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"Towards a Humane City"

Environmentally Friendly Mobility

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CHALLENGES OF BETTER SPATIAL AND TRANSPORT PLANNING INTEGRATION IN SLOVENIA

Key Words

Spatial planning;
Transport planning;
Sustainable planning;
Integration

Abstract

Sustainable urban mobility plan (SUMP) is a relatively new approach to transport and mobility planning in Slovenia. The biggest steps in this field were taken in 2016 when more than 60 municipal SUMPs were developed. Through the development and implementation several challenges were reported by local communities related to Municipal spatial plans. Quickly it became clear that it is necessary to ensure a stronger integration of both documents in terms of procedural as well as content integration. The process of integration should probably involve adjustments of both documents regarding development processes, harmonization of goals, measures, indicators, implementation and results. A study was carried out to establish current level of integration. The approach combined a survey and structured interviews among experts leading the development process of both types of documents, as well as experts managing spatial and transport planning in local communities. Results showed that current level of integration is relatively low. Even though experts from both fields were often involved in development of both documents, objectives, targets and measures are not equally included in both plans even if the topics overlap. To increase the integration, activities will need to take place on several levels: capacity building, exchange of best practice, tools and supporting guidelines and later development of new legislation.

1. INTRODUCTION

Transport and land use have a strong influence on each other. More intensive land use generates more transport. But also, good transport connections generate more intensive forms of land use. Relationships between the two are complex, with various interactive effects such as vehicle ownership and number of vehicle trips mode share, use of active transport modes [1] and after all health and well-being of the citizens [2]. Cities and municipalities use various approaches to deal with planning of land use and transport, but quite often the topics are divided by sectors into departments with limited coordination.

In Slovenian Municipal spatial plan (MSP) have been used as the main land use planning tool under different names practice for decades. MSP preparation is legally binding and highly formalized. Because it needs to be coordinated with several high-level stakeholders its development takes several years. It can be updated but as well the update process is complex and time consuming. Transport and accessibility are an integral part of the MSP, but only on the level of networks and their spatial components.

Sustainable urban mobility plans (SUMP) are a relatively new approach to transport and mobility planning. Their preparation has been promoted by the European Commission for more than 15 years and is still actively ongoing [3]. While the first practical implementation in Slovenia took place more than 10 years ago. The biggest steps in this field were taken in 2016 when more than 60 municipal SUMPs were developed within the call of the Ministry of Infrastructure which was financed by the European cohesion fund.

A SUMP defines a long-term development vision and measures for a balanced development of all forms of mobility. Its preparation is based on thorough research of the current state regarding mobility, stakeholder involvement and strong citizen engagement. The development process takes about a year and the document should be refreshed every 2-3 years. The document is currently not legally prescribed but is required in order to be eligible to apply for financing of the measures from different sources.

MSP and SUMP are two key strategic documents for land use and transport planning at local level and their content and processes overlap or complement in many aspects. Through the development of SUMPs it has become clear that it is necessary to ensure the mutual integration of both documents, but also strategic approaches. Pozoukidou [4] proposes integration on several levels: strategy oriented, target oriented, trough evaluation and trough final impact assessment. But before reaching a high level, the development of integration can go through several phases. Stead and Meijers [5] define three: policy cooperation, policy coordination and the final policy integration.

In order to determine the extent and level of current integration, challenges arising and possible steps for improvements, a research project was set up by Ministry of Spatial Planning, Ministry of Infrastructure and Slovenian Research Agency. The study took place in 2018 and 2019 and included several steps, such as overview of current national legislation regarding integration, interviews and surveys, pilot projects, planning simulations, workshops with representatives of municipalities and experts and research of best practice and approaches from abroad. The main result of the project was definition of current state and decision on next steps to be taken by both ministries in charge.

The paper presents results of the segment of the project focusing on experiences of experts leading the development process of both types of documents, as well as experts managing spatial and transport planning in local communities.

2. METHODS

Main methods used for data collection in the study were two, survey to cover a larger number of representatives and structured interviews to get an in-depth information about the current state. Both approaches have been used on two types of experts. In the first group there were experts working in the field of land use and transport planning in municipal administration. Since those two topics are often covered by different departments, we tried to include experts from same municipalities to gain view from both perspectives. Second group consisted of experts working for private consultancies which were involved in development of MSPs and SUMPs. Within the study we focused on consultancies which were involved in development of both documents.

The survey took place in June 2019 and managed to collect data from 25 respondents from experts working for municipalities and 10 from consultants. Interviews took place in the following months and included 3 experts from municipalities and 3 consultants.

In order to describe the current level of spatial and transport planning integration a 4-level scale was used, which is used in several policy related quality management scheme such as BYPAD [6], ISEMOA [7] and PARKPAD tool [8]. The scale is intended to help the evaluator to describe the current stage of development and propose appropriate actions in order to reach a next level. The first level is described as ad hoc–oriented, where there is some form of policy in place, but it's level of development is minimal and mainly limited to problem solving. Second level, also described as isolated approach is, when there are elements of a policy in place, but are neither embedded in the overall development policy nor inter-coordinated with other sectors. There might be some success stories related to this level, but there are limited to individual examples of policy aspects. Third level of development is already system-orientated. The policy in question is regarded as a system, which is integrated into the overall development policy. Besides that, there is the political will to support the policy and the allocation of sufficient personnel and means to deal with the topic. The highest, fourth level, is also called the integrated approach. On this level the policy is regarded as a continuous task with strong relationships with other policy fields. Besides political support, systematic networking and strategic partnerships characterize the considered policy.

3. RESULTS

3.1 Land use and transport planning in practice

First part of the research focused on general aspects related to land use and transport planning. The participants were asked to think about recent development projects that took place in their local community and consider if both fields were taken into consideration adequately.

Only 48% of the experts working within municipalities were positive regarding the principles and guidelines available in their MSP to be enough in securing appropriate accessibility conditions for placing new programs. The role of SUMPs here is therefore essential.

MSPs often include strategic principles that are generally helpful within strategic thinking of spatial development. But they become a big burden when considering actual projects. Some demands, written in these documents are not tested and can pose impassable obstacles or unreasonably high costs to the investors.

In practice the available criteria put too much focus on car accessibility and good parking conditions. On the other hand, the MSPs are not securing development of direct, continuous, safe and pleasant connections for pedestrians and cyclists. But these topics became more important only with the activities related to SUMP development.

But already MSPs do not provide enough leverage to local administration to influence how new development projects are placed, designed and accessible. 50% of respondents claim that the municipality can only partially influence such decisions. Partially this is related to lack of tools and mechanisms to influence the design after MSP in in place. In many cases local communities are also not willing to push the investors into better solutions because the investor might change his mind and move the project to another location (municipality). It is therefore up to knowledge and initiative of local experts to what extent the existing tools are used. But their success is depending on conditions surrounding each individual case which corresponds to ad-hoc solutions.

3.2 Relationship between MSP and SUMP

Second part of the research dealt with the actual documents available in municipalities. There are significant differences between municipalities regarding understanding the relationship between the documents. As many as 74% of municipal representatives and 70% of experts consider MSP as the parent document. Only 24% of municipal employees and 20% of experts regard the MSP and SUMP documents as equal. This is probably due to the fact that the MSP is significantly more regulated and involved in legislation, and the preparation of a SUMP is optional.

Comparing the availability and timeframe of both documents in municipalities there are different situations regarding the status and adoption of MSP and SUMP. Some municipalities developed their MSP long before the SUMP, other are still working on it. This is of course a challenge that must be anticipated in development guidelines for both documents. But even so, currently only 36% of experts working in municipalities and only 10% of the experts involved in development of SUMPs estimate that SUMP and MSP are well integrated. As many as 18% experts working in municipalities and 20% consultants involved in development of SUMPs do not. All other report on partial integration.

Even where they are, it is mainly about integrating infrastructure projects from SUMP into the MSP, where this requires a change in spatial documentation and has already been an opportunity. Such involvement is reported by 30% of experts. More complex integration elements that require both infrastructural changes and the introduction of mobility management elements are largely absent. Some mobility management approaches are in place, especially in cities, but they lack efficient mechanisms for implementation. The situation regarding the integration is far from system oriented. We could say that in most cases we can find ad-hoc solutions and in some cities isolated practices of integration.

3.2 National level support

Last part of the survey was dedicated to expectation of experts regarding future activities carried out by national level administration in order to address the described challenges.

In order to better integrate MSPs with SUMPs, only 33% of municipal employees and 40% of experts are proposing changes in the legislation. Several experts are aware that non-obligatory approaches such as guidelines and position papers are much less efficient, but since development of MSPs is already a very complex task, they are against further steps in making the process even more complex. Some experts noted that there are already strategic level national documents in place which could support the integration but are not translated into practice.

On the other hand, 67% of municipal employees and 60% of experts support development of knowledge and exchange of experiences in this field. Proposals for activities vary from trainings, development of tools and guidelines, but also extending the topic to other administrative scales such as regional planning level.

4. DISCUSSION

The responses of both groups of experts were rather consistent. Both groups agree that the current level of the integration is rather low which influences the planning processes in local communities. The overall level of development could be described as a solid level one: ad hoc–oriented. In some local environments, especially larger cities with stronger administrations and more experts working on topics related to land use and transport planning, some elements of the system are already on level two: isolated approach.

The described level is also consistent with expectations of experts from the national level. They are cautious with expectations on the system-oriented level, such as changes in legislation or additional standards. Most of them see the way forward in development of guidelines and trainings for experts in order to build capacities and increase awareness of the importance of the topics such as placing new large transport generators, designing network of mobility points, circulation plans, comprehensive parking planning and introducing efficient mobility management plans.

The conclusions of the project were directed in similar direction. The objective for next steps regarding the integration of spatial and transport planning should work to develop a system in practice to support a solid second level integration (isolated approach) and start developing knowledge, tools and approaches for third level (system-orientated). The focus of both ministries should be directed in development of best practice examples which are thoroughly evaluated. Results should be communicated to all experts working in urban administrations with similar challenges. Parallel to these, trainings for experts should take place in order to build capacities. The changes in planning approach should be tested first in various local contexts before they are implemented as the actual legislation.

