Browne, A. Woodburn and J. Leonardi, "A review of urban consolidation centres in the supply chain based on a case study approach," Supply Chain Forum: An International Journal, vol. 15, no. 4, p. 100–112, 2014.

[19] J. Lin, Q. Chen and K. Kawamura, "Sustainability SI: Logistics Cost and Environmental Impact Analyses of Urban Delivery Consolidation Strategies," Networks and Spatial Economics, vol. 16, p. 227–253, 2016.

[20] W. van Heeswijk, C. Wiskunde, M. Mes and M. Schutten, "A Simulation Framework to Evaluate Urban Logistics Schemes," 2018.

[21] B. Kin, S. Verlinde, T. van Lier and C. Macharis, "Is There Life After Subsidy for an Urban Consolidation Centre? An Investigation of the Total Costs and Benefits of a Privately-Initiated Concept," Transportation Research Procedia, vol. 12, p. 357–369, 2016.

[22] L. Dablanc, D. Patier, J. Gonzalez-Feliu, V. Augereau, J. Leonardi, T. Simmeone and L. Cerdà, "SUGAR. Sustainable Urban Goods Logistics Achieved by Regional and Local Policies. City Logistics Best Practices: a Handbook for Authorities," Regione Emilia Romagna, Bologna, Italy, 2011.

[23] S. Verlinde, C. Macharis and F. Witlox, "How to Consolidate Urban Flows of Goods Without Setting up an Urban Consolidation Centre?," Procedia - Social and Behavioral Sciences, vol. 39, p. 687–701, 2012.

[24] M. Simoni, P. Bujanovic, S. Boyles and E. Kutanoglu, "Urban Consolidation Solutions for Parcel Delivery Considering Location, Fleet and Route Choice," Case Studies on Transport Policy, vol. 6, no. 1, p. 112–124, 2018.

GROUP OF ARTICLES 5
Public transport

8th INTERNATIONAL CONFERENCE
"Towards a Humane City"
New Mobility Challenges
Novi Sad, 11th and 12th November 2021

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LINE “VRABAC” – PUBLIC TRANSPORT LINE IN THE PEDESTRIAN ZONE

Key Words

New public transport mode

Users’ opinion

Electric vehicles

Pedestrian zone

Abstract

As part of the activities on the expansion of the pedestrian zone in Belgrade, in August 2019, the City of Belgrade made a decision to introduce a new public transport line called "Vrabac" (“Sparrow”). Line "Vrabac" is specific and different in its features from other lines in public transport. It is characterized by new ecological - electric vehicles with a capacity of up to 8 passengers, it passes through the pedestrian zone and the transport service is not charged to the users.

The line is primarily intended for the elderly people and people with reduced mobility who live near the pedestrian zone, but it can be used by all visitors to the pedestrian zone. Three vehicles operate on the line, and there are 8 stops.

Introduction of such a line is in course with the principles of sustainable development and environmental protection on which public transport is based.

Several months after the introduction of the "Vrabac" line, a user survey was conducted in order to determine their satisfaction with this new public transport service.

1. INTRODUCTION

As of August 30, 2019, the line "Vrabac" served by mini electric vehicles of "Guevara City Bus" type has been operating within the public transport system of the City of Belgrade. The “Vrabac” system was established thanks to the project called

“Together for the Community” and the company “NIS”, which donated vehicles. The vehicles are parked in the very centre of the City in the public garage of Parking Service, while the maintenance of the vehicles and the provision of drivers were entrusted to GSP Belgrade. The route and elements of operation of this service are determined by the Secretariat for Public Transport.

The "Vrabac" line is 2.2 kilometres long and has a total of 8 stops (Figure 1). There are three vehicles on the line with an arrival interval of 10 minutes in the period from 8 a.m. to 10 p.m.

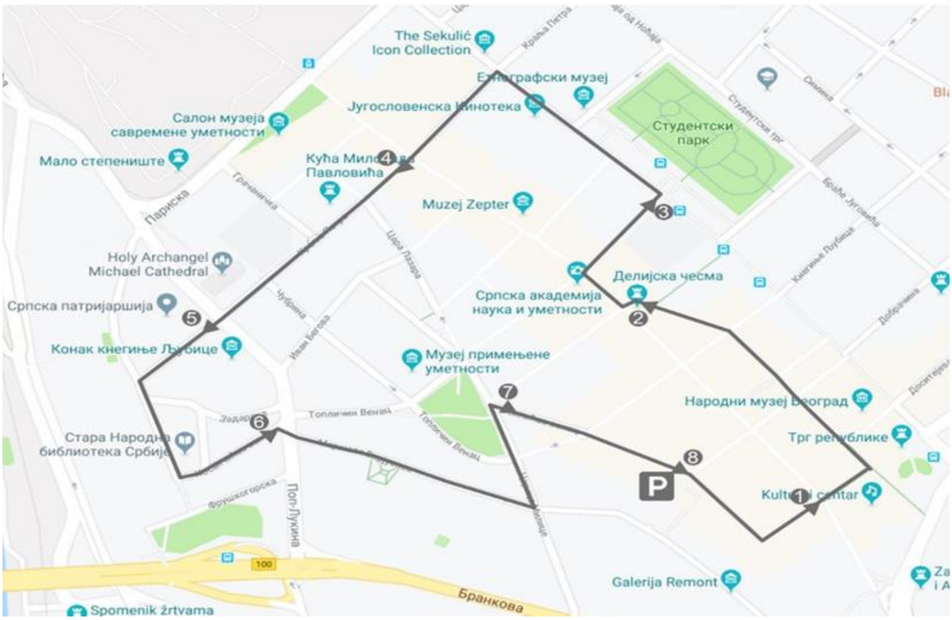

Figure 1. Route of the line “Vrabac”

The line is special in its features and different from other lines in public transport. It is characterized by new ecological - electric vehicles, smaller capacity (up to 8 passengers), operation in the pedestrian zone and free service.

The line is primarily intended for elderly citizens and people with reduced mobility who live in this zone, but it can also be used by other citizens and tourists who visit the city centre.

The vehicles which operate on the line are equipped with a 72-volt ACIM drive motor and a 72-volt 150Ah lithium battery. The battery provides autonomy for all-day operation without additional charging. The dimensions of the vehicle are: length 3950 mm, width 1500 mm, height 2000 mm, weight 1000 kg.

In 2019 (from the introduction to the end of the year), 9,216 km were realized on the "Vrabac" line, while in 2020 (in the period from May to December), 14,669 kilometres were realized.

2. USER SURVEY

After a year of operation of the line "Vrabac" in Belgrade, Public Utility Company GSP "Belgrade", conducted a survey of customer satisfaction of the line "Vrabac", with the aim to improve and enhance the offered transport service.

The research included 464 users of the "Vrabac" line services. This paper will present the most interesting results of the survey.

2.1. Characteristics of users

The starting point for the analysis of user satisfaction is to determine the characteristics and structure of the service users according to different criteria:

1. *gender* – 34% men and 66% women,
2. *age structure* – most of the users were 26-40 years old (Figure 2),
3. *occupation* – due to the specificity of the "Vrabac" line, the categories "tourists" and "people with small children" are also included.
4. *frequency of using the "Vrabac" line* – Of all surveyed users, 55% are those who use the line "Vrabac" for the first time, and 45% have used the line before.

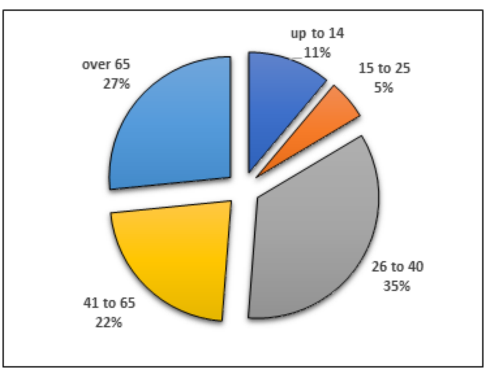

Figure 2. Age structure

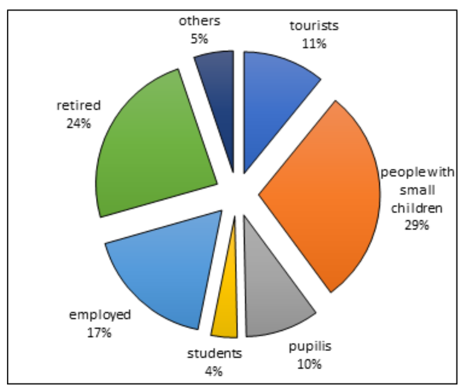

Figure 3. Structure according to occupation

Out of the total number of surveyed users, 11% are tourists and 29% are people with small children (Figure 3).

2.2. Results of research of service users on the line "Vrabac"

Frequency of using the line „Vrabac" in relation to the occupation

The line "Vrabac" is for the first time mostly used by people with small children, and the least by students and category "others" (Figure 4).

Satisfaction with the vehicle appearance

Users are very satisfied with the appearance of the vehicle. The answer "very satisfied" with the appearance of the vehicle is given by 76% of respondents, while 23.5% are "satisfied" with the appearance of the vehicle.

Safety during the ride

Almost all passengers feel safe while riding on the "Vrabac" line (97%).

Support for further introduction of "Vrabac" vehicles in the public transport system

As many as 98% of the surveyed passengers on the "Vrabac" line support the further introduction of the "Vrabac" vehicle into the public transport system.

Assessment of the “Vrabac“ service

The surveyed users rate the "Vrabac" service with the highest marks. Over 94% of passengers rate this service with the highest score of five, 4.6% rate it with a score of 4, while only 0.7% rate the line with a score of 1, 2 and 3.

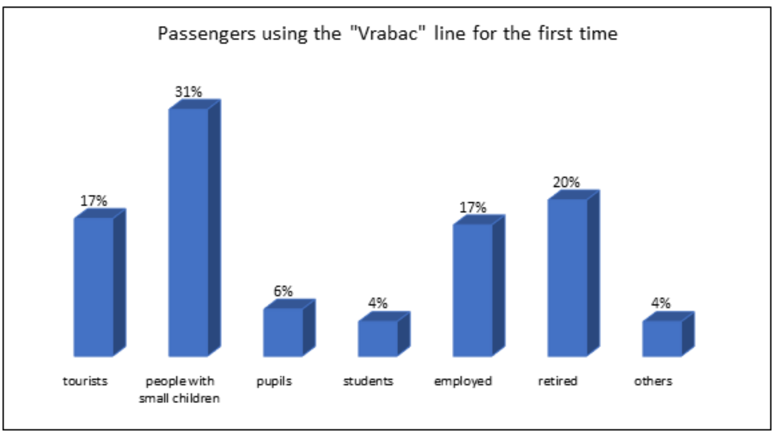

Figure 4. The structure of passengers using the line for the first time

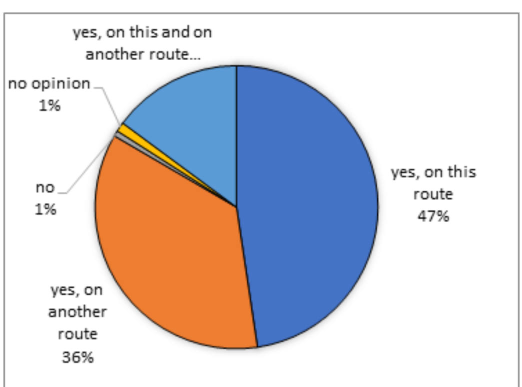

Figure 5. Support for further development of the line “Vrabac”

47% of the surveyed passengers stated that they support the introduction of more vehicles on this route, and 36% stated that they support the introduction of vehicles on another route. 15% of the surveyed passengers are both for introducing more vehicles on the existing route and for introduction of more new routes (Figure 5).

The average rating of the "Vrabac" service, according to the opinion of passengers who use it, is 4.93.

3. CONSLUSION

Users of the "Vrabac" line are very satisfied with it as well as with the vehicles that operate on it.

The opinion of the surveyed users is that the number of vehicles operating on the line should be increased as well as that more such lines should be introduced in order to make this service even more attractive and accessible to users of public transport services.

Figure 6. Electric vehicle on line “Vrabac”

Given the very positive opinion of users and compliance with modern trends of sustainable development, we can expect the expansion of this and the establishment of similar services in Belgrade and other cities in Serbia (Figure 7).

REFERENCES

[1] PUC GSP "Beograd" Business Programme for 2020.

[2] GSP „Beograd“, 2020, Business Report for 2020.

[3] Survey of user satisfaction with the line „Vrabac“, October 2020.

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DEMAND RESPONSIVE TRANSIT (DRT) : JUST A RECENT NICHE OR A FUTURE REVOLUTION?

Key Words
Demand Responsive Transit (DRT)
Public Transport (PT)
Efficiency
Passenger demand
Bus capacity
Ridership optimization
Flexible adaptation
Intelligent Planer software

Abstract

Like many sectors the Public Transport was hit by the Covid-19 pandemic resulting in lower ridership and creating the challenge of gaining back the passenger's trust.
In the UAE, in particular, parallel to the Health and Safety measures taken by the Authorities and Operators with the traditional public bus networks, created opportunity of a new service type apparition offering shared on-demand services.
This study includes a brief description of global on-demand services, the challenges and perspectives of the model and its integration possibilities to existing Public Transport urban networks.

1. INTRODUCTION

The industrial era started from the 18th Century, pathing the way for fundamental innovations like the production mechanization. The emergence and diffusion of steam engines and later the widespread use of electric motors, permitted automation and mass production. Transportation has become one of the basic branches of industry. Overland, horse-drawn carriages stepped down in favor of steam locomotives creating the rail system. The electric rail transport in alliance with the urbanization was at the origin of a new concept: Urban Public Transport (UPT).

Public transport networks started their expansion around the world diversifying both in terms of vehicle types (metro, tram, bus, trolleybus, coaches, minibuses, vans, taxis ...) and services types (regulated, deregulated routes, fixed, on-demand ...) according to the potential and the community resources which vary with the geographical context, from very populated city centers to the suburban and rural areas and their decreasing potential.

Nowadays, UPT stands at the heart of the sustainable development by its impacts on pollution and energy efficiency. The congestion reduction targets created mass transit system to influence a significant modal shift. Internally, the industry made its homework by implementing nonpolluting transport systems based on electric vehicles and adapting the size to the passenger's needs.

Along with the technical innovations we assisted to a revolution at the political level, the recognition of the strategic nature of public transport and the creation of sustainable urban mobility plans (SUMP) approved by the decision-makers as the main orientation for future developments.

The concept of on-demand transport started to be really documented from the 1960s, especially in North America and a later in Europe. Low density areas with fewer resources have been challenged to study how to reduce costs.

The research began with a project developed at the Massachusetts Institute of Technology in 1969 using computer technology. Then the first applications of automated algorithms were created in the United States in the early 1970s. During thirty years Later the model didn't see any significant change till the internet revolution. From the 2000s, the internet break-in provided quick and varied solutions to dramatically improve the reservation system and helped reduce the time between booking and trip completion. From 2012, the smartphone boom gave the possibility to enter the market for a new kind of mobility providers.

2. THE CONCEPTION OF ON-DEMAND SERVICE

2.1. The trip planner

In the complex UPT networks, a journey planner or route planner is a specialized search engine used to find an optimal way to travel between two or more given places, using several transport modes. Searches can be optimized on different criteria, for example fastest, shortest, least modifications, cheapest.

These calculator engines were developed first in the major mass transit network but were extended later to include the schedules and possibilities of other mobility actors in the area such as taxi, carpooling, etc.

The journey planners are different from the demand responsive tools in the way that the customers are being proposed an itinerary to which they need to adapt themselves. The network is not yet moving and adapting itself to satisfy the passenger.

Looking at European countries, many have designed such platforms, just a few examples taken from the European Commission website on mobility and transport:

Table 1. Some of European Trip Planner Software (without to be considered a complete list)

Software	Country
Scotty	AT
VerkehrsPilot	AT
IDOS	CZ
9292	NL
Journey	FI
BiljRejseplanen	DK
DELFI	DE
ReiseAuskunft	DE
SITkol	PL
RESROBOT	SE
TransportDirect	UK

2.2. Hail-and-Ride

Hail-and-Ride service is also an ancestor of On-Demand service. Freed from the bus stops structure and necessity to board-in and out only at dedicated stops, the Hail-And-Ride concept is inspired from developing countries where transporters are competing on high demanding corridors, dropping and boarding at a sign from passengers.

The internet technology impacted also the traditional and classic taxi services by the introduction of booking platforms taken as new business model from new entrant in the market such as Uber or Lyft.

Merging traditional Hail and Ride and new booking possibilities enhanced by technology permitted the naturel development of a new type of service: pre-booked shared bus shuttles.

2.3. The concept of On-Demand Responsive Transport (DRT)

A DRT trip is somewhere between an individual Taxi ride and a collective public bus service. The On-Demand service can be found under different format of operation:

A. Fixed (predefined) routes, with existing fixed bus stops:

- Timetable tailoring on passengers flow (peak and of-peak hours, day/night);
- Bus capacity changing as per passenger flow evolution, flexible and quick adaptation;
- Fixed trip times but conditioned trip start.

B. Defined area (district), flexible routes, predefined stops and defined trip end stop (Bus Station):

• Predefined feeder routes, flexible stops as passenger collector role to Mass Transit Station;
• Flexible timings as per passenger request from one of the predefined pick-up location to Bus Station.

C. Just working area defined, inside district no existing routes just predefined bus stop locations:

• Communication of pick-up location (from the closer bus stop) to his asked drop-off bus stop;
• No timings (or timetable) for trips, passenger's shared journeys, just common direction defined.