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A CROSS CULTURAL STUDY OF GENDER TRANSPORT POVERTY: THE EVERYDAY EFFECTS ON WOMEN'S LIVES

- Invited lecture -

Key Words

Gender transport poverty; Malaysia; Pakistan; KPIs; Hexagon-spindle model

Abstract

This paper draws on research conducted during the 18-month, collaborative WEMOBILE project, which brought together designers, planners and ergonomists from UK, Pakistan, Malaysia to raise awareness and (re)present problems women in low-middle income countries (LMICs) face in their everyday travel. Based around 3 knowledge sharing trips to Lahore (Pakistan), Kuala Lumpur (Malaysia) and Coventry (UK), the research directly addressed Rand's comments regarding the need for transport professionals to show cultural sensitivity. Each visit consisted of a series of interactions with the environment and local women to gain greater insights into the everyday problem's women experienced when travelling in their cities. Methods included workshops, empathic design, visual and autoethnography, focus groups, multi-stakeholder world café, surveys and phenomenological interviews. The paper will outline the problems faced by women and some recommendations for future action.

1. INTRODUCTION

[1] stated that 'Transportation is a challenge for women in developing nations, but it is a challenge for everyone at the same time. Transportation professionals must be careful to take culture into account when designing transportation options in developing nations.' With contributing factors being underinvestment in public transport, transport infrastructure, rapid urbanization, lack of integrated planning, corruption and rises in car ownership etc. It has been argued that inadequate pedestrian infrastructure, non-existent or badly designed pedestrian crossings, poor location of bus stops and shelters, and high steps on buses contribute to a system that is hostile to women.' '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" [2. p78].

Gender transport poverty is truly a wicked problem. It is an extreme example of transport poverty, bounded with social and cultural practices, which needs to be addressed, if women can enjoy safe mobility and the rights as equal citizens. Research [3] acknowledges disproportionate burdens on women - they earn less, have multiple roles and their mobility is restricted by social, cultural and religious norms. Lastly, the lived experience of women – WEMOBILE's focus - reveals women face more harassment on transport and public spaces and their gender transport poverty is heightened by the dual roles they undertake. The Centre of Economic Research in Pakistan's survey found nearly 30% of respondents considered it "extremely unsafe" for women to walk in their neighbourhood, with 70% of male respondents discouraging "female family members from taking public wagon services" [4]. Walking on poorly maintained roads or footpaths and avoiding vehicles [5] in urban areas is stressful and tiring owing to environmental effects - overcrowding, temperature, humidity and pollution.

2. WEMOBILE: PAKISTAN AND MALAYSIA

Wemobile's methodology developed the expertise and experience of researchers, enabling them to gain firsthand experience of women's transport in Malaysia, Pakistan and UK thereby increasing capacity and capability of female researchers and reducing the likelihood of cultural insensitivity in transportation solutions [1]. Each site conducted empathic, (visual auto) ethnographic and participatory research (supplemented by quantitative surveys) - world cafés, focus groups, multistakeholder panel discussions and pop up installations.

In terms of the two countries:

- Pakistan ranks 128 out of 182 on Human Development Index (2010), 124 out of 155 on Gender Development Index (2009) and 132 out of 134 on the Global Gender Gap Report (2009). [6] stated that:'...transport remains a neglected area among gender specialists and transport specialists are still reluctant to take on gender issues. Until this is done, the prospects for many women who live in areas characterized by poor physical accessibility and inadequate transport will remain poor'.

- Malaysia ranked 101 out of 149 countries on the Global Gender Gap Index for 2018; while it ranked well in terms of women's access to education and educational attainment, this did not translate to economic participation and opportunity (ranking of 84) or political empowerment (ranking 131) [7].

The differences between Lahore (Pakistan) and Kuala Lumpur (Malaysia), where our studies took place was noticeable, at all levels and is reflected in the results shown in below. Basically, women in Malaysia had freedom and agency, they were allowed to work, travel and see friends. Women in Pakistan enjoyed no such freedoms, gender segregation in public spaces was considered culturally appropriate and legally enforced, women can only work with the permission of their families, and their travel is restricted. Although women in both countries reported harassment on public transport, for women in Pakistan this is much worse, with many women not using public transport or venturing into the public realm. Social and cultural issues inhibit women's equality and agency, adding significantly to their mobility burdens.

As well as harassment and having to pay more for safe transport (e.g. ride hailing services), the mobility of working women in both countries was restricted by additional time and effort which needed to be expended on looking after the family. In both countries, regardless of whether women worked or not, they were still required to look after their house, household and family dependents. This not only restricts where they could find employment, but their working hours, their journeys and the length of their days.

The main factors raised by participants from all sessions are summarized below.

- Social and societal factors.

Lahore: harassment and physical assault in the public realm, on and while waiting for transport, with women's presence becoming less common on streets: mother is main care giver and housekeeper regardless of employment status.

Kuala Lumpur: women less technically competent tan men in motoring and vehicle maintenance; Women's mobility effected by their role as principle care givers/raising of children, e.g. in terms of job choice, distance they can travel and hours of working

- Cultural and religious factors

Lahore: lack of agency, empowerment and female role models. Women are censured and forbidden to go out. Cannot use motobikes. Dual burden on women

Kuala Lumpur: Malay men are head of household and approve women's travel, women are discouraged to travel at night. Women priorities their family and home duties and work a schedule around this

- Safety

Lahore: women do not feel and are not safe outside the house. Their families also fear this. Wearing long clothes on public transport and motor bikes provides additional risks of injury. Window screens used to hide female passengers

Kuala Lumpur: Women are not encouraged to travel at night. Media reporting creates fear of safety.

- Health

Lahore: Exposure to pollution from transport and construction, no opportunities for exercise.

Kuala Lumpur: Exposure to pollution from transport and construction.

- Transport operation

Lahore: Male dominance of all forms of private and public transport. Male right to mobility. Poor transport discriminates more against women.

Kuala Lumpur: Car ownership and driving lower amongst women. Attempts to make transport safer for women e.g. women only carriages. Public transport unsafe for women. Geography and climate effect transport delivery.

- Transport infrastructure and design

Lahore: Lack of joined up services and coverage of public transport, no pedestrian infrastructure, poor maintenance, overcrowding at bus stops, lack of lighting

Kuala Lumpur: need for universal design as no specific thought given to the vulnerable groups or gender friendly designs. Known crime hot spots around stations need to be attended, better wifi-coverage in the city for calling cabs

- Economic

Lahore: Classism in transport; women who travel to work on public transport have to hide this fact; upper middle-class women own their own cars to overcome mobility barriers; on demand services are to expensive for most to use regularly, even though they offer a safer alternative

Kuala Lumpur: Women on lower incomes rely on public transport even though they know it is unsafe.

- Urban planning and architecture

Lahore: lack of pedestrian infrastructure e.g. pavements, crossing points; pedestrian bridges are far apart and very unsafe for women. Lack of disabled access on transport and to buildings.

- Regulations

Lahore: Lack of awareness of regulations which could be used to reduce mobility barriers e.g. Article 9: Security of Person; Article 15: Freedom of Movement; Article 25: Equality of Citizens; Article 26: Nondiscrimination in Respect of Access to Public Spaces.

Kuala Lumpur: Lack of enforcement of regulations and policies for women's travel safety; disconnect between transport providers.

- Political /governmental

Lahore: Need for recognition of women's mobility needs and its importance; lack of female representation on decision making bodies; need for inclusive design

Kuala Lumpur: As for Pakistan.

- Environmental/ climatic

Lahore: Extreme hot weather makes it difficult to walk outside: Rural areas and villages inaccessible for public transport

Kuala Lumpur: Raining and hot climate discourage travelling; Transport infrastructure unable to cope with predictable rain patterns causing delays and alternative transport

3. TRANSPORT ERGONOMICS

Transport ergonomics has traditionally had a limited focus [8] has extended this to include macro, social, group and cultural factors. The results outlined above show very clearly that transport occurs within a context, and personal mobility is influenced by social, cultural and religious norms, which have a far greater and more profound effect.

The two countries in WEMOBILE are representative of Low-Middle Income Countries, with Malaysia allowing greater quality and freedom to women. However, in both cases, a woman's mobility was restricted by her gendered role in society, as home maker and carer. The women in our study had to

- Pay more for safer travel e.g. using ride hailing services,
- Made longer and more complicated journeys to and from work because they could not drive or ride motorbikes,
- Endure harassment (or worse) as pedestrians and passengers,
- Complete housework and care duties before and after work,
- Find employment opportunities near to child care centred or near their home,
- Plan for travel disruption (for themselves and their children).

Trip chaining by women, in particular is starting to be recognized in the EU transport community, along with the need to 'understand women's travel needs'. This research highlights the complexity of those needs. When compounded by the problems associated with inadequate, inefficient and unregulated transport, poverty and criminality, women's mobility is severely compromised. Physically tiring, long journeys, disrespect and harassment on the street, by transport staff and passengers, naturally lead to reduced mobility especially when women are also required to spend long hours on household duties. and the extra burdens inadequate transport places on women, contributing to gender transport poverty and a poorer quality of life.

In the multistakeholder discussions in both countries most participants were eager for changes to increase safety and security of women (e.g. through better transport infrastructure and through enforcing regulations) and to provide them with greater access to transport (e.g. through motorbike lessons, car maintenance, training in use of public transport).

At a wider level, it was believed that multiagency teams could come together and work towards understanding and removing gender discrimination. Investment, commitment and partnerships are needed to develop inclusive transport systems in a master plan for transformational change with regulated planning processes enabling gender mainstreaming and action planning across departments, having a key emphasis on developing and enforcing current equality legislation

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H2020 CIVITAS SUITS: SUPPORTING LOCAL AUTHORITIES' IMPLEMENTING SUSTAINABLE TRANSPORT MEASURES

- Invited lecture -

Key Words

Sustainable transport; Capacity building

Abstract

H2020 CIVITAS SUITS (**S**ustainable **U**rban **I**ntegrated **T**ransport **S**ystems: Transferable tools for Small to Medium local authorities) is a 4-year research and innovation action (RIA), entering its final 18 months. Its aim is to increase the capacity of Small-Medium (SM) local authorities (LAs) to develop and implement sustainable, inclusive, integrated and accessible transport strategies, policies, technologies, practices, procedures, tools, measures and intelligent transport systems that recognize the end-to-end travel experiences of all users and freight. The paper presents 4 case studies of sustainable transport measures implemented

during the project. Each comprises a brief description, analysis of aims and objectives, implementation requirements, scalability/replicability, target groups, challenges, financing and cost requirements, final outcomes/impact.