D. No predefined routes, no stop locations, inside a delimited area:

• By passenger request from different pick-up locations to different drop-off locations on shared trips;
• Flexible trip times with redirection of route to pick-up a new passenger for the shared minibus.

The characteristics by location definitions are included in next table:

Table 2. DRT concepts split by type of location (area, stops)

X to N: fixed number of stops to any location in the defined area	**N to N:** from any location to any location in the defined area(door to door)
X to X: from fixed number of stops to fixed number of stops	**N to X**: from any location in the defined area to a fixed number of stops

The challenge for DRT is how to be integrated in PT systems. Many cities understood the advantage to use the DRT as a feeder service to their classic networks and a way to replace fixed routes by more efficient DRT services adapted to low ridership areas.

On the fare side, the general approach of pricing can be described as "less expensive as a taxi, more expensive than a bus". The most common payments solution is via a smartphone application on which passengers must register a profile and link a credit card. As another payment method, the public transport smart cards are increasingly imposing itself with the growing understanding of integration with the public bus network.

3. DRT SYSTEMS AROUND THE WORLD

3.1. The main DRT Software market players

Many new services have been launched over the last decade, fully implemented by private actors or through partnerships between public and private actors. The various implementations need first to be described in their similarities and differences to try to get the essence of these new developments.

Table 3. A sample of DRT Software worldwide

Region/City	Country	On-Demand Software
Helsinki	FI	VIA
Arlington (TX)	USA	VIA partner
London	UK	ViaVan
Amsterdam	NL	ViaVan
Berlin	DE	ViaVan
Liverpool	UK	VIA/ArrivaClick
Oxford	UK	VIA/PickMeUp
London	UK	VIA/Go-Ahead
Boston	USA	RideKC/Bridj
Washington DC	USA	BRideKC/ridj
Paris	FR	Flexigo
San Jose (CA)	USA	VTA Flex
Bristol	UK	Slide
Sidney	AU	Bridj/Transit
Sidney/Manly	AU	Rideplus/Transdev

3.2. Financing DRT systems

DRT services are being financed either through commercial contracts or through such subsidy schemes to possibly compensate for differences between revenues and costs for the services requested by the authorities to cover certain areas with less public transport opportunities due to the service unsustainability. Here are some contracts divided into the two main categories described above: commercial or subsidized services.

Table 4. Sample of DRT system contracts

Commercial services	Subsidized DRT systems
Bridj (Boston and Washington DC)	Kutsuplus (Helsinki)
Via (NYC, Washington DC, Chicago)	Via (Arlington, West Sacramento)
PickMeUp (Oxford Bus company)	Go Connect (Miami-Dade)
ArrivaClick (Liverpool, Sittingbourne)	RideKC: Bridj (Kansas City)
Slide (Bristol)	ViaVan (BerlKönig)
	Northern Beaches (Transport for NSW and the other Sydney trials)
	Résa'Est (Orleans Metropole)
	Flexigo (Sidney)
	VTA Flex (San Jose)
	Plustur (Northern Denmark)
	Breng flex (Arnhem, Nijmegen)

3.3. The Australian experience

The KEOLIS-Downer, in partnership with Transport for NSW, started operating KEORIDE On-Demand transport in November 2017, as part of the NSW Government On-Demand pilot program, applying subsidies for sustainability. Since the launch of this service, the community has embraced KEORIDE, praising the flexibility, reliability and high service quality delivered. KEORIDE is an app-based service, which offers a unique service design that allows customers to order a vehicle when they want to travel, to go to key hubs in the Northern beaches and/or connect to the crowded B-Line (the bus line which provide7/24 services, , big buses with more seats, more on-board comfort and additional commuters car parking facility). According to a survey conducted in June 2020, a majority of customers use KEORIDE to connect to the B-Line (78%), and 57% would have used their car if KEORIDE wasn't available.

Photo 1. Adelaide On-Demand service buses

Another example, the Transport on Demand (ToD) is provided by TRANSDEV, it is the mobility offer that is adapted to areas where the demand for shared mobility is sparse, unlike in urban areas: business parks, suburban areas, rural communities or night services. In Sidney the railway stations and the Sutherland bus stops are connected with the "on-demand" shuttle service named TRANSDEV Link project. The results have met the hopes and expectations of both: TRANSDEV and the Public Authority, the Transport for New South Wales.

As it is shown in next below statistics, in the two years of operation, as the summary of Australian DRTs, the Ridership increased to reach 80,000 Passengers/Month with potential of increase in future.

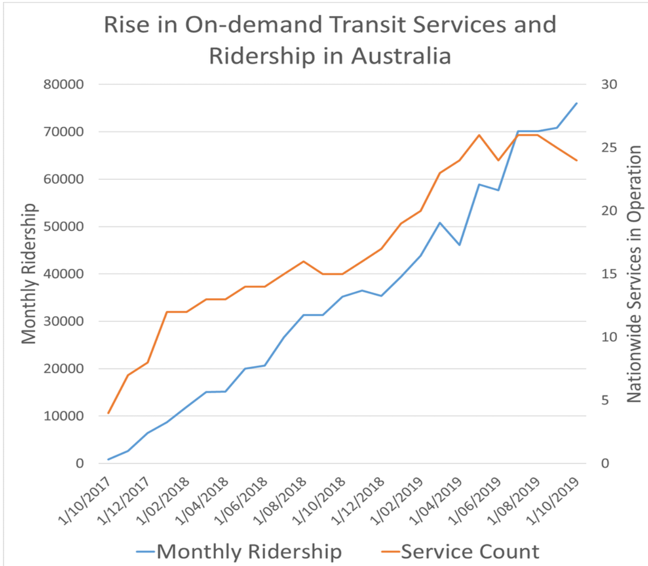

Figure 1. On-Demand Transit service ridership October 2017-2019

4. CASE STUDY: DRT EXAMPLES FROM UNITED ARAB EMIRATES

4.1. Abu Dhabi – "Links" On-Demand Service

As first the service was introduced in SHAHAMA district, a residential suburb area of Abu Dhabi with low density, with scarcity of big buildings and no real identified downtown. People who are using the public transportation are mainly commuters toward Abu Dhabi downtown, houses and farms staffing for local trips. The DRT service started on October 2020 by the collaboration between the PTA, the PT Bus Operator and VIA developer team (known worldwide for their robust software).

The user must create an account on the application and provide name, E-mail address/Mobile number. He will select the pick-up and drop-off location and make his trip order. Then the application will give a ride proposal with an estimated start time at pick-up point and the expected time of bus arrival at selected drop-off. The request can be for single passenger or a group of maximum three who should go to the same destination.

The application, using the elements of Artificial Intelligence, works automatically to identify riders request and creates routing by drawing an itinerary to link pick-up and drop-off location for all riders supported by navigation. The system will propose to the rider the closest and safest place situated in the main road for the vehicle "appointment". Payment is done through the HAFILAT smart used for PT Network.

Photo 2. Abu Dhabi On-Demand service buses

From driver side all the communications are done through an internet (GPRS) connected Tablet. He receives ride request by sequence. He has to press the Menu on Tablet (for pick-up) one a passenger is boarded. If the rider is not there, he wait select no show option after a certain time. When driver reaches to rider destination he has to press again the respective Menu on Tablet (for drop off). During trip the driver will follow the rerouting instructions received on Tablet GPS Map from Via Software.

From Operation side, the roster is established to match the service working hours as in next table:

Table 5. Driver working hours and schedules example in SHAHAMA area

<table>
<tr><th>Timing [h]</th><th>0 - 6</th><th>6 - 7</th><th>7 - 13</th><th>13 - 21</th><th>21 - 22</th><th>22 - 23</th><th>23 - 24</th></tr>
<tr><td>Bus nr. 1 - 3</td><td>0</td><td colspan="4">3 buses / 2 shifts</td><td colspan="2">0</td></tr>
<tr><td>Bus nr. 4 - 6</td><td colspan="2">0</td><td colspan="4">3 buses / 2 shifts</td><td>0</td></tr>
<tr><td>Bus nr. 7</td><td colspan="3">0</td><td>1 bus / 1 shift</td><td colspan="3">0</td></tr>
<tr><td>TOTAL buses</td><td>0</td><td>3</td><td>6</td><td>7</td><td>6</td><td>3</td><td>0</td></tr>
</table>

The Drivers roster is prepared and uploaded to the application along with driver IDs, start and end duty & bus plate numbers, in total 3x2+3x2+1=13 shifts (drivers). In the Control Centre (OCC) the dispatcher will follow in Real Time the bus movement as it is shown in Fig.2, ride requests, pending requests, the operation area and position of buses. Also he will arrange Labor Law required break timing for the drivers and set the planned break in the application.

Figure 2. On-Demand Service SHAHAMA map (Real Time - September 2021)

The analysis of “classic” PT Ridership conclude a slightly decrease, less than increase in the On-Demand service, pointing the fact that the service has attracted new users.

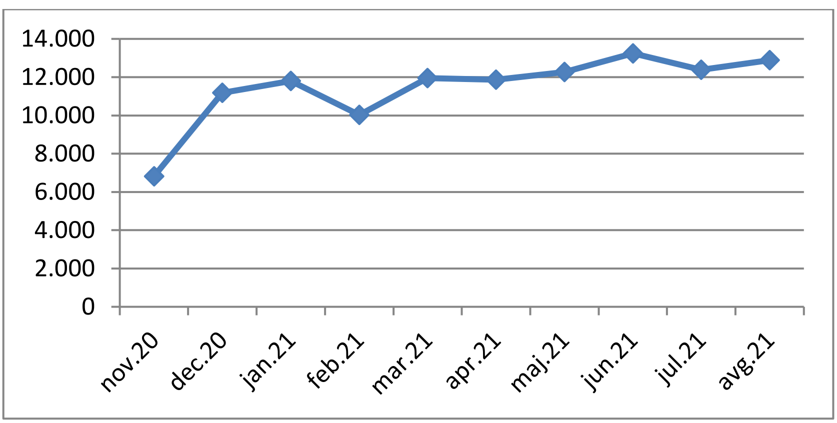

Figure 3. On-Demand Service SHAHAMA Ridership (Nov 2020 - Aug 2021)

4.2. Dubai – Bus On-Demand Service

The Roads and Transport Authority in Dubai, RTA’s service provides a fast and comfortable means of transportation for passengers who are in neighbourhoods where there are no fixed lines for mass transit routes. Passengers can download the service application to book a trip on board a "on-call bus" that goes towards their address to take them to the nearest location of public transportation from Metro stations or stations and fixed lines for public buses. The passenger can also make group reservations through the service's smart application.

Photo 3. Dubai Bus On-Demand service

The service currently is available in six regions in Dubai: Al Barsha (1, 2, 3); Dubai Internet City; International City; Dubai Silicon Oasis; The Greens and Academic City. Payment of trip it is possible via the NOL card (PT card) inside the bus, in addition to the possibility of payment via a bank credit card via the "Bus on Demand" application. RTA providing an integrated with mass transit service that encourages those in those areas to use mass transportation by reducing their waiting time, by connecting them to the nearest PT station, which ultimately serves to reduce private vehicle trips In the respective regions, and in turn contributes to reduce congestion.

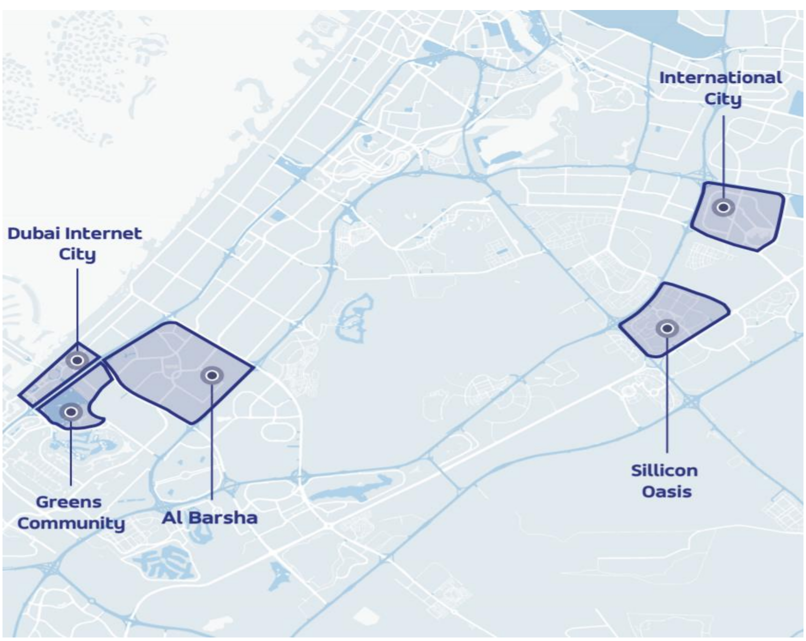

Figure 4. "Bus on Demand" Service area map in Dubai (September 2021)

The monthly average number of passengers using the service reaches 14,000 passengers, according to the statistics issued by the Authority in August 2021. The "Bus on Demand" service provides transportation within the same area, and it is not permitted to use it to travel from one region to another.

Passengers from both Emirates (Abu Dhabi and Dubai) are using with high satisfaction the newly implemented Demand Responsive Transport systems, now accepted as well-recognised and successful projects.

5. CONCLUSION

The aim of this paper is to contribute to develop knowledge about what the developments in positioning and smartphone technology bring to the table for the PT sector. Recent developments in communications and sensor technology have allowed such services to grow substantially in urban, sub-urban and rural areas. Demand responsive transport is a technology-driven shared transport service operated by a company with professional drivers with flexible schedule, and/or flexible stops and/or flexible routing. The key differentiation with traditional PT is that services are provided as a response to the demand from customers. The overarching question posed in the study was: can new technology improve DRT as sustainable service for future or is just optimization tool?

The review identified a substantial number of services that meet the criteria for what paper refers to as On-Demand PT. There are examples of both subsidized and commercial services. Typically, some services have been implemented as trials lasting for a limited period. Few of the cases have been implemented in “classic DRT territory”, in a rural, low demand context, but it appears that many of the recent or ongoing trials have been carried out in urban contexts, being implemented in major urban areas.

Four categories of routing/scheduling policies were identified in the identified cases: free floating within a continuous geographical area, fixed destination or origin, combination of free floating and fixed origin or destination, and a zone-to-zone structure. The services also utilized either physical or virtual stops.

Operating hours vary across cases with some of services in the major urban areas operating around the clock, while other services aimed at commuters operate during peak hours only.

All of overviewed cases allow bookings to be made via a smartphone application. Many of the cases also allow booking via other means, e.g. online or by phone. The study identified different approaches to handling real-time requests and pre-bookings.

There are some cases in the study where payment is integrated with the general PT system, as it’s happen in United Arab Emirates examples of Abu Dhabi or Dubai, enabling payment using PT smart cards. Additionally, there are also few examples of systems that are integrated with general PT systems, searchable in the local PT planner. Thus, it can be argued that most cases in this study operate as standalone systems, in which links to, and integration with, other forms of PT are limited.

Another issue concerns the effect on accessibility. DRT services could significantly affect accessibility for certain groups of people who live in low density areas that are genuinely hard to service using fixed route PT. In this type of context, it could be politically justified to accept a costly DRT system if it provides clear improvements in accessibility for those people in the population who have limited access to transport compared to the present situation.

On-demand ridesharing offers the opportunity to enrich the traditional PT offer and diversify the service portfolio, hence helping to attract new user groups who may currently be dependent on private vehicles. They are particularly useful where the cost of fixed route, fixed schedule services may be unusually high in proportion to the demand such as in sparsely populated areas or during random times of the day. It can also be useful in first/last mile connectivity. For PTOs, it could therefore be a good opportunity to adopt new tools and new ways of working. Coordinating on-demand ridesharing with scheduled PT, for example through the pricing system or operational time, can result in a win-win proposition. This coordination is also a key to keeping the sector relevant in the context of the autonomous vehicle revolution. Furthermore, efficiently integrating on-demand ride-sharing options by building integrated mobility platforms such as MaaS will pave the way towards more sustainable urban mobility systems.

As a main conclusion, there are no indications that technology is a game changer for improving DRT to any significant extent. A benevolent interpretation of the comparison of productivity (expressed as passengers per revenue hour) between the reviewed cases and traditional DRT indicates that, in some cases, there may be some incremental gains. However, there are also examples of cases in which productivity was lower than traditional DRT. This suggests that new technology is no panacea for fixing the problems of DRT.

DRT became undoubtedly a potential partner for the future PT Networks if it is considered as a complement to the Mass Transit systems, for dedicated areas or day types or time bands but it will never replace the Mass Transit Networks inside the dense areas.

The debate about whether is better "to spend tax payer's money" for subsidized contracts or "investors' funds" for commercial services: on DRT solution rather than improving the fixed routes will undoubtedly continue, arguments pros and cons are many, positions could be different, but PTA (and PTO) main target is to reach PT operational and financial parameters to the maximum efficiency.

REFERENCES

[1] I. Csuzi: Contribuţii la evaluarea şi optimizarea performanţelor energetice şi de disponibilitate ale sistemului de tracţiune electrică urbană (EN-Contributions to the evaluation and optimization of the energy and availability of the urban electric traction system), Ph.D. Thesys (prof.dr.ing. Ioan FELEA), 2011, Universitatea Oradea/ROMANIA.

[2] N.H.M. Wilson, J.M. Sussman, L.A. Goodman, B.T. Higonnet: Simulation of a computer aided routing systems (CARS), Massachusetts Institute of Technology, 1969, USA https://repository.lib.ncsu.edu/bitstream /handle/1840.4/7558/1969_0016.pdf?sequence=1

[3] J. Neila, A. Patrick, A. Pablo. V.M. Orlando: A bi-level model for public transport demand estimation, 23rd EURO Working Group on Transportation Meeting, EWGT 2020, 16-18 September 2020, Paphos/CYPRUS.