1. INTRODUCTION

The rationale behind H2020 CIVITAS SUITS was that SM cities are unlikely to have sufficient resources to develop, support and finance integrated urban mobility plans without a broad range of targeted capacity building measures. Rather than importing or adapting existing sustainable transport measures, or buying in expertise, cities should be supported in building up local capacity (in their governmental institutions, businesses and citizens) to grow, fund and implement bespoke and context sensitive sustainability strategies, appropriate to their needs.

In relation to sustainable transport, we argue that capacity building should embrace change, at individual, organizational and institutional levels. This includes providing knowledge, and know- how in latest transport innovations, mobility data usage, rules, regulations and citizen engagement processes. These directly impact on how the transport department goes about its business, enabling them to make better, more informed plans. To address this, SUITS developed training material in 6 discrete areas, which were identified as those in which there was a shortfall of knowledge (i.e. implementation of emerging transport technologies, urban transport safety and security measures for vulnerable users and urban freight transport measures; introduction of innovative transport schemes; data collection and analysis tools for integrated measures; innovative financing, procurement and business models).

This was accompanied by the application of a socio technical approach to the transport department in each city, to develop change visions, change agents and processes to increase their development as learning organizations, able to innovate and create transport solutions which will work for their local cities [1].

The paper presents four cases from the city partners (Turin, Rome, Kalamaria, Alba Iulia, Transport for West Midlands, Valencia; and follower cities of Palanga, Stuttgart and Dachau) in SUITS, to understand the context in which cities are working and their current efforts in sustainable transport development. Each case study includes a brief description, along with objectives and implementation requirements, scalability/replicability, target groups, challenges, financing and cost requirements, final outcomes/impact. These are followed by a discussion of the way in which SUITS outputs can influence the development of the transport measures.

2. THE CASE STUDIES

2.1. Midlands Future Mobility Connected and Autonomous Vehicle (CAV) Testbed (Transport for West Midlands (TfWM), UK

The CAV test bed aims to provide a real-world environment for testing of Connected and Autonomous Vehicles on 80 km (at a cost of £25.3m) of public roads (to be extended to 300km by 2020) in the West Midlands, thereby strengthening the West Midlands as a leader in the provision and testing of innovative technology and infrastructure projects, facilitating the development of connected and autonomous vehicles that are SAE Level 4+ autonomous, meaning that the vehicles can detect their surroundings without user input; informing the LA about what infrastructure change and investment is required for future mobility operations; providing insights into policy and regulations for CAV, ITS and mobility service provision.

Existing infrastructure has been supplemented by (e.g. lighting columns, gantries, communications links, urban traffic management and control systems, and data infrastructure) with deployment of CCTV to enable the monitoring of CAVs during on-road tests; road-side units to enable communication between test vehicles and road infrastructure; weather stations and global navigation satellite system (GNSS) correction equipment to provide additional required information to test facility users. The Testbed implements technologies based on European and International standards (e.g. ITS-G5, LTE-V2X, and ETSI) with the emphasis being on testing emerging standards to determine which are most appropriate for larger scale deployment. The target audience for the project is therefore automotive manufacturers (OEMs) and suppliers, local authorities, government and logistics operators.

The TfWM team have worked alongside those with experience in previous CAV and intelligent mobility projects, staff from LAs across the region with expertise in urban traffic control system is also essential, local academic and industry partners to successfully execute the project and ensure that it meets the user requirements, due to its innovative nature. One of the main challenges has been the need for a centralized data-hub and the identification of relevant, desirable data-sets provided in a suitable format, such as, TRO (Traffic Regulation Order) data, which defines any regulations and restrictions on named roads. Existing means of storing data vary widely across collaborating LAs, requiring standardization.

The project is still ongoing, but impact has included growth in knowledge in LAs about future mobility technologies and the policies that could support or regulate them. Later, it is expected that there will be a significant opportunity to collect data about the use and performance of the transport system. By facilitating testing of vehicles, the testbed could support faster development of new mobility technologies in the West Midlands region, and economic development by attracting companies researching CAV technology to the region.

2.2. Development and demonstration of smart technologies to improve traffic flow through Intelligent Variable Message Systems (iVMS) in Coventry, UK

Coventry, like many cities has invested substantially in traffic management systems, including seeking to utilize new technology. However there has been little attempt to integrate travel management systems and managed interventions within travel systems (e.g. to respond to major incidents). The latter tend to be highly reactive, 'blanket' in their communication to all users and require high levels of human intervention. The aim of the project was to develop, demonstrate and test new traffic management systems, based on innovative iVMS technology, on three main road routes into Coventry.

The iVMS project aimed to receive constant real time traffic and journey data from strategically placed street infrastructure (Automatic Number Plate Recognition, Bluetooth Radar, CCTV, etc.), 'connected vehicles' (including, potentially, their drivers / passengers smartphones) and utilize this data stream, through traffic prediction and simulation models, to manage the traffic system as a whole - provide live in-journey information and guidance to travelers on journey conditions, routes and alternatives

This started with a period of upgrade and development centred around the need for new ('on-street') traffic signaling and communications equipment and capability (ANPR, Bluetooth, loops detecting vehicles, cloud-based technology, etc.) covering main routes in Coventry with the existing Urban Traffic Control system (UTMC). Examples of infrastructure upgrade include the installation of ANPR cameras and Bluetooth Radar sensors and their integration with existing, and upgraded, communication systems In order to improve the level of communication between on-street devices and the UTMC system.

Therefore, the key objectives of iVMS were to 1) Increase the effectiveness of traffic management in Coventry, leading to reduced congestion and associated economic and social benefits; 2) Encourage behavioural change by individual travellers in support of congestion reduction; 3) Provide an enhanced test bed environment for future development of vehicle technologies and transport systems. 4) By enabling economic and social benefits associated with congestion reduction, providing an innovative model for traffic management technologies for the city, and a 'test-bed' capacity for future trials of innovative technology, the project is expected to support further local economic benefit to the sectors, businesses and citizens of Coventry.

7 partners from academia, industry and the local council worked together to provide accurate, reliable and timely travel information to ensure that informed choices could be made about when and how to travel. This required significant investment in roadside infrastructure such as variable message signs (VMS), improved real-time communications (vehicle to infrastructure and vehicle to driver) within the transport system allowed a more efficient use of existing infrastructure assets reducing congestion. The combination of mobile phone App technology with the latest developments in user interaction allowed virtual Variable Message Signs,

or intelligent Variable Message Systems (iVMS), to be deployed anywhere on the network. Real-time information could be tailored to the needs of specific user groups – freight, commuters, businesses, etc.

Although the project created the capacity and tool to encourage behavioural change, this could not be measured within the lifetime of the project, and up take of the system was lower than expected due to shortfalls in marketing and incentivization. However, once comprehensive traffic management plans and strategies have been put in place, enhancements to the existing UTMC system and the development of the upgraded and integrated traffic management platform will provide a greater ability to manage traffic flows, including individual behaviour, on the corridors.

2.3. Online platform for real-time passenger and freight traffic visualization in Kalamaria, Greece

Kalamaria is one of the biggest municipalities in Thessaloniki's area. Receiving transit traffic from Thessaloniki center, airport and the ring road some main roads have heavy traffic throughout the day. One of the main goals is to decrease freight and passenger traffic through the optimization of the traffic flow to promote better living standards for the local community.

SUITS supported and trialed an online platform to collect anonymous localization data reporting on location, speed and direction of freight and passenger vehicles providing a reliable and detailed overview of the entire local road network. The platform, for example, shows the points where freight vehicles stop and roads which are used by specific types of traffic. This enables estimated arrival time, accurate routing, transport assessment and planning decisions. The key objectives of the trial within SUITS were to demonstrate the value of crowdsourcing data for SM authorities, provide a cost effect way of aggregating, analyzing and presenting anonymized passenger and freight data, and aid in transport planning decision making. Therefore, the target groups were logistics operators, last mile delivery companies, drivers, local citizens, local authorities, institutions, academics who could be interested in improvements of freight distribution and routes in city centre (and deployment of parking spaces), low cost capture and visualization of real-time traffic data.

As a low-cost solution, the implementation requirements were simply the installation of GPS trackers in vehicles Usage of digital technology devices (phones, tablets, PCs etc.) and management of traffic data from platform users. This is potentially an extremely important way for SM LAs to gain the mobility data they need, with SUITS demonstrating the feasibility and number of vehicles needed to provide accurate date and ways to overcome technological, anonymization and barriers to adoption.

2.4. Intelligent public transportation provided by the Public Transport Company STP Alba and Orange Romania

Alba Iulia Municipality aims to become the first smart city in Romania. Since 2017, the “Alba Iulia Smart City” project has implemented over 100 smart city solutions in partnership with over 30 companies. Some of which are in the mobility area and are relevant also to project SUITS, such as

i) the free WIFI in the buses initiative byOrange Romania in Alba Iulia which has led to the installation of smart public transport solutions, including Wi-Fi access to secure Internet for passengers and real-time access to information related to GPS positioning, speed and direction of movement in 15 trial buses. The free WIFI solution aims to provide a professional service dedicated to public transport, providing high-speed Wi-fi during the time spent by travelers on the bus. It aims to motivate citizens to use pubklic transport by proving them with access to online content whether they are on their way to school, work etc

uRADMonitor solution integrated by Orange on the Alba Iulia Smart City platform to monitor which areas of the city have low air quality due to traffic jams. Environmental sensors have been installed in 15 buses of STP Alba Iulia, equipped with Internet connectivity or access to LoRaWAN. The data provides information about the level of pollution in the city and the surrounding area. They are transmitted in real time to a dashboard accessible from any Internet connection, providing real time information about the level of pollution and changes in pollution over time and location. This can be used to formulate citywide policy.