[4] F. Patterson: An international review of experiences from On-Demand transport services, Technical Report-K2 funded Project, 29 May 2019, ISBN978-91-985495-1-5, Lund/ SWEDEN.

[5] C. Archetti, M. Grazia Speranza, D. Weyland: On-Demand Public Transportation, https://www.researchgate.net/publication/273409078, 2016, Lugano/ITALY.

[6] P. Csrk Prasad: Public Transport Demand Estimation, Conference “Route Rationalization Techniques for Public Transport”, AITD, 10 December 2020, , New Delhi/INDIA.

[7] T. Perera, A. Prakash, T. Srikanthan: Genetic Algorithm for an On-Demand Public Transit System using EV, Nanyang Technological University, 2020, Singapore/SINGAPORE.

[8] P. Ştefănescu, M. Mocan, W. Ştefănescu, P.V. Neculai: Trip planners used in public transportation. Case study on the city of Timisoara, SIM 2013 / 12th International Symposium in Management, ELSEVIER-Procedia - Social and Behavioral Sciences, ISSN1877-0428 © 2014, p.142.

[9] B. Ubbel, P. Nijkamp, E. Verhoef, S. Potter, M. Enoch: Alternative Ways of Funding Public Transport- A Case Study Assessment, EJTIR, 1, no.1 (2001), pp. 73 – 89.

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PUBLIC TRANSPORT SYSTEM IN THE FUNCTION OF LAND USE

Key Words
Settlement
Land use
Public transport
Real estate

Abstract

The relationship between land use and transport is complex. Together they form a dynamic system and interaction in the urban environment or at the city level through urban areas and beyond. Land use is also difficult to quantify. In general, the area of land use in sustainable development represents different characteristics such as distance from the city centre, size of settlements, land use, provision of local facilities, development density, proximity to transport networks, the shape of settlements and urban form. The attractiveness of a part of the city will greatly influence the decision to accept living in it. In addition, the connection with the city centre or other important contents by public transport lines is of great importance. This paper discusses the importance of the impact of Urban Public Transport on the development of a particular settlement or part of the city, ie to what extent it will contribute to the increase (decrease) in the prices of housing units and construction land.

1. INTRODUCTION

Public transportation is crucial for the future of a nation. Strengthens the economy, conserves energy and resources, reduces congestion, reduces global warming and improves air quality and health, critical assistance in emergencies and disasters, increases the value and development of the real estate, mobility in small urban and rural communities, greater access for groups of all ages and circumstances, lower health costs… - all this contributes to a better quality of life. In 2005, U.S. residents made 9.7 billion trips by public transportation [1]. From 1995 to 2005, travel by public transport increased by 25% [2].

Also, public transport is extremely important for the transport system of a country and essential for the economic and social quality of life of citizens. New information technologies warn passengers via e-mail or mobile phone when the next bus or train arrives. People plan their trips over the internet. It helps everyone, families, students, retirees, people with disabilities, while trying to accomplish their jobs, meet daily needs and maintain a high level of traffic independence.

At the beginning of the paper, a brief overview of the importance of public transport in certain areas of life is given. The second chapter deals with the importance of housing near the public transport system and the impact on the environment. The connection between land use and public transport is presented in the third chapter, in which important scientific papers on this topic are highlighted. Also, the consequences of increased costs on the population and households, in general, are explained. The fourth chapter discusses the key elements of the functional relationship between public transport and land use.

2. THE IMPORTANCE OF HOUSING NEAR THE PUBLIC SYSTEM

Expanding the public transport system is a significant undertaking for any region. For residents and businesses for whom accessibility is important, such investments can also substantially redistribute the value of a location within a part of the city, making the area more or less desirable than before due to its proximity to the public system. The value of a residential location is best reflected in how much people are willing to pay to live there!

A place of residence located near public transportation should dictate a higher rental price or selling price than that housing unit located further away. In theoretical terms, the reduction in travel time should be reflected in the value of the property price.

The relationship between the physical environment and the role of planning, design and management is reflected in the creation of a safer community. But the benefits of living near a system or public transport line can be greater. In addition to lower transportation costs, the ability to travel within a large metropolitan area and avoid traffic jams is highly valued by some. Others are attracted by commercial and entertainment facilities that are often sorted by transit stations and busy roads.

Today, a large number of technical, regulatory, planning and other possibilities are available to reduce the negative impacts of urban transport on the environment. A successful public transport system generates significant economic value for cities because it improves the accessibility of the gravity area of the stop. There is a great need to maintain the benefits of public transport in terms of emissions and energy consumption as these are key factors in further promoting its use.

2.1. Evaluation of the impact of the public transport system on the environment

Research has shown that users are prepared to pay more for housing located in areas that represent new urban principles or are "traditional neighbourhood developed." These settlements are passable, of higher density, and have access to jobs and facilities.

Tu and Eppli (2013) found that buyers would pay 4.1 to 14.9% more for housing in new urban areas. In another study, the authors found that households were prepared to pay more for homes in settlements with a better-connected street network, smaller blocks, pedestrian access to commercial facilities, and proximity to the Light Rail System (LRT).

3. RELATIONSHIP BETWEEN LAND USE AND PUBLIC TRANSPORT

Boarnet and Crane (2001) found that the relationship between land use and transportation is very sensitive to the choice of empirical methodologies [3]. Different land use characteristics are often interrelated. For example, historic areas with large populations tend to be located near city centres in areas with good public transportation. The relationship between land use and transportation is further complicated by the close connection of both elements with several socio-economic factors, such as owning a car and income, which are interrelated [4].

Land use has the greatest impact on the daily travel of residents living there. The higher the density of the city, the higher the demand for public transport in terms of timetable, but also the shorter the length of the trip. It should be recognized that a factor such as high housing density tends to be associated with lower household incomes, while low housing density is associated with high incomes [5]. In addition, low incomes are associated with a low rate of car ownership.

3.1. Consequences of increased costs for population and households

The cost of investment in access roads and communal infrastructure is two to five times higher in fragmented than in compact settlements (Figure 1). While cities and settlements with compact structure and multi-storey buildings have on average 0 to 60 housing units/ha and road lengths of about 5 to 20 m per housing unit, the mentioned average in dispersed settlements is significantly lower and amounts to 0.4 housing units/ha, and 5 to 50 m of road length per housing unit [6].

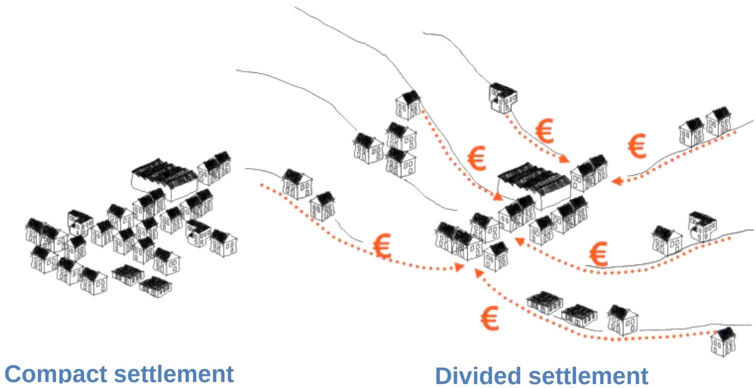

Figure 1. The cost of an inefficient settlement system [7]

Inefficient spatial planning increases the costs of the population and households, which are reflected in:

- Needs to own and use a car for transport purposes;
- Constant increase in mobility costs;
- Lack of quality transport services for the elderly and other vulnerable groups.

4. PUBLIC TRANSPORT SYSTEM IN THE FUNCTION OF LAND USE

In general, transport affects the availability of land for development and the spatial distribution of economic activities. This has an impact on land price, housing affordability, operating costs, productivity and, ultimately, economic performance.

Urban areas require a well-functioning transport infrastructure, so that traffic can contribute to increasing value by allowing better-located land to often reach its highest value [8].

By linking transport to land use, it is possible to make the urban area more efficient, thus enabling greater economic development. Traffic infrastructure determines how many people can reach a location based on a given area of space and set infrastructure, including individual modes of transportation.

Traffic infrastructure has the potential to change the geography of urban areas, affecting the degree of separation between locations [9]. The efficiency of transport networks enables greater availability and density of development, which creates economic benefits.

The expansion of the Manchester Metro will have many benefits in central Manchester through an increase in house prices along the route. It allows for an increase in jobs in central Manchester, and housing values have risen by as much as 5.4% within a 1-mile radius around the station [10].

Similarly, APTA found that U.S. homes value 41% more when they are close to quality public transportation. People living near public transportation have access to up to three times the number of jobs per square mile.

By attracting investors and tenants, affordability can influence the nature of urban form and future development [11]. Traffic infrastructure is directly related to land use, where some users require more space than others. Where public transport is not available or adequate, people are forced to travel by car, thus complicating the initial problem of traffic congestion and placing increased demands on transport space.

Many places have tried to follow the examples that come from Scandinavia, where the planning policy helped to achieve 80% of the trip without using a passenger car. TfQL (2011) [12] tells that the link between transport and urbanization should be a central policy decision to enable more efficient sustainability of cities. The importance of putting traffic planning at the centre of events is increasingly recognized to achieve several policy goals, including increasing economic competitiveness, improving quality of life, reducing traffic congestion, lower transportation costs, improving air quality, and reducing the cost of providing various services.

„Transport for London“ developed a tool to evaluate and evaluate elements of transport interventions. Plans that encourage the transition to active modes and public transport have been found to have a positive impact on land value. This principle was applied to the recent Crossrail project in London with 190,000 square meters of space, improving the environment and creating 1,335 new parking spaces for bicycles. Reducing car dominance, Crossrail enables the development of a modern urban area and is estimated to generate a 10% increase in real estate value, adding £ 5.5 trillion to real estate on the route by 2021 [13].

4.1. Use of public transport

The use of public transportation in the United States in 2013 increased to 10.7 billion trips - the largest number in the last 57 years. However, this increase in the number of public transport trips can be attributed to the increase in the number of subway passengers whose route is most often located in an extremely urban area. The number of Light Rail, Tram, and Bus passengers has increased, but much more slowly, or even declined, over the past decade (Figure 2) [14].

More than half of Americans live on the periphery of cities. Approximately 75% of the population since the post-war construction has moved to the suburbs. Many suburbs have created "urban pockets" by building high-quality public transportation to ease traffic congestion and build mixed-use or high-rise buildings instead of multiple single-family homes.

William Frey, one of the most prominent demographers in the United States, wrote that the difference between cities and suburbs is falling apart. He believes that the suburbs are becoming diverse ethnic, socio-economic spaces, with more housing and sales options near offices, flexible and other space. He also states that the benefits of cities are reflected in [14]:

– More than 10% of global GDP growth by 2025 will come from major cities in the US;
– 80% of the US population lives in large cities, compared to 60% of the population in Europe.

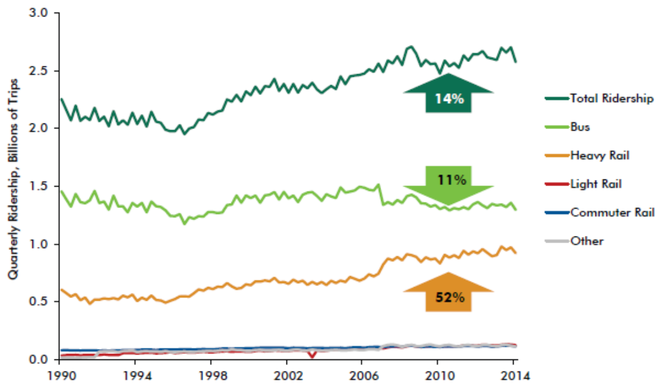

Figure 2. The ratio of the number of transported passengers to different modes of transport

The accelerated growth of the suburbs of Melbourne creates a significant backlog of the required expansion of the public transport network. BusVic from 2011 estimates that 43% of suburban settlements, which developed between 2004 and 2009, are beyond the reach of the existing network of public transport lines - namely: 400 meters from the bus or tram line or 800 meters from the train station [15]. In some cases, entire suburbs are beyond the reach of public transportation.

5. CONCLUSION

The place of residence located near the route of the public transport line should determine a higher rental price or sale price than the housing unit that is further away. In theoretical terms, the reduction in travel time should be reflected in the value of the real estate price. The general impression is that the benefits of the availability and proximity of housing in the gravitational area of the public transport line outweigh the potential side effects, leading to higher facility values in many cases.

REFERENCES

[1] Bureau of Transportation Statistics, „2005 Domestic Airline Passenger Traffic Up 4.1 Percent From 2004“, Domestic Market and Segment, Washington, 2006.

[2] APTA, “2006 Public Transportation Fact Book”, American Public Transportation Association, Washington, 2006.

[3] M. Boarnet and R. Crane, „The influence of land use on travel behaviour: specification and estimation strategies“, Transportation Research Part A: Policy and Practice, vol. 35, no. 9, pp. 823-845, 2001.

[4] D. Stead, J. Williams and H. Titheridge, “Land use, transport and people – Identifying the connections”, Achieving sustainable urban form. London: E and FN Spon, pp. 174-186, 2001.

[5] C. Maat, “The compact city and mobility: a Dutch perspective”, Transport and Environment: in search of sustainable solutions. Cheltenham: Edward Elgar, 1999.

[6] C. Doubek and G. Zanetti, “Siedlungsstruktur und öffentliche Haushalte”, Gutachten des Österreichischen Instituts für Raumplanung (ÖIR), 1999.

[7] A. Gulič, “S promenom uzoraka uređenja prostora do razvoja održive mobilnosti: saznanja iz projekta MORECO 1”, Serbian Road Congress - Belgrade, 2014.

[8] D. Banister and J. Berechman, „Transport Investment and Economic Development“, UCL Press, London, 2000.

[9] P. Townroe, “The Coming of Supertram: The Impact of Urban Rail Development in Sheffield”, Transport and urban development, E & FN Spon, London, pp162-181, 1995.

[10] Volterra, “Economic Benefits of the Metrolink extension”. Manchester Enterprises, UK, 2008.

[11] R. Vickerman, “Recent evolution of research into Wider Economic Benefits of transport infrastructure investments”, Joint Transport Research Centre Discussion Papers from OECD Publishing, No 2007/9, 2007.

[12] TfQL, “Thriving cities: Integrated Land Use and Transport Planning”. Transport for Quality of Life, Leeds, 2011.

[13] P. MacLennan, Crossrail predicted to increase property values by £5.5 billion, Crossrail, London, 2012.

[14] A. Wirth and M. Rasmussen, “U.S. Urbanization Trends: Investment Implications for Commercial Real Estate”, CBRE Global Investors, 2015.

[15] BusVic, „Bus Solutions-Cost Effective, Demand Responsive“, Issue 5, 2011.

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REGIONAL PUBLIC TRANSPORT ACCESSIBILITY – CASE OF KOROŠKA REGION, SLOVENIA

Key Words
Accessibility
Public transport
SUMP
Koroška

Abstract

Public transport plays a major role in sustainable mobility planning. This is even more obvious on regional level, where distances are often too long for cycling, therefore public transport remains only viable sustainable travel mode. In the process of preparation of regional SUMP, evaluation of accessibility is one of crucial steps. However, accessibility measurement can be a challenging task. In Slovenia, there have been several studies measuring frequency and access to closest stop, ignoring travel speed and destinations that could be reached. However rapid increase in computing power, software development and availability of schedule data in GTFS format, opened an opportunity to evaluate accessibility more precisely. We performed an analysis for Koroška region in Slovenia. Accessibility was measured in both directions for all inhabited cells in a grid resolution of one hectare and central settlements of intermunicipal importance. The results of the analysis are important in terms of understanding how many citizens can access settlements of intermunicipal importance with public transport. This will serve as a baseline measure in regional SUMP preparation and will enable future iterations and comparisons. It also enables us to see the gaps in public transport supply and propose improvements. Method is universal and could be used for accessibility measurement in other regions and countries.

1. INTRODUCTION

Public transport is one of the key sustainable mobility modes, especially on longer distances. It also plays important part in preparation of regional SUMP. Important step in planning public transport networks is measurement of accessibility that current network provides. Different methods are used to measure accessibility [1], [2]. In Slovenia several studies measured infrastructure-based accessibility [3]–[7]. Disadvantage of these type of indicators is focus on accessibility from the origin to the public transit service, thus ignoring travel speed and reachable destinations [8]. To date, no study in Slovenia included public transport travel times in accessibility measurements. In the paper we present measurement of accessibility to settlements with at least intermunicipal importance by public transport, including access to transit station, in-vehicle time, potential transfer time and walking to destination. We did not choose to weight different parts of travel time as did some studies [9], because we wanted a simple to understand indicator, that would be used as a baseline measurement in the process of SUMP preparation and communication with stakeholders.

2. METHODOLOGY

Paper focuses on measurement of accessibility with public transport to settlements of at least intermunicipal importance in Koroška region, Slovenia. Koroška had 70,253 inhabitants in year 2019 [10]. Train and regional bus connections are available. Settlements with at least intermunicipal importance were chosen because they provide enough public and private services [11]. In Koroška this are Dravograd and Ravne na Koroškem with intermunicipal importance and Slovenj Gradec with regional importance. Population data for year 2019 in one hectare grid was retrieved from Statistical office [12]. Public transport schedule data for intercity bus connections and trains in GTFS format for year 2019 was provided by Ministry of infrastructure. Pedestrian network was retrieved from OpenStreetMap [13]. Data preparation and maps were created in QGIS open-source GIS software. OpenTripPlanner [14] in combination with python script [15] was used to measure travel times. Aggregation and statistical analysis of the travel times was performed in Microsoft Access.

Travel times with public transport were measured in two directions between inhabited grid cells to 58 settlements in Slovenia with at least intermunicipal importance. Calculation for whole Slovenia was needed to enable comparison of accessibility in Koroška to national average. Total walking distance was limited to 2000 m. Travel times to regional centres were calculated for departures between 6:00 and 8:00 and back from 14:00 and 16:00. We wanted to represent best case scenario with flexible departure times and predicted that passengers would check timetable before arriving at the stop. Therefore, we calculated departures every 15 minutes and subtracted initial wait time. For each origin-destination pair, shortest travel time for each direction was used to calculate average travel time. Calculation in both directions was needed, because in rural areas with low frequency, direct connection or connection with short transfer time is sometimes only available in one direction.

3. RESULTS

In the process of SUMP preparation for Koroška region, travel times for Koroška region were analysed in detail. Some statistics were also calculated on a national level, which enabled us to put the result into the national context. Figure 1 shows catchment areas of settlements with intermunicipal importance. Red colour represent areas that are not accessible within 120 minutes of travel, or require more than 2000 m of walking in each direction.

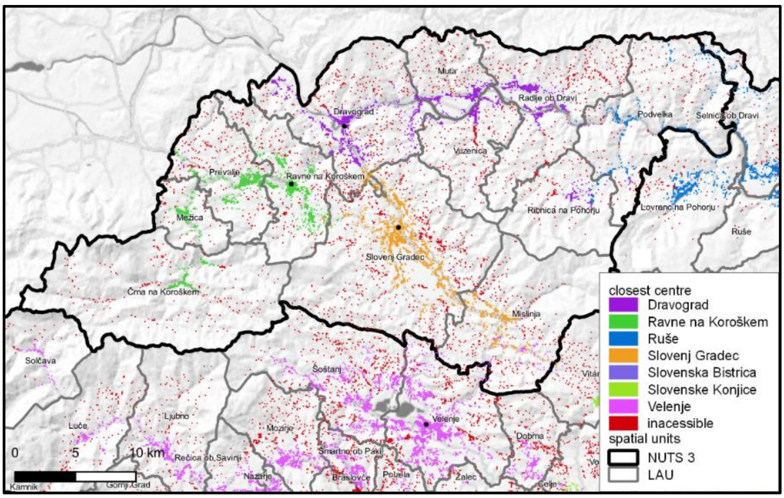

Figure 1. Catchment areas by public transport travel time

Accessibility to regional centre (Slovenj Gradec) is shown in table 1. Only inhabitants of Koroška region are included.

Table 1. Number of inhabitants by travel times with public transport to Slovenj Gradec

travel time - minutes	inhabitants	share of inhabitants
up to 45	30.173	43 %
45–90	25.305	36 %
90–120	952	1 %
more than 120 or inaccessible	13.823	20 %
SUM	70.253	100 %

Table 2 shows travel times for inhabitants of Koroška region to three settlements in Koroška with at least intermunicipal importance - Slovenj Gradec, Dravograd and Ravne na Koroškem by public transport.

Table 2. Accessibility of Koroška residents to closest intermunicipal centre by public transport.

travel time - minutes	inhabitants	share of inhabitants
up to 45	53,836	77 %
45–90	4,206	6 %
90–120	192	0 %
more than 120 or inaccessible	12,019	17 %
SUM	70,253	100 %

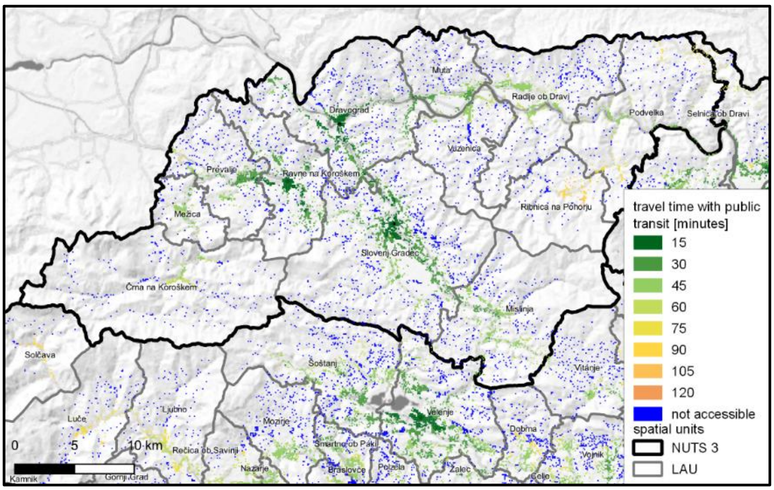

Figure 2. Travel times with public transport to cities with at least intermunicipal importance

Figure 2 shows travel times for residents of Koroška with public transport to closest settlement with at least intermunicipal importance. Note that closest centre can be outside of Koroška region – see figure 1.

4. DISCUSSION

Slovenj Gradec as a regional center can be reached in 45 minutes by public transport by 43 % of inhabitants of Koroška region, which is significantly lower than 77 % that can reach centers with at least intermunicipal importance. Nevertheless 80 % of Koroška residents can reach Sovenj Gradec by public transport. For services that are not needed daily even a longer travel time is better than no accessibility. For services needed daily, intermunicipal centers play a major role. Spatial distribution of three intermunicipal centers is enabling public transport travel times under 45 minutes for 77 % of inhabitants, compared to 81 % on national level. Only 17 % of inhabitants of Koroška region can't reach intermunicipal centers. Considering rugged terrain, accessibility to intermunicipal centres in Koroška is sufficient. All valleys and major settlements have public transport connections available. Areas outside of valleys are so sparsely populated, that it is not viable to provide a regular public transit. These areas could be served by on-demand service and/or integration of school bus lines to regular public transport as feeder lines to existing bus and train connections.

Public transport service areas are quite evenly distributed between Slovenj Gradec, Ravne na Koroškem and Dravograd – see figure 1. This enables lower travel times to closest center. Therefore, it is vitally important, that Dravograd and Ravne na Koroškem provide enough public services and amenities. Municipality of Podvelka in the eastern part of the region has better connections with Ruše, that lie in Podravska region, which shows a discrepancy between traffic region and NUTS 3 region. Podvelka should therefore be included or at least considered in preparation of SUMP for Podravska region.

Despite relatively good accessibility, there is still room for improvement. Especially with train connection, which is outdated and does not enable sufficient speeds. But train has a great potential, since it is independent of any traffic jams. Another opportunity is cross border connection to Bleiburg, Austria, where Koralm railway connecting Graz and Klagenfurt is under construction.

New infrastructure is also planned on Slovenian side, but in this case a new motorway between Velenje and Slovenj Gradec is being built. This provides opportunity to organize new express bus lines, but existing bus lines passing through settlements should remain active to maintain current accessibility level.

5. CONCLUSION

Measurement of public transport travel times proved to be useful and easy to understand indicator, which was used for the purpose of regional SUMP preparation. Results showed that residents of Koroška have a relatively good connectivity to regional centres, especially if we consider roughed terrain. However, this does not ensure high usage of public transport since travel time with private car is still more competitive. Our use case is also not representative for whole population, since we measured public transport travel times only in a best-case scenario. Moreover, some services are not available close to the city centers, and therefore require more walking time. The question remains, how to organise public transport, once the new expressway will be built. Settlements that lie by existing regional road should maintain same level of service. New express lines that would use newly bult expressway can reduce travel times for longer distance travel. However, travel time with public transport will still be slower than by car due to lover maximum speed of busses. Proposed methodology could be also used in other regions, since it relies on standardized GTFS data and OpenStreetMap data which is available world-wide.

REFERENCES

[1] A. Malekzadeh and E. Chung, ‘A review of transit accessibility models: Challenges in developing transit accessibility models’, *International Journal*

of Sustainable Transportation, vol. 14, no. 10, pp. 733–748, Aug. 2020, doi: 10.1080/15568318.2019.1625087.
[2] K. T. Geurs and B. van Wee, 'Accessibility evaluation of land-use and transport strategies: review and research directions', *Journal of Transport Geography*, vol. 12, no. 2, pp. 127–140, Jun. 2004, doi: 10.1016/j.jtrangeo.2003.10.005.
[3] M. Gabrovec and D. Bole, 'Dostopnost do avtobusnih postajališč', *Geografski vestnik*, vol. 78, no. 2, pp. 39–51, 2006.
[4] [4] J. Kozina, 'Modeliranje prostorske dostopnosti do postajališč javnega potniškega prometa v Ljubljani', *Geografski vestnik*, vol. 82, pp. 97–107, 2010.
[5] M. Gabrovec and N. Razpotnik Visković, 'Dostopnost do javnega potniškega prometa kot pogoj za socialno vključenost dijakov', *Geografski vestnik*, vol. 90, no. 2, pp. 109–120, 2018.
[6] J. Tiran, L. Mladenovič, and S. Koblar, 'Dostopnost do javnega potniškega prometa v Ljubljani po metodi PTAL', *Geodetski vestnik*, vol. 59, no. 4, pp. 723–735, 2015.
[7] A. Zavodnik Lamovšek, M. Čeh, and U. Košir, 'Analiza dostopnosti prebivalcev do javnih dejavnosti z medkrajevnim avtobusnim potniškim prometom', in *Geografski informacijski sistemi v Sloveniji 2009-2010*, D. Perko and D. Perko, Eds. Ljubljana: Založba ZRC, 2010, pp. 251–260. [Online]. Available: https://omp.zrc-sazu.si/zalozba/catalog/view/649/2733/214-2
[8] S. Kaplan, D. Popoks, C. G. Prato, and A. (Avi) Ceder, 'Using connectivity for measuring equity in transit provision', *Journal of Transport Geography*, vol. 37, pp. 82–92, May 2014, doi: 10.1016/j.jtrangeo.2014.04.016.
[9] B. Tahmasbi and H. Haghshenas, 'Public transport accessibility measure based on weighted door to door travel time', *Computers, Environment and Urban Systems*, vol. 76, pp. 163–177, Jul. 2019, doi: 10.1016/j.compenvurbsys.2019.05.002.
[10] 'SiStat', *Statistical Office of the Republic of Slovenia*, 2019. https://pxweb.stat.si/SiStat (accessed Mar. 18, 2020).
[11] J. Nared *et al.*, 'Central settlements in Slovenia in 2016', *Acta geographica Slovenica*, vol. 57, no. 2, Art. no. 2, Jan. 2017, doi: 10.3986/AGS.4606.
[12] 'SURS STAGE', *SURS STAGE*, 2019. https://gis.stat.si/ (accessed Aug. 26, 2019).
[13] OpenStreetMap', *OpenStreetMap*, 2021. https://www.openstreetmap.org/copyright (accessed Sep. 15, 2021).
[14] 'OpenTripPlanner'. https://www.opentripplanner.org/ (accessed Aug. 05, 2019).
[15] R. H. M. Pereira and L. Grégoire, *Tutorial with reproducible example to estimate a travel time matrix using OpenTripPlanner and Python*. 2019. doi: 10.5281/ZENODO.3242134.

8th INTERNATIONAL CONFERENCE
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THE CONCEPT OF FORMING INTERMODAL TERMINALS AS AN ESSENTIAL PART OF SUSTAINABLE MOBILITY

Key Words
Intermodality
Terminal
Passengers

Abstract

Passenger intermodality is regulated in various European political documents and it is recognized as a matter of national importance in the policies of individual countries. Intermodality is an integral part of sustainable mobility and its analysis and improvement is vital for congested urban environments. The weakest link in the intermodal passenger transport chain is, most often, the intermodal terminal. Inadequate planning of these terminals leads to a reduction in the level of service, and thus to a reduction in the number of users of the intermodal terminal and their transition to other modes of mobility (most often to private passenger cars). Within this paper, certain factors have been singled out that need to be taken into account when forming intermodal passenger terminals.

1. INTRODUCTION

The conventional approach to building passenger terminals, which has long been present in passenger transport, is increasingly giving way to intermodal terminals. Intermodal passenger transport involves the use of two or more modes of transport during the same journey. Any interchange of passengers, i.e. change of the mode of transport, is the most challenging operation in terminals. The process of changing the mode of transport is the weakest link in the transport system, so the role of intermodal terminals is extremely important. Passengers, in addition to the economic aspect that is implied, during the planning of their trip, consider the conditions of comfort and travel time. That is way comfort and practicality during changing the mode of transport have become imperative. The goal of the concept of intermodal passenger transport is to make these interchanges as fluid and efficient as possible. The application of this concept will contribute to easier selection travel routes, easy access, a higher level of service, reliability of services and increasing the efficiency of complete passenger transport system.

The formation and construction of intermodal passenger terminals is influenced by numerous factors that need to be taken into account when planning. Within this paper, the basic guidelines that should be taken into account when planning intermodal terminals will be presented.

2. LEGISLATIVE FRAMEWORK

In the past two decades, intermodality has become a very important goal of transport policy in the European Union. Passenger intermodality is included in several European policy documents and more or less in national or regional policies. The concept of passenger intermodality was first mentioned in the „Green Paper on the Citizen's Network", in the 1995.

The commission, which discussed intermodality within this document, took the position that the European Union must support integrated transport planning, in order to prevent parallel investment in passenger transport. This would prevent unnecessary spending of both financial and physical resources, which could be diverted to other sectors. The commission even offered to coordinate transport services with countries that are not members of the European Union, in order to increase the attractiveness of this way of traveling.

During 2001, the European Union issued a "White Paper", which presented common transport policy of the European Union for the first decade of the XXI century. Within the "White Paper", the main goals of passenger transport were set, which included the development of safe, secure, socially acceptable and environmentally satisfactory transport services. This document identifies the concepts of "integrated tickets", "baggage handling" and "travel continuity", as key priority issues for intermodal passenger transport. Subsequent revisions of the „White Paper", in 2006, 2009 and 2011, also included passenger intermodality and its integration into the future vision of sustainable transport. In 2006. 4 key points in the further development of intermodality have been defined: increasing mobility, taking care of environment and energy security, technological innovations in the service of intermodal systems related to efficiency and sustainability and international connectivity with countries outside the European Union. In the 2009 White Paper, the European Commission emphasized the need to apply new technologies and integration different modes of transport into a single system, in a more integrated internal market. In 2011, the European Commission highlighted as a priority door-to-door mobility, sharing information about schedule and booking tickets via the Internet, smart and integrated tickets, etc. In this way, efficiency would be achieved, especially in the field of service quality, which includes defining measures necessary for further integration of different modes of passenger transport and development of framework conditions for promoting the use of intelligent systems for intermodal transport system functionality.

3. INFLUENTIAL FACTORS FOR THE CONSTRUCTION OF INTERMODAL TERMINALS

Most travels are always intermodal. People interchange different modes of transport, practically on all the trips they make. Intermodal terminals simplify the travel process, which is usually certainly intermodal. However, it is not always easy to organize an intermodal terminal. There are various factors that significantly influence their planning and construction. Public budgets of cities and the state in general are limited to finance public transport. Even when long-term positive financial and many other aspects are taken into account, detailed research and planning is necessary. Figure 1 shows some of the more important factors that need to be considered before forming an intermodal terminal. The listed factors are covered in five steps.

First of all, it is necessary to know the legislation, both at the national and European level, all depending on transport lines you want to organize. The member states of the European Union have similar laws but the specifics of each region, as well as its legislative framework, must be taken into account. Therefore, all legislative acts in this area are highlighted, which are necessary to guarantee cooperation and integration of transport services. It is very important to know the relations with countries that are not members of the European Union, because it is necessary to include existing agreements if certain lines cross their territory.

The main participants involved in intermodal passenger transport are certainly passengers and carriers of different modes of transport. Consequently, the main actors can include airports, bus terminals, railway terminals, passenger ports and etc. All of the above makes a unique system during intermodality transport planning, depending on the availability and development of certain modes of transport in the observed area. Secondary participants appearing in the passenger intermodality system are travel agencies, city authorities and society as a whole, as well as many other intermediary agencies. Each of the participants in intermodal passenger transport has certain positive expectations and requirements in relation to the system and which they believe will be realized.

Quality of service, travel time and transportation costs are generally the most important for passengers. At the same time, there are different categories of passengers, because e.g. travelers who make business trips are the most sensitive to travel time, while some other categories of passengers prioritize travel prices. It is important for passengers to be well informed about the possibilities provided by intermodal transport, both before entering the system and in the terminals, when changing from one mode to another. If all the advantages are well used - lower transport costs compared to conventional transport, shorter travel time, which means the integration of schedules of different modes, tariff integration, which means that one ticket valid for all modes, etc. then passengers will be motivated for intermodal travels and the simultaneous use of intermodal terminals.