The key objectives of these and other projects in Alba Iulia are to 1) increase effectiveness of public transport at Alba Iulia and AIDA through introducing better services and encouraging the use of public transport, thus reducing congestion; 2) contribute to development of smart cities, eg in area of smart mobility; 3) encourage youth and other groups to use public transport and change mentality from car-oriented to sustainable transport oriented; 4) provide an enhanced test bed environment for future development of vehicle technologies and transport systems and 5) reduce the level of pollution from car transport by monitoring, analysis and impact studies. Hence the solutions target local citizens, Public Transport providers, drivers, and local authorities. Knowledge gained in Alba Iulia can contribute to knowledge about how to improve freight distribuiton, develop urban logistcs plans, and supervise/regulate private carriers activities.

The main problems which have been faced have been to record the qualityof air and the main pollutants within the city to show what the effect of these have been in terms of health, and the effects of car dependence on the quality of the city environment. Although Alba Iulia has been recognised as having one of the best public trnasport systems in Romania, people are reluctant to leave the perceived seurity of their cars to swirch modes. Improving the services provided by public trnasport is seen as a possible way of encouraging modal shift.

The two solutions have had a positive impact of Alba Iulia, contributing to a beahioural change with citizens being provided more attractive public transportation, high quality Internet in transit;better communcation with the municipalty about mobility issues and through e-Alba Iulia and Civic Alert applications, better air quality and less congestion. Using the city apps the administration can better measure the pulse of the city, bus surveys show passenger profiles and intelligence can be fed into transport planning. The Public Transport Company Alba Iulia now has a cloud based platform from which can be used to gather statistics on passengers and wifi use, Details of the configuration and operation of the equipment in public transport;monitor the fleet in real time, control connection settings, use a captive portal, create questionnaires and generate targetted banner advertising campaigns.

3. DISCUSSION

The SUITS project aims to support SM local authorities in their planning, implementation and evaluation of sustainable transport measures through a capacity change programme to transform, traditionally conservative, closed and male dominated departments into ones that are more diverse, open and innovative; who are not afraid to work outside their silos, consult with the public, or be innovative. We support this with a set of learning modules, to support staff who may be unfamiliar with latest financing and procurement legislation, the use of real time data or latest transport technology.

All the case studies demonstrate that there is a need for such outputs. All LAs were engaged with latest technology, implementations, using and combining data sets and engaging/changing behaviour of citizens. They needed to work across boundaries and institutions, and persuade operators, drivers and citizens to use new systems and travel in new ways. The case studies show variable levels of success in uptake and user engagement, but they have all provided valuable and transferable experiences to staff and citizens engaged on them, and to other LAs who need to create employees, organizations, cities and citizens who are more sensitive to the need to prioritize smart and sustainable lifestyles,

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OVERVIEW OF H2020 CIVITAS SUITS: SUPPORTING LOCAL AUTHORITIES' DELIVERING SUSTAINABLE TRANSPORT MEASURES

- Invited lecture -

Key Words

Sustainable transport; Capacity building; H2020 CIVITAS SUITS; Crowdsourcing; Organizational change

Abstract

H2020 CIVITAS SUITS (**S**ustainable **U**rban **I**ntegrated **T**ransport **S**ystems: Transferable tools for Small to Medium local authorities) is a 4-year research and innovation action (RIA), entering its final 18 months. Its aim is to increase the capacity of Small-Medium (SM) local authorities (LAs) to develop and implement sustainable, inclusive, integrated and accessible transport strategies, policies, technologies, practices, procedures, tools, measures and intelligent transport systems that recognize the end-to-end travel experiences of all users and freight. This paper provides an overview of the three core pillars of our capacity building approach; data collection; capacity building and organizational change

1. INTRODUCTION

H2020 CIVITAS SUITS recognized that small – medium local authorities (SM LAs), citizens and stakeholders have shortfalls in capacity which limit the extent to which they can act as 'equal partners' in the development of sustainable transport. This places them at a significant disadvantage in challenging, leading, promoting or implementing new sustainable transport measures, to the detriment of the social and economic well-being of their cities. It has targeted 4 key areas:

1.Capacity gaps in S-M local authorities' knowledge and work practices which may have arisen due government and economic cutbacks, re-organization, changing technology (e.g. open data), new business entrants, shifts in mobility, changing expectations of citizens and new directives (e.g. in terms of financing and procurement). Significantly these impact at individual, organizational and institutional levels, all of which need to be recognized to make transport departments resilient and responsive to new challenges.

2. The need for integrated urban mobility planning of both freight and passengers based on the capture and use of information relating to the diversity of active, private, public, shared and multimodal forms of transport, journey types and travelers/freight.

3.The need to exploit future transport technologies to improve transport efficiency and enhance quality of life, such as traffic management and control systems, real time travel and to create real opportunities for citizen engagement.

4.The need to maximize the effectiveness and sustainability of transport measures through transferable best practice (e.g. in terms of evaluation metrics), new funding models and create sustainable opportunities for new business entries, e.g. in areas of user focused end to end services deployment of new forms.

2. THE SUITS' APPROACH

As a Research and Innovation Action, SUITS has been funded for 4 years (2016-2020) to develop validated, practical and replicable tools and methods in relation to:

1. Cultural and behaviour change from a socio-technical, perspective at individual, organizational and institutional level;
2. The collection and use of real-time, open source and legacy data to inform urban mobility plans;
3. Addressing requirements of vulnerable and hard to reach groups;
4. The integration of freight and passenger information and measures;
5. Increasing the appreciation of the wider benefits of sustainable transport to citizens and cities by all stakeholders in the transport ecosystems;
6. Sustainable and innovative financing for new transport measures;
7. Compliance with new procurement directives;

8. Development of appropriate evaluation methods and tools for sustainable transport and mobility needs.

The paper provides an overview of three key areas of work in relation to data, capacity building and organizational change.

2.1. Data integration and crowdsourcing approaches in Kalamaria and Torino

Gap analysis performed in the 9 local authorities in SUITS (Alba Iulia, Coventry, Erfurt, Kalamaria, Palanga, Rome, Stuttgart, Torino and Valencia) showed the need of increasing information about freight flows, O-D, the traffic matrix (i.e. transport patterns and demand characterization (e.g. purpose of journeys, frequency and type of freight loads, vehicle propulsion systems, fleet characteristics or passenger satisfaction data) and active mobility (especially about bike trips and infrastructures).

Being able to capture as much data as possible does not guarantee that the information will be valuable, accurate and useful. Data analysis methods allow local authorities to interpret data gathered in order to assess the current situation, support decision making and evaluate future effects of these measures. Mobility data collected in cities is habitually used to calculate performance indicators, which allow the quantification of the added value generated by the application of a (set of) mobility measure(s). KPIs are crucial for the assessment of current situation of urban mobility, but even more to be able to compare evolution over time (e.g. when introducing some measures).

To demonstrate the value of mobility data, and how crowdsourcing could be used to by LAs, for example to develop and evaluate performance against KPIs (Key Performance Indicators) and visualise /analyse data, 2 pilot trials were held [7].

The Torino pilot addressed the KPI, ‘‘Delays in road traffic and in public transport during peak hours compared to free flow travel” by measuring the way in which congestion selectively affects different traffic streams, with special emphasis on light duty vehicles, according to the specific service points that need to be reached in the city and of the time of the day / day of the week in which such trips are taken. This was achieved by combining three datasets 1) light and heavy vehicle flows on major arterials entering the city; 2) traffic flows on the whole network; 4) GPS traces of logistics vehicles; 4) shopping survey and observational data. Data fusion methodology was developed through specialised scientific software, namely QGIS (https://www.qgis.org) for the analysis and visualisation of spatial data such as GPS traces and road network graphs, and R (https://cran.r-project.org/) for statistical computations of the KPIs. The software is open source and freely usable, thus making the proposed SUITS method fully reproducible without any barrier.

The Kalamaria pilot addressed the integration of passengers and freight using 4 data sets relating to 1) traffic design; 2) passenger data; 3) logistics vehicles; 4) and large goods vehicle data, However, SM LAs may not have appropriate datasets or skills needed to work with such tools. SUITS has therefore proposed the use of crowdsourcing mobility traces is a scalable and sustainable means of collecting such data.

A popular and preferred format for recording and storing crowdsourced traces is GPX, or "*GPS eXchange format*", which is an XML file format for storing coordinate data. It can store waypoints, tracks, routes and traces in a way that is easy to process and to convert to other forms. Millions or billions of GPX trace files can be uploaded by individual contributors (citizens, logistics or transport operators) and be made available from global Open Data Repositories (as open, big data) for further exploitation. Within SUITS, SBOING developed a suite of tools to facilitate the flexible collection and selection of crowdsourcing traces in SUITS' Data Repository (https://dare.suits-project.eu/tools).

The scalability and sustainability of the use of crowdsourcing for urban traffic management was tested using SBOING's sbCarNavi® app as a fleet management platform to automatically records the vehicle's route as soon as the driver runs it on the vehicle's console. This generates real-time traffic data for the city and allows the fleet operator to monitor its vehicles (see MyPolisLive.net).

This work has demonstrated the strength of combining datasets for developing KPIs and the potential of crowdsourcing for smaller SM LAs. All SUITS outputs have been documented [8] and LAs are free to use the resources on the websites. Further support is also offered through SUITS' capacity building program.

2.2. Capacity Building Programme (CBP)

Working extensively with the transport departments of partner cities (Alba Iulia, Transport for West Midlands, Kalamaria, Turin, Rome and Valencia and follower cities of Dachau, Stuttgart and Palanga) SUITS has determined firstly existing gaps in knowledge and secondly what changes need to be made within the organizations for them to work more effectively, apply, use and measure the impact of capacity building measures. This has confirmed that LAs face many challenges developing sustainable urban planning measures and deploying innovative mobility solutions and technologies. Despite comprehensive EU Guidelines, LAs may struggle to perform exhaustive preliminary analyses, develop SMART goals coupled with long-term vision and impact assessment. Furthermore, substantial drawbacks occur in the implementation phase, particularly in terms of improving conceptual planning processes and establishing sustainable financing schemes. This derives from the lack of appropriate expertise and organizational structures which impede innovation and barriers to interdepartmental working needed for smart city development.

Requirements analysis and reviews of existing guidelines, has led to the development and implementation of 6 tailorable modules, especially designed for SM LAs which aim to 1) increase the capacity to develop and implement sustainable, inclusive, integrated and accessible transport; 2) support development of SUMPs by transforming them into learning organizations and 3) increase resilience and responsiveness of transport departments to new challenges and changes.

The 6 modules relate to:

1. Implementation of emerging transport technologies
2. Introduction of innovative transport schemes
3. Implementation of urban transport safety and security measures for all users
4. Implementation of urban freight transport measures
5. Innovative financing, procurement and business models
6. Data collection and analysis tools for integrated measures

Each module includes a Facilitator Guide, appropriate training material delivered either as classroom courses or e-learning modules. The courses have been structured in order to clarify the value of measures for SM LAs, analyse successful case, present innovative financing and procurement procedures tailored to topic requirements as well as tools and guidelines for the enhancement of measures' implementation and user engagement.

The CBP has been assessed piloted with SUITS cities. In the next 12 months, all material will be released (in Italian, Spanish, Portuguese, Greek, Lithuanian, German, and Romanian) as the SUITS Capacity Building Manual and Toolbox (freely available to the Open Research Data Portal and to the CIVITAS Urban Mobility Tool Inventory).

2.3. Organizational change

As a CIVITAS project SUITS supports the view that Sustainable Urban Mobility Plan" (SUMP2.0) is an important part of sustainable urban transport innovations. A SUMP is a strategic transport plan that helps cities to deliver on their sustainability objectives by outlining the city's transport and mobility measures. Not all cities, and especially SM cities, have the resources to develop such wide scale plans [1].

Therefore, SUITS' outputs support cities developing sustainable transport measures. The nature of the organizations (i.e. local authorities) responsible for the design and implementation of transport measures is a key factor in the in the design and implementation of sustainable transport measures.

To do this, the transport departments in LAs must increase their organizational capacity. Many are already facing extremely challenging situations, affecting and disrupting their business model and institutional logic, which threatens public sector employees. Organizational change is a necessity, driven by socio-political-environmental and financial imperatives.

In the context of transport and mobility, the technology is already in place, it is the employees in local authorities which need to be considered as without their support and knowledge sustainable transport measures will not be implemented. Employees have to be willing, able and motivated to deliver against sustainability targets. To do so requires them thinking and working in new ways, with new teams, using new information and supporting technologies which they are unfamiliar with.

By bringing technological/technical and social/behavioural change together, organizations can achieve better operational performance. Recognizing the importance of these two facets of change, SUITS is demonstrating how a socio-technical approach to change in LAs underpins implementation.

A learning organization is one "skilled at creating, acquiring, and transferring knowledge, and at modifying its behaviour to reflect new knowledge and insights" [4, p.3]. It is characterized by establishing and communicating a clear sense of direction and purpose; empowering employees at all levels; accumulating and sharing internal knowledge; gathering and integrating external information; challenging the status quo and enabling creativity [5].

SUITS has developed, in consultation with its city partners an 8-step approach to transforming traditional transport departments in to learning organizations. The steps are outlined in Table 1. All cities are working through, and supported in, working through the stages, with action learning sets, joint city workshops, regular exchanges with the Coventry team and feedback reports. Cities are now entering steps 7 and 8 of the cycle, with the whole socio – technical approach due for completion and write up in 2010.

Table 1. 8 Steps for organizational change

Step 1	Understanding the urgency for organizational change
Step 2	Creating a guiding coalition
Step 3	Developing the change vision
Step 4	Communicating the change vision
Step 5	Empowering broad-based action
Step 6	Generating short term wins
Step 7	Consolidating gains and producing more change - Evaluation
Step 8	Adopting new approaches in the organizations

3. DISCUSSION AND CONCLUSIONS

SUITS is one of a number projects which aims to support local authorities in the development of sustainable transport measures (www.eltis.org). Such projects can proceed with or without a SUMP. SUITS outputs are supportive of, and feed into the SUMP 2.0 planning, but do not require LAs to have one to use the outputs.

There has and will continue to be massive investment in different forms of sustainable transport projects and development of new transport technologies. Having worked on SUITS for 3 years and FP7 METPEX prior to this [3], it is difficult to underestimate the challenges which cities face – in gaining investment, choosing the right technology, the right transport measure, in working with new concepts and in engaging the public and convincing them to switch transport modes. Although painful, with so many pressures, LAs need to buy into and use the resources provided by projects such as SUITS, to make sure that they make the right decsions for their city and their citizens.

Technology and large infrastructure projects continue to attract the largest funding, the biggest headlines, but they have been shown to not provide equal benefits to all citizens, or even be value for money. LAs are often left to struggle with obsolete technology, disruptive technology which may decrease inclusivity and cause extra problems [2].

The heart of sustainable mobility debate does not lie with open data, CAV or electric vehicles, at its heart are those who deliver the service in the city and those who have to use it. H2020 CIVITAS SUITS has tried to address these needs, but future funding calls need to continue to ensure that people and LAs are placed at funding.

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ENHANCING COMPETITIVENESS AND INNOVATION IN THE GREEN AND SMART MOBILITY

Key Words
Green and smart mobility;
Urban mobility;
Innovation;
Competitiveness;
Sustainability;
Market intelligence;
Public funding;
B2B matching;
Smart cities

Abstract
Accelerated urbanization, technological development and raise in awareness of man-made impact on the environment evoked the need for greener and smarter mobility in urban areas all over the world. While green and smart industry is growing worldwide, small and medium enterprises (SMEs) in the green and smart mobility sector (GSM) in Bosnia and Herzegovina's are struggling to be competitive and innovative. Primarily due to the lack of systematic support. This paper focuses on the analysis of the needs of GSM industry in BIH in field of market intelligence, business-to-business matching and public funding screening, developed and tested pilot services. Lessons learned are presented and recommendation for future steps are proposed in order to provide the needed support for the development, innovation and competitiveness of the GSM sector in BIH.

1. INTRODUCTION

Contemporary development and the growth in the number of inhabitants in major cities of Bosnia and Herzegovina (BIH) (i.e. Sarajevo, Banja Luka, Tuzla, Zenica, Bijeljina) with the tendency of creating one urban area, have brought a number of demands for increased mobility and more efficient provision of transport services. There is a need to utilize sophisticated and innovative methods, techniques and technologies when it comes to the organization of urban transport.

The ongoing debate with regards to transport and the environment is paradoxical. On one hand, transport activities support increasing demand for mobility of passengers and goods, especially in urban areas. Whereas, on the other hand, transport activities manifested in increased motorization and congestion in traffic. As a result of this, the transport sector is becoming more and more related to environmental issues. With technologies that are almost completely based on the use of oil and its derivatives, as well as internal combustion engines, the impact of transport on environmental (ecological) systems has increased. In recent years, this has reached a point where spatial accumulation of transport is the dominant factor behind the emission of most pollutants and its environmental impacts.

As a solution to these evident problems, the concept of Green and Smart Mobility (GSM) has been proposed which is in line with European Union ambitious climate and environmental policy whose implementation can transform modern cities economically, socially and environmentally, and support formation of smart cities. Green and smart mobility includes transport services and technologies (vehicles and components, computer applications, clean fuels, infrastructure, etc.) aiming to improve the mobility of people and goods and to reduce its environmental impacts. It concerns different sectors (i.e. transport and logistics, automotive, information technology, energy, etc.). It is developing quickly as a result of technological change but also in response to the growing need of reducing the environmental impacts of transport in the context of more and more restrictive environmental policies.

This concept has been rapidly growing all around the world, while in Bosnia and Herzegovina lacks fundamental business support to achieve noticeable growth. Therefore, the progress has been slow. Having that in mind, this paper is focused on the analysis of needs of the GSM industry in BIH in field of market intelligence, business-to-business (B2B) matching and public funding screening, developing and testing pilot services for GSM SMEs. Lessons learned are presented and recommendation for future steps are elaborated and proposed in order to provide the needed support for the development, innovation and competitiveness of the GSM sector in BIH. Following the introductory part, the theoretical background and methodological framework of this paper are presented. Finally, the results of the implemented activities are analyzed, important conclusions drawn, and suggestions for future steps provided.

2. THEORETICAL BACKGROUND

2.1. Green and Smart Mobility

Urban mobility that is smart – and green in consequence – is referred to as GSM and – in the light of the definitions provided by Lyons [1]; Bąk Makolska-Tenold [2];

Chon and Lee [3]; WBCSD [4]; ECMT [5]; and Manville et al. [6] – is defined as a mobility system that performs efficiently with the aid of new technologies and to the benefit of all economic, social and environmental aspects. In other words, a mobility system that supports growth and development, equity and inclusiveness, and sustainability and nature preservation, all at once. By being multi-faceted, GSM facilitates efficiency in all terms of lower costs, reduced emissions and improved services. Although green is included in smart, the GSM term is preferred to the others (or new ones) as it stresses the importance of both research (and practice) streams and makes the meaning of the concept clearer.

GSM targets and succeeds in reducing the environmental impact of transportation by maximizing its efficiency, speed and intelligence. This is facilitated by reducing the amount of travelling, boosting modal shift, and minimizing the length of trips. Consequently, GSM manages to decrease certain mobility constraints and minimizes traffic-related risks and aggravating factors (i.e. accidents, noise, smog), reduce the effect of time and land loss, and to create broad economic and societal benefits (i.e. livability, health and safety improvements, equal opportunities) [7] and [2]. Based on our screening of the market actors, within the project, we classified GSM SMEs into eight groups according to their primary activity:

- Transport Infrastructure / Infrastructure Technologies,
- Environmentally Acceptable (Clean) Fuels,
- Low Carbon Economy,
- Green / Eco-Friendly or Clean Vehicles,
- Intelligent Transport Systems (ITs),
- Cooperative ITs (C-ITs),
- Mobility as a Service (MaaS) Or Transport as a Service (TaaS),
- Automated Vehicles,
- Planning and Education in Mobility.

2.1. Business Support Services

In order to achieve such sustainable solutions efficiently, the need for a supportive network becomes apparent and requires the participation of actors that are active in different green and smart mobility sectors and areas of application. This supportive network should include services that can improve the GSM industry performances and enable its growth, in terms of market intelligence, B2B matching and access to public funding, which are defined below.