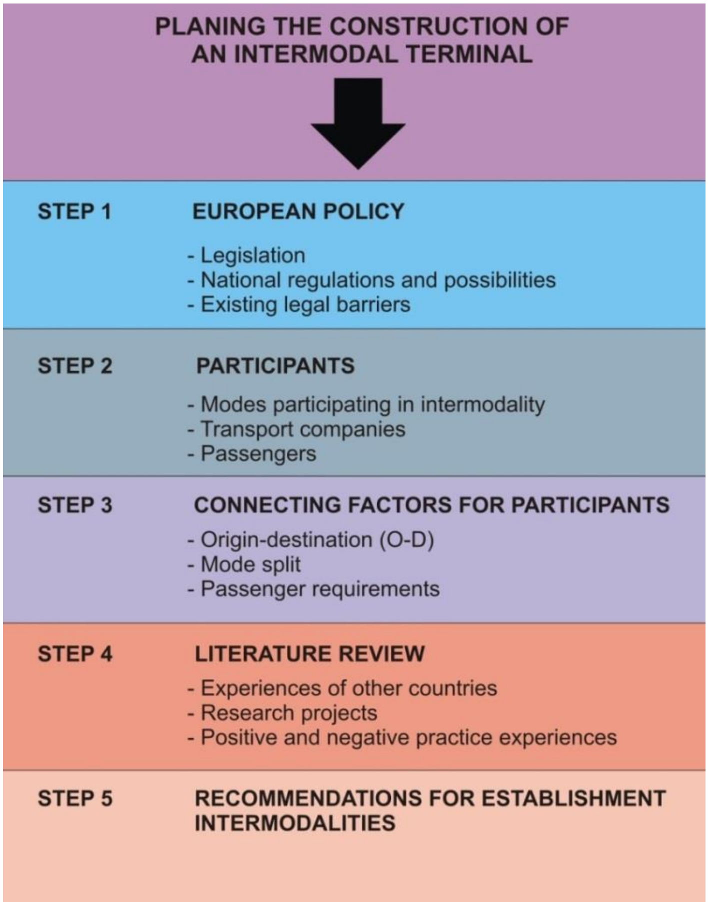

Figure 1. Planning steps for construction of intermodal terminals

Each region is specific in the number of modes that can be included in intermodal transport. In some areas there are physical restrictions. There are no navigable rivers to develop port transport, nor e.g. there are potentials for the construction of the airport, due to the impossibility of filling the transport capacities. Thus, both, different modes of transport used in a given area and which can be included in the intermodality system and size of the city are important during the establishment of modality. In smaller places there is no need for intermodal terminals because they have, for example, bus transport, taxi transport, transport by private passenger cars and bicycle transport. For these reasons, it is very important to make a comprehensive analysis that will determine the justification for the construction of intermodal terminals.

The inclusion of certain modes in intermodal passenger transport would bring many benefits to the participants. By entering the global transport network, carriers are motivated to work on improving their infrastructure in order to increase their market share. Generally speaking, each mode of transport can find its place in intermodality. Planning the construction of a passenger terminal and the choice of modes of transport that will be included in the system are inevitably accompanied by certain research. Researches gives data relevant to the establishment of the system. It is necessary to analyze the population of a particular area. Surveys are used to determine the needs of the population for the use of transport in general. in this way, the share of existing modes of transport in the mobility of the population is considered. The origin-destination trips, the frequency of trips, the readiness to accept the intermodal system, the expectations and requirements are examined. Passengers are the most important for the successful functioning of the system, so it is necessary to devote the most attention to passengers as participants in intermodality. During the construction an intermodal terminal, the geographical position and mutual distance of already existing terminals should be analyzed. If two terminals of different modes of transport are quite far from each other, additional analyzes will be needed. This can require more funding. When a terminal is built from the ground up, its future impact on the existing public transport network as well as on the environment should be determined. It is also necessary to take into account the ecological aspect, the existing infrastructure, the function of the surrounding facilities, etc. If two terminals of different modes of transport are in the immediate vicinity the conversion one of them into an intermodal terminal is performed. Finally, the economic gain in the future should be considered, after terminal’s inclusion in the public transport system.

Certainly, there are many good examples of passenger intermodal terminals in the world that function successfully and whose experiences can be valuable. As intermodality is becoming increasingly important, both in Europe and around the world, many institutions are also funding projects related to passenger intermodality. All projects result in certain conclusions and recommendations, which are based on researches and results of these studies. It can be an additional support in the formation and construction of passenger intermodal terminals.

4. CONCLUSION

Although the European Union has recognized intermodality in passenger transport as a system that would improve and facilitate travels, and at the same time bring numerous benefits to carriers, various challenges and problems make their efficient functioning difficult. Barriers appear in various fields, such as the policies of individual regions and countries in general, planning and organizing terminals and the entire system, coordination and cooperation, legal issues, financing, technical issues and many other aspects that need to be considered. One of the problems may even be language, since intermodality is conceived at the interstate level. Therefore, it often takes a long time to take the first steps towards intermodality, which would be widely accepted by transport users. This is the reason why in many less developed areas, instead of integrated passenger transport in urban areas, there is mutual competition and competition of different modes of transport, which have led to a segmented transport system. In order to overcome this problem, it is necessary to create a unique strategy for the establishment of intermodal transport and, accordingly, intermodal terminals, as important links in this system.

The mutual exchange of experiences of individual countries should contribute to greater support for transport networks of European cities and urban areas and increase the intermodality of different modes of transport. Creating an efficient transport network is necessary to form space for maximum use and to promote public transport in order to reduce travel by passenger cars.

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REFERENCES

[1] https://op.europa.eu/en/publication-detail/-/publication/1a970856-6d0d-4854-981d-5a2d6f83a7f4/language-en (30.08.2020.)

[2] http://www.rupprecht-consult.eu/uploads/tx_rupprecht/LINK_Guidance_Brochure.pdf (02.09.2020.)

[3] http://cabri-volga.org/DOC/EG4/TowardspassengerintermodalityEU-casestudies.pdf (02.09.2020.)

[4] M. Pitsiava-Latinopoulou and S. Basbas, “Passenger intermodal terminal stations: role and infrastructure”, WIT Transactions on The Built Environment, Vol 101, 2008, pp. 233-242; ISSN 1743-3509 (on-line), Urban Transport XIV, DOI: 10.2495/UT080231

[5] European Commission, White Paper on transport, Roadmap to a single European transport area — Towards a competitive and RESOURCE - EFFICIENT transport system”, Publications Office of the European Union, 2011, ISBN 978-92-79-18270-9, doi:10.2832/30955

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HISTORY, CURRENT STATUS AND TRENDS FOR FURTHER INTRODUCTION OF ELECTRIC BUSES IN THE CITIES OF EUROPA AND WORLD

Key Words:

E-bus

Development of E-bus subsystem

Public urban transport

Abstract

The electric bus (E-bus) is a new concept of environmentally friendly and energy-efficient bus subsystem of public urban transport, which is increasingly present in many cities around the world. The introduction of this type of bus has a steady upward trend and is a major alternative to conventionally powered buses. The paper presents a brief chronology of the most important events related to the application and introduction of electric buses around the world, the current situation in terms of the number of vehicles in operation, an overview of the electric bus market, and future directions of further implementation of this new concept in public transport systems, with special reference to Europe.

1. INTRODUCTION

The transport sector occupies an important place in meeting the needs of society in the transport of goods and passenger transport, but at the same time, it is a source of emissions of harmful gases and carbon dioxide as a result of burning fossil fuels. The use of fossil fuels is directly proportional to the country, region, or city's industrial and economic development [1]. According to Borowik, currently, 75% of the population in Europe lives in cities, which will lead to a further increase in carbon dioxide emissions and traffic-related pollution [2]. Trends in the increase of the city's population also affect the increase in the number of vehicles, which imposes the growing importance of the application of alternative propulsion in vehicles (electric vehicles, hydrogen, natural gas, etc.) and the use of renewable energy sources. In the transport sector, the activity of passenger transport is very important. The bus subsystem of public urban transport in cities is one of the most important segments of the city's urban life. The application of fully electric drive in buses for public urban transport should further reduce the level of emissions of harmful gases from traffic in cities, increase energy efficiency and contribute to the strategy of using zero-emission vehicles in cities, which is planned after 2050 [3,4]. The accelerated development of battery technology and charging systems has contributed to the electric bus concept since 2008 being increasingly present in many cities, primarily China, Europe, North and South America. It can be considered that the concept of the electric drive today has the greatest possibility and justification for use in buses used in the public transport system, given that the performance of electric buses in terms of operational requirements (autonomy, capacity, charging time) has reached such a level that can be a successful replacement for conventionally powered buses [5].

2. HISTORICAL OVERVIEW

The use of electricity to drive road vehicles has been a well-known concept since 1881 when Trouvé constructed the first electric road vehicle in France. The first commercial electric vehicle was Morris and Salom’s Electrobat from 1901, which was used as a taxi vehicle in New York City. It can be considered that this taxi was the first vehicle intended for the public transport of passengers [7]. The concept of an electric public city bus was first introduced in Frankfurt in 1969 when Mercedes-Benz introduced the first hybrid, diesel-electric test bus. Until 1979, trial tests and continuous improvements of the hybrid concept of propulsion in public transport buses lasted, and in 1979 a total of 13 standard city diesel-electric buses Mercedes-Benz OE 305, were on a five-year test in regular traffic [8].

In 1982, the German bus manufacturer MAN produced the MAN SL-E200 bus, which was exclusively electric, which can be considered the first model of a bus with fully electric drive. This type of bus towed a trailer with batteries on it Figure 1 [9].

Figure 1. MAN SL-E300

The application of this concept was unsustainable due to the extremely large mass of the vehicle, low autonomy of movement, as a consequence of the small capacity of the batteries (accumulators), long charging time, and the necessary replacement of batteries (accumulators) at the terminals. The introduction of hybrid-powered buses was the first phase of the application of electric propulsion. The first application of diesel-electric city buses in Japan began in 1991 when the manufacturer Hino delivered buses to eight cities. In the USA and Canada, there has been a significant use of diesel-electric buses since 1997, so that their number in 2010 was 6300, which made them leaders in the use of this type of bus [16]. In Europe, the significant introduction of hybrid buses has been recorded since 2006, when London procured 56 hybrid buses. Since then, other European cities have started introducing hybrid buses, so that in 2012, about 1191 buses were in operation [10].

The beginning of the use of fully electric buses, as a new concept in the system of public city transport, is considered to be August 28, 2006. year, when in Shanghai, China on line no. 11, started exploiting this concept of city buses [11]. Chinese bus manufacturer HIGER produced a standard city bus that used a supercapacitor to store electricity from manufacturer AOWEI (Figure 2). Recharging of the supercapacitor was performed at each station while the bus was standing. In this way, the autonomy of movement was limited to one inter distance (Figure 3).

Figure 2. E-bus Higer

Figure 3. E-bus line no.11 (Shanghai)

From then until today, the accelerated development of electricity storage technology using batteries and supercapacitors and the development of a fast-charging system has impacted that concept of the electric bus in the last few years to be in many cities all over the world.

2.1. Introduction of electric buses in China and Asia

China is a world leader in the production of electric buses and their implementation in many public urban transport systems. The demonstration of the operation of a fully electric bus in Beijing in 2008 during the Olympic Games opened a new chapter in the development of this drive concept. Already in 2010, there are fully electric buses on the Chinese market with a standard length of 12 meters, which can achieve autonomy of 250 ÷ 300 km, with a single charge. According to a report from 2017 by the IEA (Report – Global EV, Outlook 2017), there were about 345000 electric buses in use worldwide, of which 343500 vehicles or 99.5% were in use in China. Of that number, it is estimated that about 300000 are fully electric buses that use batteries as an electricity storage system [12]. The introduction of electric buses in Chinese cities is a state project, as one of the measures to reduce air pollution, especially in large cities: Beijing, Shanghai, Shenzhen, etc. The city of Shenzhen is the first city in the world to have 16500 electric buses in operation since 2018, which makes the bus subsystem of public city transport 100% "electrified". The plan to introduce electric buses in Beijing is to reach 10000 E-buses in 2020. In 2018, the city of Guangzhou procured 4810 electric buses [13]. Production volume of New Energy Buses, which is the official name in China for electric buses, which include a battery, hybrid plug-in, and fuel cells, reached a record number of 135305 vehicles in 2016. [14] The largest producers are companies: Yutong, BYD, Zhontong, Yinlong, whose percentage share in production for 2016 is 19%, 13%, 10%, 7%, respectively [14]. In 2018, the world's largest electric bus manufacturer, Yutong, sold 24,748 "New Energy Buses", of which 22744 were battery-powered fully electric buses [15].

India represents a large market for public city buses whose annual sales in 2017 are around 70000 buses of all types. In 2018, 932 electric buses were sold in this market and represent great potential in the Asian market [13]. Of other Asian countries and cities, there is greater use of electric buses in Singapore, where after a testing period conducted from November 2016 to May 2017 with an e-bus manufactured by BYD on three city lines, in 2019 the procurement of 60 BYD E-buses and 50 Volvo hybrid plug-in buses [13].

2.2. Introduction of electric buses in Europe

The beginning of the introduction of fully electric buses in Europe dates back to 2013, when in some cities: Rotterdam, Milan, Barcelona, Bremen, London, Copenhagen, Hamburg, etc., trial tests were performed, usually with one or two e-buses [16]. An important step in the greater use and affirmation of electric buses was the ZeEUS (Zero emission urban System) project, which was launched by the European Union in the period 2013/2017. years. The aim of the project was to test and consider the exploitation, environmental, economic, and social aspects of using the electric concept of city buses. 40 partners from different fields took part in the project [14]. In addition to the ZeEUS project as the most significant, many cities in Europe have launched their own projects to introduce electric buses: Amsterdam, Gothenburg, Berlin, Vienna, Sofia, Belgrade, which resulted in the official report of the ZeEUS project published in October 2017. in Europe, there were more than 800 electric buses in 90 cities, including fully electric, plug-in, and battery-powered trolleybuses. Increase in the number of electric buses in Europe by years for the period 2013/2017. year is shown in Figure 4 [17].

Of the total number of electric buses, 67% are fully electric buses that use batteries to store electricity, 2% are fully electric buses that use supercapacitors, 12% are hybrid with plug-in charging and 19% are trolleybuses that have batteries for autonomous movement [14]. The trend of increasing the number of fully electric buses continued in 2018 when 562 new battery buses were registered in the EU, which represented about 5% of annual sales of buses for PT in the EU [5].

Tenders for the procurement of new E-buses are started: Rome 200, Milan 150, Groningen 160, Wiesbaden 56, Venice 30, Berlin 30, Hamburg 30 [105]. Since

December 2019, the city of Nantes has started with the regular operation of 22 E-buses on a fully electric drive, 24.5 m long manufactured by Hess [5].

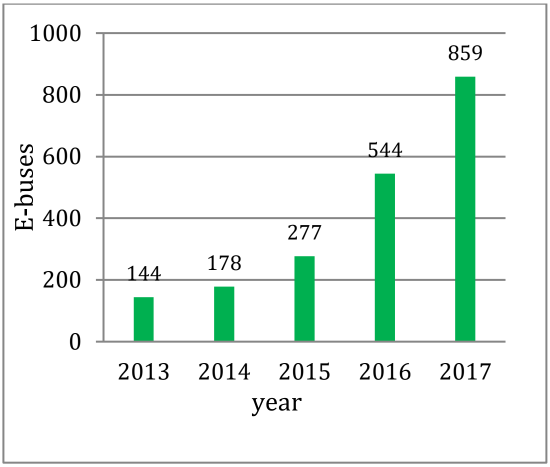

Figure 4. Number of E-buses in Europe

In Europe only until 2019 (as of September 30), 1123 new electric buses were registered [5]. In September 2018, the city of Moscow began regulating the operation of 15 fully electric buses. In 2019, the purchase of 285 electric buses from the manufacturers KAMAZ and GAZ was realized, which made Moscow one of the leading cities outside China in the number of electric buses. The trend of introducing electric buses in Moscow continued in 2020, and by the end of 2020, there were 600 E-buses on 24 city lines [18].

Since August 2020, the Norwegian city of Bergen has had 102 standard Yutong electric buses in regular operation. More than 150 fully electric buses have been in regular operation since July 2020 in Paris as well as in Gothenburg, where 145 electric buses from the Volvo manufacturer have been in operation since December 2020. From March 2021 In the EU, there are 2713 electric buses and 120 buses with fuel cell drive in operation [20].

2.3. Introduction of electric buses in North and South America

In the USA, the introduction of the first fully electric buses began in 2013 when 24 battery buses were first put into operation. These buses used are in intercity transport [21]. According to data from August 2018, published by the Calstart Institute-Pasadena, the total number of fully electric buses was 1650, of which 67 buses with a drive on fuel cells, and 1583 battery-electric buses. The largest number of 877 fully electric buses is registered in California, which makes 53% of the total number. There are 154 e-buses in operation in Washington state, 70 in Florida, 66 in Indiana, and 59 in Illinois. In Canada, the first test with a fully electric bus was conducted during 2013/2014. by STL (Societe de Transport de Laval). It should be noted that STM has had 51 hybrid buses in operation since 2016, accounting for 12% of the buses inventory. [23] In 2018, the city of Toronto conducted a special test with 10 electric buses from different manufacturers: BYD, Proterra, New Flier, and based on the test results, 20 electric buses were bought.

In South America, the first test with two fully electric buses, the Chinese manufacturer BYD was conducted in the company Transantiago-Santiago de Chile in November 2017. Based on the positive test results in November 2018, the procurement of 100 standard BYD electric buses was contracted. At the proposal of the Government of Chile, in order to introduce new ecological buses with zero emissions and replace buses with diesel fuel, it was adopted as a state strategy [5]. At the end of March 2021, 776 electric buses were in operation in Santiago de Chile, [20]. Electric buses are widely used in Bogota 351, Mexico City 337, Medenin 69 [20].

In Argentina, since July 2019, 12 E-buses by BYD and 6 by Zhongtong are in regular traffic in the city of Mendoza. South American cities: Buenos Aires, Panama City, San Jose, plan to purchase electric buses in the near future [5]. As of May 28, 2020, 20 electric buses by manufacturer BYD are in regular operation in the Uruguayan capital, Montevideo.