Market Intelligence is a term that is used to describe the “holistic collection of internal and external business environmental data, by a business, which is to be used to make decisions on the viability of the current business market” [8]. Kohli and Jawoski [9] identified three core marketing intelligence processes:

- Marketing intelligence generation refers to finding the customer needs and market defining factors (i.e. regulation, technology, competitors, environmental forces, etc.).

- Marketing intelligence dissemination refers to the diffusion of the aforesaid information to the organization (or the network) for analysis, and finally
- Market responsiveness refers to the actions taken after analyzing the gathered information.

B2B Matching is “the process in which agents, representing traders that are interested in having exchange of economic value are put in contact with potential counterparts to negotiate” [10]. In other words, it is a usual marketing tactic that matches companies together on a basis of their needs, strategies, and organizational philosophy. There are several forms of B2B matching that range from employing intermediaries and agents, to large gatherings, and online applications/services. The two most important forms are B2B trade fairs and online B2B matching services [11].

Public Funding Screening is a term that describes every process with a view to assess the potential existence of available public funding opportunities and initiatives [12]. In this particular case, public funding screening refers to monitoring of relevant EU and national programs and funds. Public funding screening must not be viewed and understood only in purely financial terms, but every potential intervention must be viewed holistically and within a more general perspective [13] to generate long-term and sustainable outcomes [14].

Under the light of the discussed literature and the proposed definitions, and in understanding the GSM in depth, a look at the business support concept’s practical nature is deemed as important. In doing so, the following research questions have been developed:

1. What are the needs of “Green and Smart Mobility Industry” in BIH?
2. How can business support accelerate the growth of “Green and Smart Mobility Industry” in BIH?
3. What are the future steps for the development of “Green and Smart Mobility Industry” in BIH?

3. METHODOLOGICAL APPROACH

By answering the aforementioned question, a research methodology was employed based on this paper for the following steps:

- Market analysis which included a survey of the GSM SMEs needs, requests, obstacles, and their capacities for innovation and enhancing competitiveness,
- Development and testing of three pilot services for market intelligence, B2B matching and public funding screening,
- Analysis of results and evaluation of pilot services impact on SMEs,
- Defining future steps for enhancing the GSM industry in BIH.

4. GSM MARKET ANALYSIS

The market analysis survey was conducted on a sample of 21 SMEs from Bosnia and Herzegovina, mostly based in the wider Sarajevo region, who answered in detail and concrete 28 questions for the purpose of defining innovative capacities, potentials and developmental needs in terms of market intelligence, B2B networking and access and usage of funds, and assessing their readiness to test out new pilot services that could help out their development and growth.

The 21 SMEs that filled out the questionnaire pointed to the fact that BIH possesses (albeit undeveloped) GSM industry, and that the market is dominated by small enterprises with less than 250 employees who are majority (83%) on the market for over 5 years. Also, the survey indicated that companies are targeting a small number of workers to green and smart mobility - an average of less than 35% working in the before mentioned GSM sectors, which is also the main basis for the recorded low average growth rate of companies below 15%.

Concerning the market intelligence, B2B networking and access and usage of funds, the survey showed that:

- 80% of companies do not analyse their position compared to other companies in the market,
- 76% do not use services, programs or market data sources or market analysis,
- 71% of companies are not familiar with the available B2B events within the region and the EU,
- Companies rarely participate in B2B events, the main reason/goal for their participation is mostly to find new costumers or place a product on a foreign market,
- Key parameter for decision making on participation is magnitude of the event and number of participants,
- 76% of companies are not familiar with available grants or loans within the EU and the region,
- 81% of companies do not use sources of grant or credit information and calls within the EU and the region,
- 76% of companies do not possess the needed knowledge to apply for EU and regional calls for funds and projects,
- All of the SMEs are willing to test and see the need for development of new business services that could help them be more competitive and innovative.

5. ENHANCING GSM INDUSTRY IN BIH

Based on the above listed findings of SMEs survey in the GSM sector, three pilot services were developed:

1. Market Intelligence Readiness Level tool – as market intelligence service,
2. Handbook for application to EU funds – as public funding screening service,
3. Handbook for B2B events – as B2B matching service.

The tool for market intelligence readiness level (MIRL) had an objective to allow SMEs evaluate its potential position on other markets, customers or the competition and provide help in making sound business decisions which will allow them embrace new market opportunities. The tool is based on calculating market intelligence indexes, using well-known models for the level of readiness and helps

SMEs to determine the level of technical, non-purpose, production, and commercial maturity. The market intelligence service was tested with three companies that are working in the fields of green vehicles and information communication technologies (ICT) and have shown potential and ambition to expand their markets. The companies perceived the tool as a valuable asset in determining their week points and enabled them to improve their business and make it ready for entering the new markets. Using the tool, two of these three companies, reshaped their business and adapted it to the needs of BIH regional market, and have successfully positioned themselves as leaders in producing green and smart mobility solution in the region.

Handbook for applying to EU funds [15] was prepared with the goal of distributing the information on availability and conditions for applying to EU funds to help fund the innovative projects in GSM sector. The handbook included a list of available EU funds, identification and detailed information of most relevant EU funds (relevance for each GSM sector, general information about the call, conditions for applying, etc.) and provided advice for the further application process and screening of new funding opportunities. The pilot service was tested on nine companies, with low or none experience in applying to EU funds. Seven companies provided feedback that after receiving information about the available funds, they have applied for funding of their new innovative projects that will bring new GSM products and services to BIH market.

The Handbook on B2B events [16] aimed to assist SMEs in the following segments:

- organizing B2B events targeting a specific sector with green and smart mobility,
- participation in a regional / national / international B2B event,
- promoting networking activities with other relevant clusters / networks,
- identification of joint actions / services for setting up a regional network / association / cluster in the green and smart mobility sector.

The handbook contained information such as regional / international meetings, web addresses of events, contact information's, programs and objectives of the events, obligations of the participants, form of participation, funding models, types of participants and benefits that they can gain from going to that specific event. This kind of B2B service, as was proven through testing with 15 SMEs, and cooperation and communication between companies helps in the development of cooperation, experience and knowledge sharing in the fields of technology and product development, therefore represents one of the necessary first steps in BIH to help and support the development of GSM industry. Eleven out of the 15 companies used the handbook as the tool that helped them decide to participate in EU fairs and conferences, emphasizing that the participation helped them form new partnerships that will for sure enable their growth and make them competitive with the traditional and highly polluting mobility product and service providers.

6. CONCLUSIONS AND FUTURE STEPS

From the activities undertaken and presented in this paper, we can conclude that the state of the GSM sector in Bosnia and Herzegovina is unregulated, and that there is a high potential for further improvements. The companies lack business support to help them overcome the barriers to accessing the markets and implementing their innovative solutions for enabling green and smart mobility in BIH.

The above presented pilot services have shown that even simple actions, such as improving the information flow can have high influence on business development. The greatest potential can be found in enabling access to project financing, where GSM SMEs can use available EU funds to develop new services and products and enhance their development, while at the same time supporting the development of Bosnia and Herzegovina's society and Sarajevo as a future green and smart city.

However, actions such as these, can be seen just as first step towards enhancing competitiveness and innovation of GSM in BIH. For further and more noticeable growth, it is necessary to further invest into development of business support services and gain institutional financial and regulatory support, as the lack of interior funds of the GSM SMEs in BIH makes it harder to penetrate new markets and bring innovative ideas to implementation phase. Only with this kind of support can the green and smart mobility industry achieve its potential and directly support the development of smart cities in BiH.

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SUSTAINABLE URBAN MOBILITY PLAN FOR MUNICIPALITY OF VELES 2019-2030

Key Words

Sustainable urban mobility plan;
Traffic planning;
Traffic studies

Abstract

Integrative traffic planning is a new way of planning that originates from experiences and good practices of many European cities and regions that have been working on successfully implementing its key principles. Its main objective is to reduce environment related burden caused by transport system and contributing to establishment of a sustainable, livable, attractive, accessible and healthy environment. The central element of the integrative traffic planning is Sustainable urban mobility plan (SUMP). It is based on EU documents and guidelines set by European commission. Integrated traffic planning does not reject, but upgrades current planning practices and it has a long-term and strategic vision striving towards sustainable mobility. SUMP is a document in which the Municipality of Veles drafted a set of measures which will help achieve a shift toward more sustainable transport modes and higher quality of living. The key to the change is a shift towards integrative traffic planning.

Public involvement in all stages of the planning process allows set a clear vision and goals whose achievement is measurable and that are accepted by relevant stakeholders and general public. SUMP of the Municipality of Veles is aiming towards an attractive public passenger transport, branched network of safe cycling routes and good conditions for pedestrians. It focuses on city center as a regulated, attractive, accessible and safe urban space. This paper summarized the sustainable measures and projects that are planned for implementation and have impact on the city and its inhabitants.

1. INTRODUCTION

Integrative traffic planning is a new way of planning that originates from experiences and good practices of many European cities and regions that have been working on successfully implementing its key principles. Its main objective is to reduce environment related burden caused by transport system and contributing to establishment of a sustainable, livable, attractive, accessible and healthy environment.

The central element of the integrative traffic planning is Sustainable urban mobility plan (SUMP). It is based on EU documents and guidelines set by European commission. SUMP offers possibility for transition from classic to modern and comprehensive traffic planning. Integrated traffic planning does not reject, but upgrades current planning practices and it has a long-term and strategic vision striving towards sustainable mobility.

SUMP is a document in which the Municipality of Veles drafted a set of measures which will help achieve a shift toward more sustainable transport modes and higher quality of living. It is aiming towards an attractive public passenger transport, branched network of safe cycling routes and good conditions for pedestrians. It focuses on city center as a regulated, attractive, accessible and safe urban space. Municipality of Veles will use the proposed document to upgrade existing spatial acts and strategic documents, leading to more comprehensive planning and inclusion of sustainable strategies into planning act.

2. SUSTAINABLE URBAN MOBILITY PLAN (SUMP)

A Sustainable urban mobility plan (SUMP) is a document that incorporates and upgrades existing strategic documents of municipality. It is a new way of thinking and planning that represents a step towards more sustainable traffic planning in the region - in line with modern guidelines and recommendations of the European commission.