3. ELECTRIC BUS MARKET

Electric buses as a relatively new technology, have a tendency to constantly improve and strain primarily electricity storage systems (batteries, capacity up to 400 kWh for 12m E-bus and supercapacitors 40 kWh), chargers "slow" with electric power 60÷80 kW, "fast" with power 400÷600 kW), traction control system, optimization of energy consumption, reduction of empty vehicle weight.

At the moment, all the world's bus manufacturers have electric buses of different lengths in their production program: midi (8÷9 m), standard (11÷13 m), articulated (18÷19 m) and double-articulated. 24÷27 m) and they become part of the standard offers on the bus market (Figures 5,6,7) [5].

Figure 5. E-bus BYD 12m

Figure 6. E-bus Solaris Urbino 18m

Figure 7. E-bus Hess, 24m

According to ZeEUS E-bus report # 2 from October 2017, 32 manufacturers of electric buses and 8 manufacturers of equipment and systems for charging electricity were registered on the European market [14]. The most represented manufacturers of electric buses that are currently present on the European market are BYD, VDL, Solaris & bus, Volvo, Kamaz, GAZ, Yutong, Ebusco, Optare, Caetano, Skoda, Irizar, Van Hool. Leading manufacturers of equipment and systems for charging electric buses are ABB, Siemens, Shunk, Jema Energy, Bombardier Primove.

4. FUTURE TREND INTRODUCTION OF E-BUSES IN EUROPE

It is a very important Directive 94/2014 / EC which refers to the application of alternative fuels to commercial vehicles in the public sector for the countries of the European Union [25]. The states are obliged to implement the prescribed participation of "clean vehicles" (electric, hybrid, with combined natural gas propulsion-CNG) in the public urban transport system by 2025, ie 2030 in the cities, as shown in Table 1.

Table 1 Directive 2014/94 / EC, participation of "clean" buses in EU countries

EU country	Target year 2025 Participation "clean" buses [%]	Target year 2030 Participation "clean" buses [%]
Luxembourg	50%	75%
Sweden	50%	75%
Denmark	50%	75%
Germany	50%	75%
Netherlands	50%	75%
Austria	50%	75%
Belgium	50%	75%
Italy	50%	75%
Ireland	50%	75%
Spain	50%	75%
Cyprus	50%	75%
Malta	50%	75%
France	48%	71%
Lithuania	47%	70%
Finland	46%	69%
Czech Republic	46%	70%
Hungary	42%	63%
Portugal	40%	61%
Latvia	40%	60%
Slovakia	39%	58%
Bulgaria	39%	58%
Greece	38%	57%
Poland	37%	56%
Estonia	36%	53%
Slovenia	33%	50%
Croatia	32%	48%
Romania	29%	43%

The representation of electric buses in the total number of buses for public urban transport in the European Union, according to the estimate of the UITP from 2017, is shown in Figure 8 [17].

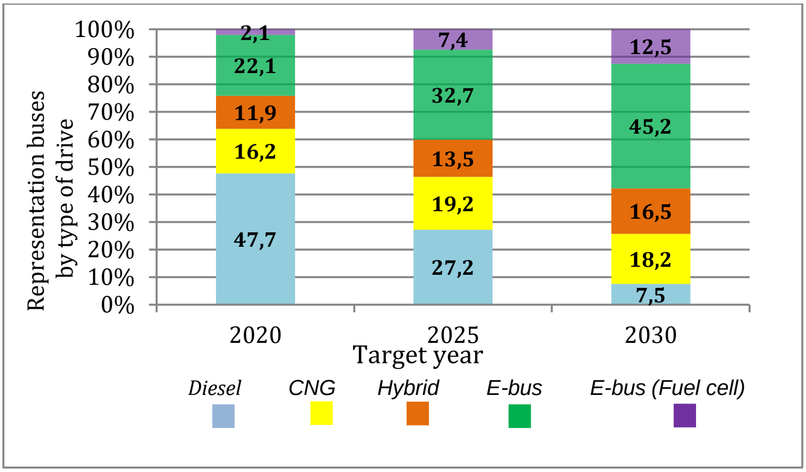

Figure 8. Representation of buses by type of drive

The forecast is that in 2025, the share of fully electric buses will be 40.1% and in 2030 it will reach 57.7%.

5. CONCLUSION

Based on the trends of increasing the number of electric buses in operation around the world, a large number of tender procedures around the world related to the purchase of electric buses, the growing supply on the market by almost all bus manufacturers, positive experiences in operation as well as legal regulations that prescribe the increasing participation of "clean" buses in the transport systems of cities, which is best seen in the example of EU member states (Directive 94/2014 / EC), it follows that in the coming years the presence of electric buses to be growing in the public transport systems of many cities in Europe and the world as the main alternative to conventional buses.

REFERENCES

[1] Werner Z.: *Alternative World Energy Outlook 2005 a possible path towards a sustainable future,* Conference ''The soul of the empire'', workshop 3: ''Mankind on a hot tin roof. Kyoto heretics braving the greenhouse effect'', Rimini, 28-30 October, 2005.

[2] Borowik, L., & Artur.: *Modernization of a trolleybus line system in Tychy as an example of eco-efficient initiative towards a sustainable transport system*. Journal of Cleaner Production, pp. 188-198, December 2015.

[3] EC 2011a - *European Commission White Paper, Road to a Single European Transport Area e Towards a Competitive and Resource Efficient Transport System*, Brussels :EC, 2832011 COM (2011) 144 Final, 2011.

[4] Clean Buses – *Experiences with Fuel and Technology Options*, Clean fleets,February 2014, http://www.clean-fleets.eu/fileadmin/files/Clean_Buses-Experiences_with_Fuel_and_Technology_Options.pdf

[5] Mišanović S.: Energetske i ekološke performanse autobusa na električni pogon u sistemu transporta putnika, doktorska disertacija, Fakultet inženjerskih nauka Univerziteta u Kragujevcu, 2021.

[6] Ehsani M.,Gao Y.,Gay S., Emadi A.: *Modern Electric,Hybrid Electric and Fuel Cell Vehicles-Fundamentals,Theory and Design*, CRC Press edition ISBN 0-8493-3154-4, 2004.

[7] Živanović Z., Nikolić Z.: *The Contribution and Prospects of the technical development on implementation of electric and hybrid vehicels*, (Book chapter 2). In:Stevic Z. (ed) *New generation of electric vehicles*, InTech, Rijeka 2012, pp. 29-66, ISBN 978-953-51-0893-1, http://dx.doi.org/10.5772/51770.

[8] Živanović Z., Nikolić Z.: *The Application of Electric Drive Technologies in City Buses*,(Book chapter 6). In:Stevic Z. (ed) *New generation of electric vehicles*, InTech, Rijeka 2012, pp. 165-203, ISBN 978-953-51-0893-1, http://dx.doi.org/10.5772/51770.

[9] Putz R.: *Options for fully electrified operation of urban bus line (EBSF Study)* - Landshut University of Applied Sciences, Brussels, 2012.

[10] Misanovic S.: *Exploitation and environmentally aspects of hybrid buses in European cities* International Congress Motor Vehicles & Motors 2012, Kragujevac, 3-5 October 2012, pp.280-288, ISBN 978-86-86663-91-7.

[11] http://www.aowei.com/en/program/applicationinfo-16.html, (last accessed on 21.01.2016).

[12] International Energy Agency: Global EV Outlook 2017, https://www.iea.org/publications/freepublications/publication/GlobalEVOutl ook 2017.pdf . (last accessed on 19.11.2018).

[13] https://www.sustainable-bus.com/electric-bus/electric-bus-public-transport-main-fleets-projects-around-world/ (last accessed on 16.04.2019).

[14] ZeEUS, *E-bus report #2, An updated overview of electric buses in Europe*, 2017.

[15] Yutong Confidential: *Yutong bus introduction for EU*, 2017.

[16] Zivanovic Z., Misanovic S.: Fully Electric Buses are Promising Technology in the Future, *International Congress “Motor Vehicles & Motors 2014”,* October 9th-10th, 2014, Kragujevac, Proceedings on CD, Introductory Lectures, MVM2014-IL8, pp. 81-106, ISBN 978-86-6335-010-6.

[17] Guida U.: *State of the Eurpean battery electrical buses,* US ZEB Conference 2018, 11-12 September 2018, Los Angeles.

[18] ГУП Мосгортранс: Электробус для Москвы, апрель 2020, (презентација у PPT).

[19] https://www.busworld.org/industry/industry-news/all (last accessed on 15.08.2020.).

[20] Bekkers H.: The Technology and market of E-bus,UITP E-bus trening Webinar, 21 January 2021.

[21] American Public Transportation Association. *2013 Public Transportation Vehicle Database.* August 2013.

[22] CALSTART, *A Survey of Zero Emission Buses Across America*, August 17th, 2018, Pasadena.

[23] http://www.stm.info/en/about/major_projects/bus-network-electrification/electric-bus. (last accessed on 22.04.2019.).

[24] https://www.sustainable-bus.com/electric-bus/byd-electric-buses-montevideo-uruguay-cutcsa/ (last accessed on 30.05.2020.).

[25] Directive 94/2014/EC: *On the deployment of alternative fuels infrastructure*, 22 October 2014, L 307/1.

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ENERGY ASPECT OF IMPROVING THE PUBLIC CITY PASSENGER TRANSPORT SYSTEM IN SARAJEVO

Key Words

Public city transport
Urban mobility
Green City
Smart city
Energy efficiency
Green economy

Abstract

In the last 5 years, several projects have been initiated in Sarajevo Canton that are focused on strengthening the identity of the city, promoting and implementing the concept of urban mobility, green and smart city. The issue of energy efficiency is included in all projects and from that aspect, among other things, the improvement of the public city passenger transport service is observed. This paper analyzes the state of public urban transport from the energy aspect, the savings that are achieved, the methodology for calculating savings and the effects that would be achieved through the implementation of planned projects for the development and reorganization of public urban passenger transport.

1. INTRODUCTION

Projects in the last 5 years in Sarajevo Canton are aimed at strengthening the identity of the city with the concept of urban mobility, green and smart city. To achieve this goal, a green economy transition approach is essential, involving the construction of low-carbon and resilient economies, and includes three categories of projects, reducing greenhouse gas emissions, increasing resilience to climate change and other environmental benefits (including improving resource efficiency, reducing local pollution, improving resilience and ecosystem restoration.

There are several transport systems on the network of lines in Sarajevo Canton that use different energy resources [1]. A significant number of vehicles have diesel engines.

Reliance on public urban transport, in the concept of urban mobility, is inevitable, so the issue of energy efficiency (EE) is very topical in the process of improving the public urban passenger transport service [4].

Given the fact that the state of the vehicle fleet changes over time, that new projects seek to propose more energy efficient systems and that for each city energy management is imperative, it is necessary to know the methodology for determining the savings achieved by specific measures and effects to be achieved. realization of planned projects of development and reorganization of public city passenger transport [2, 6]. In addition to the above, it is necessary to build a system for monitoring and verification of energy savings (SMiV) that contains Internet applications [3, 10].

2. RECENT AND EXISTING ACTIVITIES RELATING TO THE PUBLIC URBAN PASSENGER TRANSPORT SECTOR IN SARAJEVO CANTON

Existing and recent activities related to the public transport sector in Sarajevo energy efficiency:

- Feasibility study for the extension of the tram line from Ilidža to Hrasnica (2015)

- Green Cantonal Action Plan for Sarajevo (2019)

- Development of Sarajevo public transport and Sarajevo city roads, technical, economic, environmental and social analysis (2019-2020)

- Main project for overhaul of tram line (2018-2020)

- Sustainable Urban Mobility Plan ("SUMP") (published in September 2020).

The SUMP predicts that a total of € 379 million will need to be invested between 2021 and 2025 in order to achieve, inter alia, the following goal: reduce CO_2 emissions by 12% (or 57,505 tons of CO_2); increase the share of low-carbon public transport vehicles to 60% (currently to 30.7%); increase the number of public transport without engines by 200% (from 78 to 234); increase the coverage of the public transport system by 10%.

- Project “Development of public transport in order to increase mobility and reduce air pollution” in Sarajevo, Japan International Cooperation Agency (“JICA”) (2019-2021 / 2022)

- Technical and economic analysis for the introduction of an adaptive traffic management system along the tram corridor in Sarajevo (2021-2022)

Current issues and projects related to the energy aspect include the "Study of e-mobility in Bosnia and Herzegovina" which should assess the short and medium term market potential and readiness to introduce electric vehicles (EV) in selected cities, as well as the development and design of charging infrastructures in at least three selected cities and the installation and use of RES (solar photovoltaic systems) to charge electric vehicles on the road along at least one of the busiest highways. The study should include: Market study (macro) and policy; Assessment of investment in charging infrastructure; Assessment of potential economic benefits; Market (micro) and immediate opportunities of the private and public sector; Impact on the energy sector; Stakeholder Awareness Raising and the e-Mobility Plan.

3. METHODOLOGY FOR DETERMINING ENERGY SAVINGS IN PUBLIC TRANSPORT OF PASSENGERS

Energy efficiencies for the transport sector, to which public urban transport also belongs, cover energy consumption in passenger and freight road, rail and inland waterway transport. To determine energy savings in public transport, it is necessary to define energy efficiency indicators and the calculation procedure [1].

The European Commission has developed recommendations for two types of approaches to data collection and savings budgeting. The top-down approach is based on national statistics, and the bottom-up approach is linked to a series of equations used to directly calculate energy savings for each implemented project.

3.1. Energy efficiency indicators in public transport

Energy efficiency indicators for the transport sector cover petrol and diesel consumption together. It is also possible to separate the consumption of these two fuels and calculate the indicators separately for each of them, in order to take into account the effect of fuel change [6]. Total energy savings in the sector are calculated by summing the realized savings by individual types of vehicles and by individual forms of transport. This does not take into account the negative savings that occur when the indicator in the reporting year is higher than the indicator in the reference year [9].

The use of preferred energy efficiency indicators gives more accurate results, which are closer to the actual technical energy savings. Minimum indicators are likely to underestimate savings because they include the impact of non-energy efficiency parameters.

3.2. Determining energy savings when replacing existing and procuring new vehicles in public transport

Measure EE, replacement of existing and procurement of new, more efficient vehicles (T1), refers to the calculation of energy savings in case of replacement or procurement of new vehicles in local government units, government agencies and companies. Unit energy savings are defined as the product of the difference between the average fuel consumption per unit length (100 km) before and after the implementation of the measure in question and the average annual distance traveled by the vehicle [11].

3.2.1. Calculation method

In this measure, which provides a way to determine the savings when replacing or buying new more energy efficient vehicles, two typical cases are distinguished:

a) Replacing old vehicles with new, more efficient vehicles.

In this case, the calculation is based on the difference in fuel consumption of old and new vehicles, multiplied by the average annual mileage and the number of cars replaced. An example of this case is the replacement of old petrol or diesel vehicles with new vehicles that use petrol, diesel, LPG, CNG, electricity or hybrid drive. In the case of vehicle modifications, the budget is identical.

b) Procurement of new more energy efficient vehicles.

In this case, the savings are calculated based on the difference between the unit fuel consumption of the reference vehicle and the new vehicle, multiplied by the average annual mileage and the number of cars planned for purchase. An example of this case is the purchase of new vehicles that use gasoline, diesel, LPG, CNG, electricity or hybrid propulsion.

The calculation of energy savings for both cases is given by the expression:

$$FES = \frac{FC_{prije} \cdot f_{C_{prije}} - FC_{poslije} \cdot f_{C_{poslije}}}{100} \cdot D \cdot n \qquad (3)$$

Where is:

FES (kWh/year) - Total annual energy savings

FC_{prije} (l/100 km ili kg/100 km) - Fuel consumption of old vehicles

$FC_{poslije}$ (l/100 km ili kg/100 km) - Fuel consumption of new vehicles

$f_{C_{prije}}$ (kWh/l ili kWh/kg) - Fuel consumption to energy consumption conversion factor of old vehicles

$f_{C_{poslije}}$ (kWh/l ili kWh/kg) - Fuel consumption to energy consumption conversion factor of new vehicles

D (km/god) - The average distance a vehicle travels per year

n - Number of replaced or new vehicles within the EE project.

3.2.2. Input data

Taking into account the relation for the calculation of energy savings, it is necessary to have information on the average fuel consumption of old and new vehicles, as well as their average annual mileage. In the case of purchasing a new more energy efficient vehicle, it is necessary to have information about the fuel, as well as its average consumption.

3.2.3. Reference values

It is recommended to always use the actual consumption values before and after the implementation of the measure, but in case of lack of some data it is necessary to determine the reference values [11, 9].

1. Fuel consumption and conversion factor

In the case of the analysis of the measure of procurement of new more energy efficient vehicles, for values FC_{prije} i $f_{C_{prije}}$ reference values are taken depending on the type of vehicle. When purchasing new electric or hybrid vehicles, the data on fuel consumption for a petrol car, for FC_{prije} i $f_{C_{prije}}$ respectively.

2. The average distance a vehicle travels per year

Reference values for the average distance traveled by the vehicle during the year for Bus is D=54.500 (km/god).

3.2.4. Emission reduction CO_2

The annual reduction of CO_2 emissions as a consequence of the implementation of the measure of replacement of existing or purchase of new vehicles can be determined by the term [5].

$$E_{CO_2} = \frac{e_{prije} \cdot FC_{prije} \cdot f_{C_{prije}} - e_{poslije} \cdot FC_{poslije} \cdot f_{C_{poslije}}}{100 \cdot 1000} \cdot D \qquad (4)$$

Where is: E_{CO_2} (t/god) - Emission reduction CO_2

e_{prije} =0,267 (kgCO_2/kWh) - Emission factor for fuel consumed by an old vehicle

$e_{poslije} = 0{,}202$ (kgCO_2/kWh) - Emission factor for fuel consumed by a new vehicle

3.2.5. Lifetime measures

The lifetime of the measure of replacement or purchase of new more efficient vehicles is 8 years (100,000 km).

4. ENERGY SAVINGS, CO_2 EMISSIONS AND ENERGY COSTS IN PUBLIC PASSENGER TRANSPORT IN SARAJEVO

Energy efficiency in public urban passenger transport in Sarajevo could be improved if diesel vehicles were replaced by Compressed Natural Gas - CNG vehicles.

The hypothesis was tested using the previously described methodology for the case of replacing old vehicles with new, more efficient vehicles in two ways:

- based on the actual values on the structure of the vehicle fleet of the passenger transport company (KJKP GRAS) and fuel consumption for 2020.
- based on reference values.

1. Actual fuel consumption values (Diesel→CNG)

Diesel fuel consumed in 2020. is 1.310.151,71 (litre)

D =54.500 (km/year) - The average distance a vehicle travels per year

$n = 80$ (vehicles) Diesel Bus+Minibus replaced or new vehicles

FC_{prije} =40 (l/100 km) - Fuel consumption of old vehicles - Diesel

$FC_{poslije}$ =36 (kg/100 km) - Fuel consumption of new vehicles- CNG

$f_{C_{prije}} = 10{,}03$ (kWh/l)-Fuel consumption to diesel consumption conversion factor

$f_{C_{poslije}} = 13{,}30$ (kWh/kg)-Fuel consumption to CNG consumption conversion factor

According to expression (3), the total annual energy savings for 80 vehicles were calculated FES

$$FES = \frac{(40 \cdot 10{,}03 - 36 \cdot 13{,}3)}{100} \cdot 54500 \cdot 80 = -2.912.480 \text{ (kWh/year)}$$

Savings per vehicle FES_1 =-36.406(kWh/year).

2. Fuel consumption reference values

D =54.500 (km/year) - The average distance a vehicle travels per year

$n = 80$ (vehicles) - Number of replaced or new vehicles within the EE project

FC_{prije} =27,2 (l/100 km) - Fuel consumption of old vehicles - Diesel

$FC_{poslije}$ =25,4 (kg/100 km) - Fuel consumption of new vehicles- CNG

$f_{C_{prije}} = 10{,}03$ (kWh/l)-Fuel consumption to diesel consumption conversion factor

$f_{C_{poslije}} = 13{,}30$ (kWh/kg)-Fuel consumption to CNG consumption conversion factor

Total annual energy savings for 80 vehicles according to expression (3) FES

$$FES = \frac{(27{,}2 \cdot 10{,}03 - 25{,}4 \cdot 13{,}3)}{100} \cdot 54500 \cdot 80 = -2.834.174 \text{ (kWh/year)}$$

Savings per vehicle FES_1 =-35.427,2(kWh/year).

Annual emission reduction CO_2 when replacing existing vehicles with new ones it is determined via formula (4) for input values:

e_{prije} =0,267 ($kgCO_2$/kWh) - Emission factor for diesel fuel

$e_{poslije}$=0,202 ($kgCO_2$/kWh) - CNG emission factor

For one vehicle annual emission reduction CO_2 is

$$E_{CO_2} = \frac{0{,}267 \cdot 27{,}2 \cdot 10{,}03 - 0{,}202 \cdot 25{,}4 \cdot 13{,}3}{100 \cdot 1000} \cdot 54500 = 3{,}846379 \text{ (t/year)}$$

For 80 vehicles annual is $E_{CO_2} = 80 \cdot 3{,}846379$ =307,7103 (t/year).

Annual energy procurement costs [7], [8]

$c_{dizel} = 2{,}10\ (KM/l)$ - price of diesel fuel; $c_{CNG} = 1{,}30\ (KM/l)$ - price CNG

For one vehicle, the difference in the cost of purchasing energy is

$\Delta C_1 = Cprije - Cposlije$ (KM/year) , where is:

$Cprije = FC_{prije} \cdot c_{dizel} \cdot \mathrm{D}$ (KM/year) $-$ $diesel\ procurement\ costs$;

$$Cposlije = FC_{poslije} \cdot \mathrm{c}_{CNG} \cdot \mathrm{D}\ (\mathrm{KM/year}) - CNG\ procurement\ costs$$

$$\Delta C_1 = \frac{FC_{prije} \cdot \mathrm{c}_{dizel} - FC_{poslije} \cdot \mathrm{c}_{CNG}}{100} \cdot \mathrm{D} = 13.134{,}50\ (\mathrm{KM/year})$$

For 80 vehicles annual is $\Delta C = \Delta C_1 \cdot n = 13.134{,}50 \cdot 80 = 1.050.760{,}00\ (\mathrm{KM/year})$.

Conclusion of the savings analysis: From the energy aspect, the variant of transport with diesel vehicles is more favorable, and from the aspect of CO2 emissions and energy costs, the variant with CNG fuel is more favorable.

5. CONCLUSION

Based on the conducted analysis of the benefits of fleet replacement in public passenger transport, it can be concluded that energy savings, CO_2 emissions and energy costs do not have to be on the same side, favorable or unfavorable.

Special attention should be paid to ensuring that investments are on the path of low emissions and environmental impact. For the same transport work of one or more vehicles, it is more favorable that there are energy savings when purchasing vehicles. Energy costs should not carry the greatest weight when choosing a supplier in the procurement process.

Consultants should take these considerations into account in project preparation and gather relevant data in order to select the more favorable option.

REFERENCES

[1] Mahanović, M. "Planiranje ponude usluga u gradskom prometu putnika." Fakultet za saobraćaj i komunikacije Sarajevo (2011).

[2] Kosovac, Amel & Berković, Mirza. (2016). Annex Research of Methods the Measuring and Improving Energy Efficiency of Axial Tunnel Ventilation. Suvremeni Promet - Modern Traffic. 212-221.

[3] Ezgeta,D.,Ezgeta,I.,Jozak,M.: Holistički pristup razvoju ITS-a u prostornom planiranju, Suvremeni promet, Vol 5-6, pp. 344-350, rujan,2014.Akcioni plan za energijsku efikasnost u Bosni i Hercegovini za period 2016–2018., Službene novine BiH, broj 40/18

[4] Mehanović, Mustafa, and Nermin Palić. "A model of managing the urban mobility planning process/model upravljanja procesom planiranja urbane mobilnosti." EMC REVIEW-ČASOPIS ZA EKONOMIJU 16.2 (2018).

[5] Mahanović, M. "Ecological Aspects of Optimizing the Movement of Vehicles in Road Network." Suvremeni Promet-Modern Traffic (2017)

[6] Mehanović, M. "„Planiranje u saobraćaju, prevozu i komunikacijama "." Faculty of Traffic and Communications, University of Sarajevo (2017).

[7] Mehanovic, Mustafa. "Financing Public Transport Is an Important Dimension of Sustainable Urban Mobility: The Model for Determining the Prices of

Passenger Transport Services." Journal Of Advanced Research in Engineering& Management (IJAREM) ISSN: 2456-2033.

[8] Mehanović, M. "Assignments and examples from theory and practice in public transport of passengers." Faculty of Transport and Communication, Sarajevo (2005).

[9] Direktive 2006/32/EZ, 2010/31/EU, 2012/27/EU

[10] Akcioni plan za energijsku efikasnost u Federaciji Bosne i Hercegovine za period 2019-2021 – EEAPF**,** „Službene novine FBiH“, broj 11/21

[11] Pravilnik o informacionom sistemu energijske efikasnosti FBiH, 2019.

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OVERVIEW OF ELEMENTS OF ACCESSIBILITY ON RAILWAY TRANSPORT FACILITIES AFTER THE PERFORMED WORKS FROM ASPECTS OF PERSONS IN WHEELCHAIRS

Key Words
Cross checking
Reconstruction
Railway
Accessibility

Abstract

Modernization and reconstruction of railways include measures that require the application of standards in both design and execution of works. The obligation to adhere to the application of both domestic and foreign standards, instructions, and regulations is defined by the law on construction. Although the project documentation also performs the necessary control and approval of the facilities that need to be reconstructed or modernized, it happens that the constructed facilities do not meet the needs of all users or are not constructed adequately. This paper includes examples of two facilities: the Belgrade Centre railway station and the Rakovica - Resnik railway section. The paper presents the elements of accessibility, with the observed advantages and disadvantages, on the facilities and planned railway traffic services after the performed works from the aspect of persons in wheelchairs.

1. INTRODUCTION

Although significant progress has been made in the development of transport infrastructure for many years, there are still obstacles for all users of the transport service that do not allow full access [1]. Whether it is road, rail, water or air transport, attempts are being made to implement similar measures not only on infrastructure, to which it is necessary to provide adequate access, but also on the arrangement of adequate vehicles. With such a universal approach, it is possible to provide better service to all transport users.

The improvement of the railway infrastructure in the Republic of Serbia, after a long period of inability to invest in the regular maintenance of the railway, is increasingly gaining another more favorable situation. Special attention in railway traffic is increasingly paid to the accessibility of facilities and the service provided to persons with reduced mobility, which includes persons with disabilities.

This paper presents certain problems that people in wheelchairs may face in the realization of railway transport on the reconstructed parts of railways and stations.

2. LITERATURE REVIEW

Responsibility and access of the whole society can have the impact of better living conditions, which enables equality of persons with disabilities in all aspects of social needs [2]. Although this document was published twenty-three years ago, the principles set are still relevant today and a lot of effort and understanding is needed to establish them.

Solving the problem of people with disabilities in wheelchairs and access to railway stations was done by physical arrangement and enabling accessibility. Some research on the level of train accessibility and opportunities for barrier-free travel are analyzed per regions in the Czech Republic, after certain interventions on infrastructure as well as comparisons of the situation with other countries [3]. Based on the observed accessibility criteria, a database of urban railway systems and their assessment by continents for people in wheelchairs was created [4]. The conclusion of this document is that such studies can contribute to indications for improving the accessibility of railway systems. One of the regular ways of evaluating transport systems is the assessment of user satisfaction with the level of quality and accessibility. In [5] it was found that on the Danish Railways as an important influence on overall travel satisfaction that accessibility is very important.

Numerous literature in this area indicates that it is necessary to observe the personal opinion of railway users in order to make certain improvements, whether it is infrastructure or type of service.

3. FUNCTIONAL SPACE OF RAILWAY STATIONS AND HALTS

In the area of the station or stop where the reception-dispatch of passengers is performed, it is necessary to provide safe access, easy navigation and movement in the area with good connections and orientation that such a facility requires. It is necessary to bring and take the passenger from the area of the official place in the best and shortest way, and in the area of the station or stop it is necessary to provide him with insight and give all the information about the station contents [6] - [7].

4. ASSESSMENT OF THE FUNCTIONAL SPACE OF RAILWAY STATIONS AND STOPS IN THE PART OF THE BELGRADE RAILWAY JUNCTION

In order to review the performed works, their accessibility and usability, the reconstructed sections of the railway and the station in the Belgrade railway junction were selected, namely the section Rakovica-Resnik and the station Belgrade Center.

4.1. Rakovica - Resnik railway section

There are two stations and two stops on this reconstructed section. Passengers are received and dispatched at the observed stations and halts.

Rakovica station

Access to the platforms is done through roads and underpasses that lead to the platform. As part of the reconstruction that was carried out, the access roads were not treated, so it is not possible for people with disabilities to reach the platform because the existing stairs are not adapted, Figure 1-2. For access to the platforms for people in wheelchairs, mobile platforms that are not in function have been set up, Figure 3. The platforms that have been reconstructed have been placed at a height of 0.55 m, through which it is possible to enter in the level of new railway passenger vehicles without hindrance, Figure 4. There is no parking space for people with disabilities in the station area.

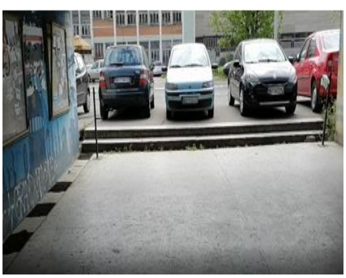

Figure 1 . Access by street

Figure 2 . Access by street

Figure 3. Access to platforms

Figure 4. Platforms

Knezevac halt

Access to this halt exists on both sides, and the platform is reached with a footbridge, Figure 5. Arrival by footbridge is not possible for people in wheelchairs because there is no elevator, Figure 5. The reconstructed platform was placed at a height of 0.55 m, through which unhindered entry into new railway passenger vehicles was enabled. In the stop there is no arranged parking space for people with disabilities.

Figure 5. Access to the platform and platform

Kijevo halt

Access to this halt exists on both sides, and the platform is reached via pedestrian and road roads. On the one hand, the slope of the access ramp enables independent movement of persons in wheelchairs, Figure 6, and on the other hand, independent access of persons in wheelchairs is not possible, Figure 7. There is no parking space for people with disabilities in the stop.

Figure 6. Access to the platform

Figure 7. Access to the platform

Resnik station

Rakovica station is open for receiving and dispatching passengers and goods. Reconstructed capacities for passengers and platforms were accessed via local roads and footpaths, (Figure 8-9). The first and third platforms have been reconstructed to a height of 0.55 meters, which enables wheelchair access to level all new passenger railway vehicles. Direct independent arrival of persons in wheelchairs is possible only on the first platform, (Figure 10). Access to the third platform can be done only through underpasses and mobile platforms that are not in function, (Figure 11). Another platform on which it is possible to receive a passenger train due to its height is not possible for people in wheelchairs to enter. The width of the second platform does not provide sufficient safety for the movement of all passengers when there are passengers in wheelchairs on it. There is a parking space for access for people with disabilities.

Figure 8. Access to the underpass, platform and parking lot

Figure 9. Access to the underpass from the street

Figure 10. Access to the platform

Figure 11. Access to the platform from the underpass with movable platforms

4.2. Belgrade center station

The Belgrade Center station is the largest passenger station in the Belgrade railway junction. Arrival and departure of passengers at the railway station is possible through city and taxi transport and private cars from access roads and pedestrian paths. Access to station capacities and tracks is realized through stairs and elevators. The height of the access sidewalks, although done almost level, does not allow independent safe movement of persons in wheelchairs, (Figure 12-13). The built-in elevator construction enables unhindered movement from the access plateau to the platform for people in wheelchairs, (Figure 14). For the reception of passengers who cannot move independently or a person with a disability, there are also stationary wheelchairs, (Figure 15). In the area of the Belgrade Center station, there is access to the station ticket office from the platform via a mobile platform that is not able to transport a person in a wheelchair, (Figure 16). Access to platforms in all vehicles that cannot be entered in the level is possible only from the platform (closest to the exit) by means of a movable vertical ramp for wheelchairs, (Figure

16). Arrival from one platform to another in the current state is not possible between all platforms and it is done exclusively through the underpass. Access to platforms where there are sloping ramps is not possible due to the large slope that cannot be overcome by people in wheelchairs, (Figure 17).There is a parking space for access for people with disabilities.

Figure 12. Access to the pedestrian road next to the station

Figure 13. Curb on the pedestrian road next to the station

Figure 14. Access elevator construction towards the platforms

Figure 15. Station service for transportation of a person in a wheelchair

Figure 16. Station service for entering railway vehicles and moving ramp for going to the ticket office

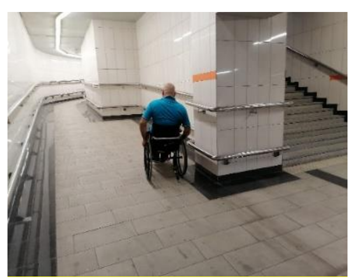

Figure 17. Sloping vertical ramp to the platform

5. CONCLUSION

In various activities carried out by associations of persons with disabilities at the national level, the Republic of Serbia, are not always able to independently achieve the desired results. The results of the research on the line Rakovica - Resnik indicate: 1. partial solution of platform and track capacities in the station Rakovica and the Kneževac stop did not provide accessibility of the complex, 2. access pedestrian paths on one side in the Kijevo halt were not built at an adequate slope, 3. in the station Resnik direct access without problems is provided only on the 1st. platform. The results of the research at the Belgrade Center station indicate to us: 1. Access pedestrian paths on roads and platforms do not enable independent movement of persons in wheelchairs, 2. Access to all station facilities is not possible. The general conclusion for the line Rakovica - Resnik and the station Belgrade is that despite the great effort in arranging accessibility, access to all facilities and independent access to the platform for people in wheelchairs is not provided. Another important note is that instead of installing movable platforms for the movement of persons in wheelchairs, it can only be replaced by an elevator construction that allows all other persons with reduced mobility to move freely. Although there are many positive solutions for people with disabilities, the example of the city of Vienna with the latest solutions could be taken as an example in the entire Republic of Serbia. As the first next step, it is considered that partial observation and solution of railway lines or stations cannot bring significant results and improvements, but this must be observed on the entire railway network and expanded in interaction with other modes of transport. As the second next step is to present this problem of insufficient technical knowledge of associations of persons with disabilities, they must have the support of the wider professional (technical) public to solve individual problems in performing works and educating supervisory bodies on construction sites.

REFERENCES

[1] "Improving Transport for the People with Mobility Handicaps," European Conference of Ministers of Transport, 1999.

[2] "The Disability Concept of The Austrian Federal Government", Federal Ministry for Labor and Social Affairs, Section IV, 1998

[3] J. Matuška, "Railway system accessibility evaluation for wheelchair users: case study in the Czech Republic", Transport, Volume 32 (1): pp 32–43, 2017.