SUMP is comprehensive integrated traffic planning that upgrades current planning practices and it has a long-term and strategic vision striving towards sustainable mobility. Sustainable urban mobility plan is a result of the participation of an expert group on transport planning, local authorities and affected social groups. Local institutions and citizens played an important role in the creation of the document as their values and proposals serve as a basis for proposed measure packages.

The planning process consists of eleven main steps made up of 32 activities. They should be taken as part of a regular planning cycle in the sense of a continuous improvement process.

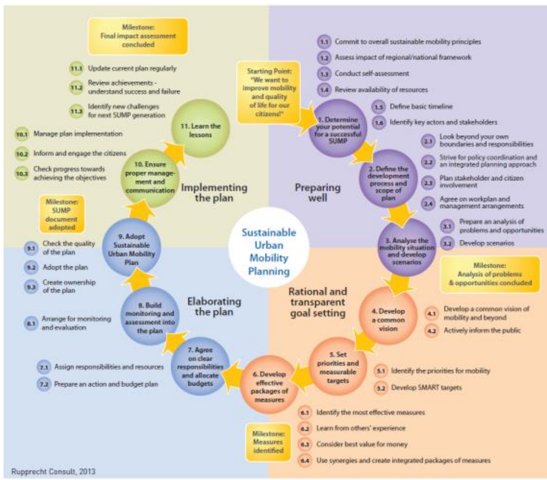


Figure 1. Planning cycle for a sustainable urban mobility plan, source: Guidelines, 2014, https://www.eltis.org/guidelines/sump-guidelines

3. SUMP OF MUNICIPALITY OF VELES

The document reflects the planned development of city of Veles and is prepared in line with existing spatial and urban planning documents. Individual measures can be implemented and coordinated with existing and incorporated in future planning documents. Infrastructural projects will be implemented in connection with soft measures, aimed at reducing demand for private motorised transport and incentivising other more sustainable modes of transport, strengthening each other's impacts.

In course of preparation of the document, public consultations regarding challenges and opportunities that municipality faces were held with local authorities and interest groups. The participants presented their aspects and views on the existing situation in the municipality while their comments were evaluated and utilised in preparation of proposed vision and measures.

3.1. Challenges

An analysis of the current situation in the Municipality of Veles was made in the framework of the development of the Sustainable Urban Mobility Plan.

Identification of current situation represents an important step in achieving sustainable mobility in the municipality of Veles.

UNSUSTAINABLE TRAVEL HABITS - In the development of Sustainable Urban Mobility Plan, a questionnaire was prepared for the general population of municipality. The survey of 4200 inhabitants (almost 10% of population) examines travel habits and the opinion of citizens on the current situation in the field of transport. Majority of population (53%) uses car as primary means of transportation. Other more sustainable means of transport are used by 47% of respondents of which 39% are pedestrians, 7% use JGPP and cycling only 1%.

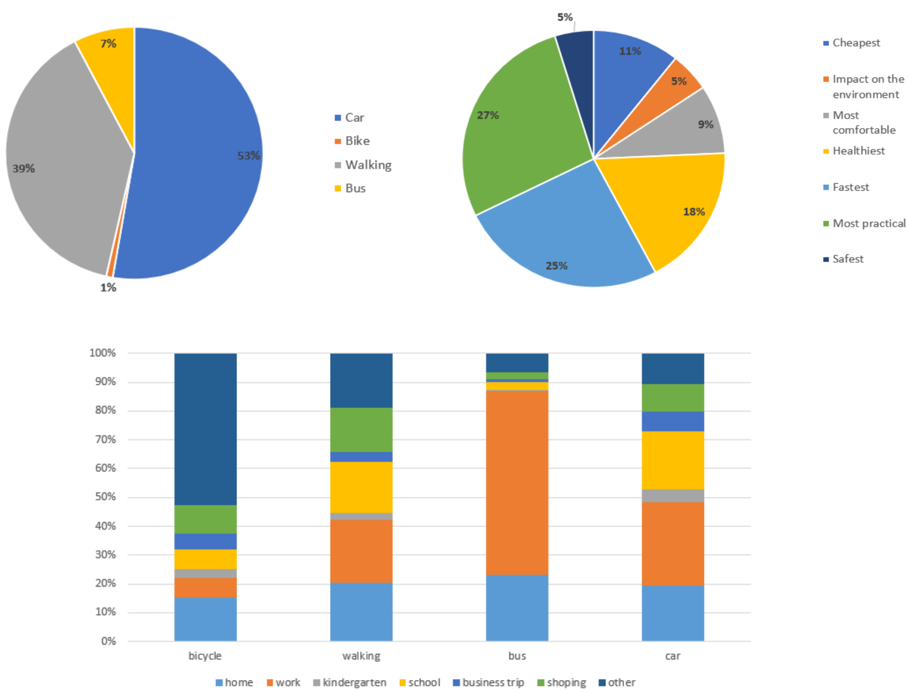


Figure 2. Modal split and purpose of trip by individual means of transport

LACK OF INTEGRATED TRANSPORT PLANNING -Traffic planning investments were oriented in motor traffic and in most of the cases were carried out within the framework regulation of motor traffic.

REDUCED ACCESSIBILITY FOR PEDESTRIANS - While the city centre is well equipped with pedestrian infrastructure the existing sidewalks are in many cases deteriorated, their surfaces are in bad condition and there are frequent conflicts in relation to other traffic modes (parking, crosswalks) in addition the infrastructure is inadequately equipped for access of sensory and physically impaired citizens.

UNSUITABLE CONDITIONS FOR CYCLISTS - Despite many advantages of cycling there is almost no cyclist infrastructure available in the Municipality of

Veles. In most of regional and local roads the cyclist is a subordinate position compared to the motor traffic.

UNOPTIMISED PUBLIC PASSENGER TRANSPORT - Public passenger transport has been largely neglected in urban planning after the increase in motorization and could not flexibly follow personal car use. Only 7% of citizens use public transport as their main mode of transport for daily trips. More than half of respondents never use public transport, and 31% use it rarely.

HIGH DENSITY OF MOTOR TRAFFIC IN CITY CENTRE – City of Veles is located on the X European corridor. The consequence of heavy traffic load (especially freight traffic) is a decrease in road safety and quality of life due to noise, vibrations and emissions. Illegal parking occurs on sidewalks, bus stops, traffic lanes and greenery and hinders accessibility for pedestrians (especially for people with disabilities) and cyclists and additionally decreases the attractiveness of the area.

3.2. Vision and objectives

The Municipality of Veles has the potential for successful future development of transport and the vision has been established as: *"The City of Veles will implement people-centric and environmentally friendly transport policy. Integrated and innovative approaches will encourage the establishment highest level of road safety and an environment for high quality of life and benefits local economy and tourism. „*

Strategic objectives proposed in this document strive for liveable urban environment and safe and accessible transport network based on sustainable planning principles:

- Greater accessibility for all population groups for a higher quality of life in the municipality,
- Establishing greater integration, competitiveness and accessibility among all transportation modes, with an emphasis on existing public passenger transport,
- Establishing a smart parking policy that will relieve the city centre of vehicular traffic,
- To halve the number of accidents with serious injuries and to achieve zero mortality on the roads in the municipality,
- Promotion of sustainable travel methods for all groups of citizens, with an emphasis on young people.

3.3. Scenarios and transportation model

Within the framework of the working group and cooperation with stakeholders, four scenarios for the development of the transport network in the Municipality were designed. For each scenario, measures were identified that are integrated and verified using traffic modelling tools for the period 2019 to 2030 year.

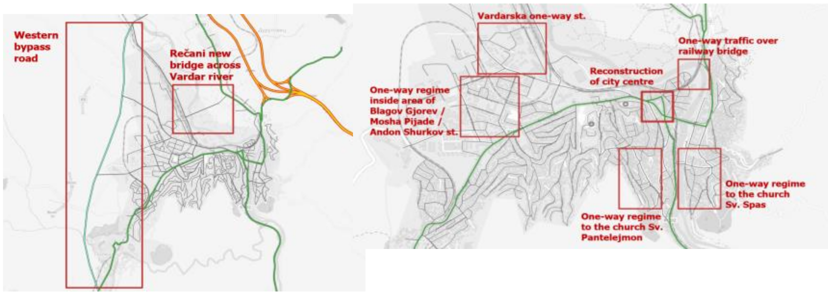


Figure 3. Different scenarios and measures for development of transport network

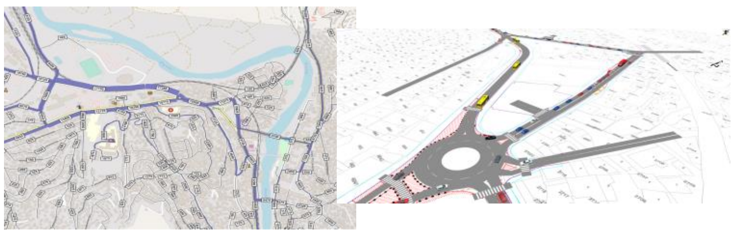


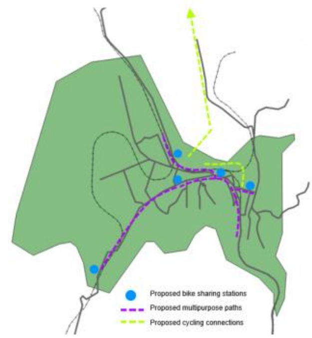
Figure 4. Transportation model and traffic simulation of city center

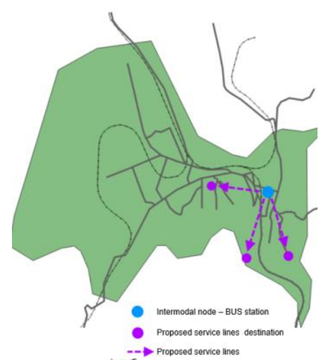
4. SUMP MEASURES

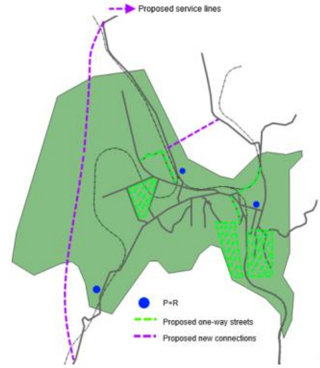
Sustainable urban mobility plan of the Municipality of Veles is based on five key areas of action. The objectives have been defined for five intervention areas and a set of measures was assigned to each of them. Measures include infrastructural projects and soft measures which will be developed and implemented and represent tools for implementation of the Plan. By realizing goals in complementary strategic areas, the vision of an intelligently organized city in the field of transport can be achieved.