[4] A.F. Ferreira, A.D. Leite, L.F. Pereira, et al., Wheelchair accessibility of urban rail systems: Some preliminary findings of a global overview, IATSS Research, https://doi.org/10.1016/j.iatssr.2021.01.003

[5] M. Brons, M. Givoni, P. Rietveld, "Access to railway stations and its potential in increasing rail use", Transportation Research Part A 43, pp 136–149, 2009.

[6] UIC 10181 (User information in Railway Stations), https://uic.org/passenger/passenger-railway-stations/

[7] UIC 140 (Eurostations - accessibility to stations in Europe), https://uic.org/passenger/passenger-railway-stations/

[8] COMMISSION REGULATION (EU) No 1300/2014 on the technical specifications for interoperability relating to accessibility of the Union's rail system for persons with disabilities and persons with reduced mobility

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FEASIBILITY OF CROSS-BORDER MARITIME SERVICE BETWEEN KOPER AND TRIESTE

Key Words

Sustainable mobility

Maritime passenger transport

Public transport

Cross-border

Feasibility

Abstract

Maritime traffic usually involves the transport of large quantities of cargo over long distances. Under such circumstances, maritime transport achieves the highest efficiency. Sometimes, however, it is indispensable or simply useful for shorter distances and for the carriage of passengers.

In some cities, passenger transport by ship is an integral part of public transport. In fact, some 420 million passengers use regular maritime services in the EU; most of these journeys are made within territorial waters.

In this paper, the authors analyze the possibility of introducing a public maritime transport service between two neighboring cities located in two different EU Member States, namely Koper in Slovenia and Trieste in Italy. Although both cities are located in the EU, this is considered an international voyage and as such is subject to strict regulations imposed by International Maritime Organization, which consequently increases capital, operational and travel costs.

1. INTRODUCTION

Transport contributes to European competitiveness and to economic, social and territorial cohesion. Well-developed cross-border transport links are essential for regional cooperation and competitiveness and for promoting the development of small businesses in border areas.

The European Union (EU) wants to improve the quality, safety and environmental performance of transport. One of the ways in which it intends to achieve this is by introducing more sustainable forms of transport for goods and people, for example maritime transport.

Passenger transport by sea in the EU decreased between 2008 and 2014 and then increased steadily and intensively until 2019, when almost 420 million passengers boarded ships [1]. As maritime passenger transport takes place mainly within the territorial waters of each country (63%) and to a lesser extent between EU Member States, virtually every passenger in the EU is statistically recorded twice, firstly when embarking and secondly when disembarking.

This paper presents the demand and feasibility analysis of a cross-border maritime link between Slovenia and Italy, more specifically between the cities of Koper and Trieste. The paper has several objectives: (a) an analysis of the existing network and organization of public passenger transport in both areas, including a review of studies already carried out on cross-border public transport links between Italy and Slovenia, (b) an analysis of demand of the local population for the cross-border maritime link, (c) the selection of a suitable vessel and determination of sea route in accordance to navigation rules, and (d) the estimation of time requirement and costs of indicated sea connection.

2. THE SNAPSHOT OF PUBLIC TRANSPORT IN THE REGION

Slovenia and Italy are two very different countries that share the border and the shores of the North Adriatic.

Slovenia is a small country with a short coastline of only 46 kilometers. Although there have been attempts to connect coastal towns to the sea line, these attempts have mostly not been very successful. Nevertheless, the Interreg Crossmoby project established a free shipping service in Slovenian territorial waters in the summer of 2020. In the summer of 2021 the same service was offered for a symbolic payment to skip the abuses from the year before. Theoretically, there is also a sea Uber in Slovenia called Wayv [2].

With a population of about 27,000, Koper is the largest city on the Slovenian coast. It is a port city whose cargo port is one of the most important in Northern Adriatic; in passenger traffic, however, it plays a minor role.

Koper has a well-organized and subsidized public transport system and is well connected to the other coastal cities. However, connections to the villages in the hinterland, where another 25,000 people live, are rather poor, so that private transport often has to be used even for short distances.

There are about 4,000 parking spaces in Koper, most of which can be used for a fee of about EUR 1 per hour (summary from [3]).

On the other hand, Italy is one of the EU countries with the highest number of ferry passengers in Europe: more than 80 million in 2019. The ferries, which are designed either for passengers only or also for vehicles, operate daily throughout the country. Passenger-only ferries have been operating near Slovenia, from Trieste to Muggia, for about 20 years. Although there is a dense and frequent network of bus connections on this route [4], there are also 10 boat connections in each direction per day on weekdays and 6 on weekends [5]. The boats that provide this service have a capacity of 200 to 300 passengers and the trip takes about half an hour, less than by bus, while the price of a single ticket is twice as much as by bus ([4], [5]). However, it should be noted that Trieste is a large city with more than 200,000 inhabitants, which creates a great demand for public transport. About 10% of the population of Trieste spends a lot of time on public transport every day, on average 49 minutes, half of them even more than two hours. About 26% of the population of Trieste uses public transport for trips longer than 12 km in one direction. Almost half of the users have to change the means of transport at least once in one direction, while 15% of them have to change at least twice (summary from [6]).

The two countries, more precisely the two cities of Koper and Trieste, are currently not connected by sea, at least not in the form of public transport. Instead, they are connected by 9 regular bus services per day; the number of busses decreases on weekends.. A single ticket costs EUR 3.30 and the journey takes between 45 and 65 minutes [7]. In the summer season there are 2 Flixbus connections per day, in other periods less. These are faster, but also much more expensive than the regular busses [8].

It is estimated that about 5,000 migrants travel from the Slovenian coast to Trieste every day [9]. Italy is traditionally a shopping destination for Slovenians. Trieste provides work for some Slovenian workers, either as formal regulated employment or as unregistered help in households. Finally, University of Trieste is also attractive to students from the region, who prefer Trieste to Ljubljana or Maribor. There are more than 16,000 full-time equivalent students at the University, of which about 9% are foreigners [10]. Moreover, the two cities are also tourist destinations and both cruise passengers and guests from the countryside might want to visit the neighboring country.

3. THE ANALYSIS OF PUBLIC OPINION

In order to determine the attitude of the locals towards the possible introduction of a maritime link between Koper and Trieste, we distributed the survey information to local citizens and Italian associations on the Slovenian coast.

The questionnaire, which consisted of 9 topic-specific questions and 2 demographic questions, was posted on the web platform ensuring anonymity of respondents and was open for 7 weeks in July and August 2021.

There were 398 unique clicks on the survey link, of which 128 (32%) expressed interest in the topic. The main conclusion from the survey is that the demand for a maritime connection between Koper and Trieste is low; in fact, currently only 4% of respondents use public transport to travel to Trieste.

The majority of respondents travel to Trieste occasionally (43% rarely and 26% at least once a month) and 30% of respondents travel to Trieste several times a week (including weekends). Although the majority of respondents travel to Trieste alone (probably for professional reasons), they would mainly use the boat to travel in pairs or even in groups (82%). Moreover, 57% believe that they would use the service more intensively during the summer season. This suggests that respondents would likely use the boat service for occasional leisure trips to Trieste, rather than daily. In fact, only 9% indicated that they would use the ship to travel to work and 3% to reach the university; they would travel less during summer time.

The majority of respondents, 58%, would be willing to pay EUR 5 for a one-way ticket and almost a quarter of respondents, 24%, would be interested in buying a package of ten tickets at a price of EUR 45. Some respondents would be willing to pay even more.

Half of the respondents would accept a 60-minute journey (52%), but the other half would expect a shorter journey, mainly between 20 and 30 minutes or at least not longer than by bus.

4. THE SEA ROUTE BETWEEN KOPER AND TRIESTE

The shortest sea distance between the cities of Koper and Trieste is only 6.5 miles (12 km) [11]. However, if we take into account the navigation rules, especially Traffic Separation Scheme, this distance increases to 11 and 16 miles, respectively, as can be seen in Figure 1.

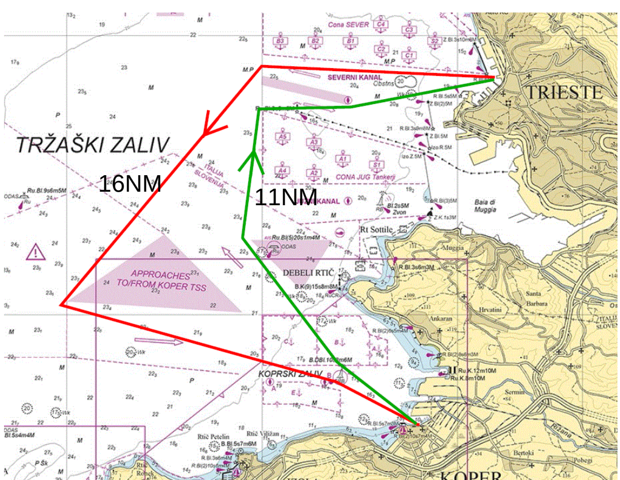

Figure 1. Navigation routes from Koper to Trieste and vice versa

In addition, for safety reasons, ships must navigate at a maximum speed of 6 knots when arriving at the port aquatorium. In Koper this applies to a distance of 2 miles from the pier, and a similar distance is used in Trieste. This means that it takes 20 minutes to cover this distance, regardless of the maximum or optimum cruising speed of the vessel.

The following table shows the time required to navigate from Koper to Trieste and back at different speeds.

Table 1. Time requirements to cover the sea distance from Koper to Trieste and back at different cruising speeds while taking into account mandatory slow speeding

Cruising speed [knots]	Koper-Trieste [min]	Trieste Koper [min]
14	59	80
16	54	73
18	50	67
20	47	62
22	45	58

5. THE COST CALCULATION FOR A SELECTED SHIP

A voyage between two ports not located in the same Member State or a voyage from a port in a Member State to a port outside the EU and vice versa is considered an international voyage. Although the route from Koper to Trieste is short, it is an international voyage. This means that the ship and her crew must comply with the requirements of International Maritime Organization (IMO) for passenger ships on international voyages. The requirements of SOLAS (International Convention for the Safety of Life at Sea), MARPOL (International Convention for the Prevention of Pollution from Ships), STCW (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers), LL (International Convention on Load Lines) and some other conventions must be taken into account.. These requirements mainly concern construction materials (ships must be built of steel or equivalent in terms of fire resistance), safety equipment (number of lifeboats, life rafts and safety vests, and communication equipment) and a minimum number of adequately trained crew members. Consequently, the costs increase.

Like other tangible assets, passenger ships lose value over time, but their lifespan can be very long; ferries in operation for 40 or more years are not uncommon. Their lifespan depends on the size of the vessel, the shape of the hull, actual use, maintenance regime, etc.

We have done a cost calculation on a used vessel that meets IMO requirements for international voyages. It is an aluminum vessel built in 1999 with a length of about 20.2 meters and a capacity of 145 passengers. The vessel is powered by two 602 kW engines capable of reaching a speed of 18 knots and costs around EUR 850,000 [12]. The initial price increases if the ship is debt financed.

Ships can only be used on international voyages if they are insured. The insurance of passenger ships is special because, in addition to the ship (hull and machinery) and its equipment and fittings, the crew and passengers must also be insured under general liability insurance. The factors that affect the insurance premium can be the value of the vessel, the length of the vessel, the age and category of the vessel, the type and size of machinery, the area of operation, previous claims made by the owner, etc. Together with the costs for maintenance and certification, these costs would amount to at least 60 to 65,000 EUR per year.

A vessel of such capacity would require at least 5 crew members. In Slovenia, their total monthly remuneration would be around EUR 20,000 gross per month or around EUR 250,000 per year.

The cost of consumables, including lubricants, hygiene products, crew supplies, and ticketing can be estimated at around 15 to 20,000 EUR per year.

All of the above costs are considered fixed costs. The variable costs relate to the voyage itself and include port charges and bunker costs. Bunker costs depend on consumption and fuel price, which can be very volatile. The higher the speed, the higher the consumption, but the relationship is not linear. A ton of bunker fuel currently costs around EUR 520 at North Adriatic. The ship from our example consumes about 300 liters of fuel per hour at a cruising speed of 18 knots and about 50 liters per hour at 6 knots. A round trip per day throughout the year would cost about EUR 73,000 in fuel (calculated at the current bunker price). Harbor dues usually consist of two elements: a monthly rate depending on the size of the vessel and the location in the port (EUR 7 to 14 per meter per month in Koper), and a price per passenger embarked or disembarked (EUR 0.40 per passenger in Koper).

6. DISCUSSION

If we look at investment from the individual's point of view, it is the payback period (PP) that influences a person's investment decision. In the simplest calculation, we can neglect the changing value of money over time and use a simple equation:

$$PP = \frac{initial\ investment}{annual\ cash\ flow} \tag{1}$$

We can turn the equation around and determine how many passengers would be needed to recoup the investment, knowing that the majority would be willing to pay EUR 5 for a one-way trip, and assuming that the number of passengers is constant over the years and that the ship makes 4 round trips per day

A rather conservative approach to cost estimation results in a total cost of EUR 625,000 per year, which is independent of the number of passengers. We have to add the cost of EUR 0.40 for each passenger using the service. The maximum number of passengers per day would be 580 in each direction.

Table 2. The costs calculation for sea line Koper-Trieste-Koper

PP	TC	TR	TR-TC	Pax (year)	Pax (day)	Utilisation
5	694,130	864,130	170.000	172.826	473	41%
10	686,739	771,739	85.000	154.348	423	36%
15	684,275	740,942	56.667	148.188	406	35%
20	683,043	725,543	42.500	145.109	398	34%

Note: PP-payback period, TC – total costs, TR – total revenues

In a broader aspect, the sea link could help to decrease road traffic and hence road emissions and improve road safety. If local authorities want that, direct (ticket prices) or indirect (e.g. parking charges for ship passengers) subsidies could be used. However, it should not be forgotten that ships also produce emissions (e.g. [13]) and cause severe health problems (e.g. [14]).

7. CONCLUSION

In some European cities (and not only there) ferries are connected to land public transport and serve a number of purposes, notably offering passengers choice and relieving pressure on land links. Ferries also connect more distant places, especially in the Mediterranean and Baltic Sea; but usually where the land connection is impossible or much longer than the sea connection. This is not the case with the sea connection Koper-Trieste. The distance is very short and the navigation rules would make it very time consuming. Also, the ship passengers have to leave home, get to the terminal or embarkation point, board the ship, travel, disembark and reach their destination. This can be very time-consuming and inconvenient, especially for short-distance routes. In fact, the demand survey for a sea line Koper-Triste has shown low interest, and although the costings show that the load factor to recover the costs would not need to be very high, it is very likely that it could not be achieved unless potential passengers are offered something more.

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REFERENCES

[1] Eurostat, “Maritime passenger statistics,” Eurostat, December 2020. [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php?title= Maritime_passenger_statistics&oldid=535719 [Accessed August 2021].

[2] Wayv, “Travel by sea,” Wayv, 2021. [Online]. Available: https://wayv.si/en/ [Accessed September 2021].

[3] Marjetica, “Parkirišča,” Marjetica, August 2021. [Online]. Available: https://www.marjeticakoper.si/sl/dejavnosti/parkirisca/ [Accessed August 2021].

[4] Trieste trasporti, “Linee e orari,” Trieste trasporti, June 2021. [Online]. Available: https://www.triestetrasporti.it/orari-e-percorsi/linee-e-orari/ [Accessed August 2021].

[5] Delfino Verde, “Servizi di linea,” Delfino Verde, October 2020. [Online]. Available: https://www.delfinoverde.it/servizi-di-linea/ [Accessed August 2021].
[6] Moovit, “Commute time in Trieste,” 2021. [Online]. Available: https://moovitapp.com/insights/en/Moovit_Insights_Public_Transit_Index_Italy_Trieste_e_Gorizia-2182 [Accessed August 2021].
[7] Arriva, “Vozni red” Koper - Autostazione di Trieste,” Arriva, August 2021. [Online]. Available: https://arriva.si/vozni-redi [Accessed August 2021].
[8] Flixbus, Flixbus, August 2021. [Online]. Available: https://shop.global.flixbus.com/ [Accessed August/September 2021].
[9] Arko, J., “Krek: “V Trst vsak dan odide 5000 Slovencev, ki morajo delati zaščiteni!”,” *Primorske novice,* 24 4 2020.
[10] TWUR, “University of Trieste,” 2021. [Online]. Available: https://www.timeshighereducation.com/world-university-rankings/university-trieste. [Accessed Avgust 2021].
[11] Hidrografija, “Splošno o pristaniščih in sidriščih slovenske obale,” Hidrografija, August 2018. [Online]. Available: https://www.hidrografija.si/splosno-o-pristaniscih-in-sidriscih-slovenske-obale/. [Accessed August 2021].
[12] YachtWorld, “1999 Commercial Passenger Boat 20 m - 145 pax,” YactWorld, 2021. [Online]. Available: https://www.yachtworld.co.uk/boats/1999/commercial-passenger-boat-20-m----145-pax-3750185/. [Accessed August 2021].
[13] H. N. Psaraftis, “Logistics-emissions tradeoffs in maritime transport,” Augsburg, 2009.
[14] J. J. Corbett, J. J. Winebrake, E. H. Green, P. Kasibhatla, V. Eyring and A. Lauer, “Mortality from ship emissions: a global assessment,” *Environmental Science Technology,* vol. 41, pp. 8513-8518, 2007.
[15] FORTIS, "Strengthening institutional cooperation in the cross-border area through innovative solutions in public transport and civil motorization procedures" [Online]. Available: https://www.ita-slo.eu/en/fortis [Accessed August/September 2021].

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