	MEASURE - EFFECTIVE GOVERNANCE
G1	Acceptance, commissioning, revision and reform of the SUMP
G2	Personnel training in field of sustainable mobility and its implementation in planning processes
G3	Preparing a balanced budget
G4	Periodic survey on travel habits
G5	Promotional and educational campaigns for promotion of sustainable transport modes

	MEASURE – PROMOTION OF WALKING AS IMPORTANT TRANSPORT MODE
W1	Pedestrian areas
W2	Implementation of safe pedestrian crossings
W3	Building a new and improving the current infrastructure
W4	Adaptation of infrastructure for people mobility impairments
W5	Safe school routes documents
W6	Promotion of walking
	MEASURE – BICYCLING IMPROVEMENT
C1	Arrangement of cycling along the main road across the city
C2	Regulated traffic signalling on long distance cycling routes
C3	Construction of the bicycle network - multipurpose paths
C4	Parking lots for short-term and long-term parking of bicycles
C5	Bike rental system
C6	Promotion of cycling
	MEASURE – PUBLIC TRANSPORT DEVELOPMENT
P1	Improvement of existing bus stops and arranging safe access for Public transport users
P2	New bus service lines
P3	Reassignment of main bus station into intermodal transport centre
P4	A comprehensive study of the development of Public transport
P5	Public transport on-demand
P6	Promotional campaigns to promote the use of public passenger transport
	MEASURE – TRAFFIC FLOW OPTIMIZATION
M1	Implementation of a parking policy
M2	Regulation of one-way roads
M3	Implementation of P+R system
M4	Analysis and registry of accident blackspots
M5	Expanding the network of charging stations
M6	Extension of the road network
M7	New environmentally friendly vehicles
M8	Urban consolidation centre







5. CONCLUSION

Measures and projects that have impact on the city of Veles and its inhabitants are planned and will be implemented in line with the framework proposed in this document. Strategic transport development practices are in synergy with urban development of the area and give priority to increasing quality of life by promotion and implementation of sustainable measures.

Adoption of the SUMP of Municipality of Veles does not mean its conclusion, but a transition to its implementation.

The planning process will not come to an end with adoption of Sustainable urban mobility plan of Municipality of Veles. The process will continue with gradual preparation and implementation of proposed measures. The monitoring system is set to evaluate implemented measures and their contribution to set strategic goals. Integrated traffic planning is a cyclic process and should be considered as a continuous improvement process with regular reassessments and renewals.

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THE IMPACT OF DOUBLE-PARKED DELIVERY VEHICLES ON TRAFFIC CONGESTION IN URBAN AREAS

Key Words

Traffic congestion; Urban freight transport; Double-parking; Sustainable city logistics

Abstract

Road traffic congestion generates many problems in urban areas, such as delays, increased fuel consumption, contribution to air pollution, etc. Urban goods delivery operations typically occur on the streets, which significantly contributes to the occurrence and amount of congestion. This paper investigates the negative external impact of double-parked delivery vehicles in order to perform loading operations when there are no separate loading areas. Therefore, the data on the vehicles affected by the double-parked delivery vehicles are needed for the purpose of the research. The data collection is conducted by video recording of delivery operations on the streets of Novi Sad (Serbia). The results of the analysis show that the total annual delays are 264,4 hours on two-lane street and 866,5 hours on four-lane street. The above results are related to the current state in year 2019 (base scenario). The delays for the year 2029 (projected scenario) are estimated to increase for about 135% on two-lane street and 90% on four-lane street. The research results will be discussed in the context of the sustainable urban logistics development.

1. INTRODUCTION

Sustainability of the system involves the use of existing resources to meet the current needs of people, but in a way to ensure that the needs of the future population can be met. Sustainable logistics, aims to meet the needs for moving material goods at the right time, in the right place with limited impact on the social, environmental and economic aspects of human society [1].

Congestion is one of the main problems which do not contribute to sustainable city logistics principles. The urbanization trend tends to increase the number of people in urban areas and, consequently, to increase the demand for goods. Therefore, there is an increasing risk of traffic congestion in large urban areas due to higher demand for goods transport.

The aim of this research is to determine the impact of double-parked delivery vehicles on congestion in medium-sized cities. In order to reach the aim, we analyzed the relation between the duration of delivery vehicles on-street parking and their impact on other vehicles in the traffic flow. The time lost by the delivery vehicle can be seen as internal effect because it is accounted by transport company. However, the time lost by other road users because of the double-parked delivery vehicles is an external effect. The impact on other vehicles in the traffic flow is observed through the dwell time behind the double-parked delivery vehicle.

In the second Section, the sustainability basics and traffic congestion are described. The third section the research methodology is explained in the third Section, and in the fourth Section the results of the research are shown and discussed. The Section 5 gives concluding remarks of the research conducted in this paper.

2. SUSTAINABLE LOGISTICS AND TRAFFIC CONGESTION

In recent decades, there has been an increasing absorption of natural resources as a consequence of poor planning. The increasing population growth is uncontrollably affecting the destruction and pollution of the environment. The increasing negative impact on the environment will result in an increased decline in food supply and an increased energy consumption in the following decades [2]. It is necessary to find solutions to ensure the growth and development of the human population, but at the same time to ensure the conservation of natural resources. Conservation of resources, prevention of negative impact on the environment and bringing the best balance in the development of human society are possible only by applying the principles of sustainable development [1]. Sustainable development represents meeting the needs of current generations without compromising the ability of future generations to meet their needs [3].

In order to ensure a sustainable transport system, it is necessary to ensure sustainability throughout the supply chain from the first producer to the final consumer. Demand for transport is increasing and thus there is an increasing need for the introduction of sustainable supply chains and sustainability in all logistics processes [4]. The problem of sustainable development is directly linked to the development of the economy and society.

The logistics branch that deals with sustainability of urban areas is named city, or urban logistics. Cities, as places of concentration of economic activities, are the basic areas in which the sustainability of the logistics system can be implemented. In order to ensure the sustainability of logistic activities in the city area, primarily urban freight transport, various measures have been defined. These can be divided into political measures initiated by local government and measures initiated by companies involved in the implementation of logistics activities [5].

Urban freight transport is one of the causes of traffic congestion. Parking, loading and unloading vehicles are challenging parts of urban delivery, due to the lack of space. Also, the double-parking of the delivery vehicles for loading/unloading processes causes traffic congestion in cities by interrupting the traffic flow and temporarily reducing road capacity. Better planning for moving and stopping trucks allows a potential reduction in congestion in cities [6]. Therefore, it is necessary to understand this problem and measure its impact.

3. RESEARCH METHODOLOGY

The initial phase of the research involves data collection. The first step is to choose representative streets where data should be collected. One of the most important criteria for selecting a street is the type, number and density of the facilities. Commercial establishments such as consumer goods retail outlets, computer equipment stores, bakeries and other similar objects require product delivery several times a week, and some of them require daily deliveries. Also, facilities such as coffee bars and restaurants also require frequent delivery of food and beverages and frequent collection of return materials. For these reasons, city streets that have a large number and density of described facilities should be preferred.

Delivery vehicles that do not have reserved space for loading and unloading operations most often stop on the roadway, thus occupying the surface intended for the movement of vehicles. This problem often occurs in densely populated urban areas. Therefore, the city centre and areas near by the central district should also be preferred for the survey location.

The extent of impact on other road users is in direct correlation with number of traffic lanes per direction of traffic movement. Therefore, the data sample should be collected from the different lane-per-direction structure of the street.

Next step of the research is to choose the periods of the day when the data should be collected. The two characteristic periods for traffic congestion are: peak and off-peak period. The peak periods occur when people are traveling to work (morning peak period) and when people are returning home from work (afternoon peak period). The off-peak periods are periods other than peak periods. The data was collected from both periods because of the different traffic patterns.

There are different ways of the sample collection from the field. The preferred collection method for this research is video recording of the delivery operations. After the field collection is finished, the recordings can be analyzed multiple times. This is why this method of sample collection ensures the high quality and completeness of the data collected.

Based on the video, the double-parking times and the number of delivery vehicles in the observed streets were determined. Also, the number and the time spent by the vehicles that had to stop behind the double-parked delivery vehicle is determined, as well as the number of vehicles that overtook the double-parked delivery vehicle without being affected.

The selection of the surveyed street was made on the basis of various criteria, such as: the number of traffic lanes, the location of streets, the number of retail and commercial establishments in the observed streets, such as the protocol reached during the day.

We analyzed the case study of Novi Sad. There is a number of streets that fit the criteria described in the methodology section and two streets have been selected for the purpose of research:

- The Danila Kiša Street;
- The Novosadskog sajma Street.

Danila Kiša Street is a two-lane street (one traffic lane per direction of movement) and the street is 480 meters long. The street is located near by the central city district and there are various types of facilities. There is organized parking on the Danila Rain Street parallel to the roadway but there is no reserved parking space for goods delivery vehicles. From the source [7] one can obtain the flow of vehicles in the observed street at the busiest hour and it amounts to 307 veh/h.

The Novosadskog sajma is a four-lane street (two traffic lanes per direction of movement). This street is also located in the vicinity of the central city area, its length is 850 meters. At the part where the video recording took place there are two cafes, two grocery stores, three bakeries, a bus stop and two access streets. In the observed part of the street the traffic flow is 781 veh/h [7].

Data were collected by recording videos over 3 periods during the day. For both observed streets, the data were measured in three 2-hour periods:

- period 1 - the morning peak from 08:00 to 10:00,
- period 2 - off-peak period from 12:00 to 14:00, and
- period 3 - afternoon peak from 16:00 to 18:00.

4. RESULTS AND DISCUSSION

4.1. The two-lane street analysis

For the analysis purpose, all the vehicles in the traffic flow were divided into two categories: affected and non-affected vehicles. Affected vehicles are those that had to stop behind the delivery vehicle. Non-affected vehicles are those that had a free lane from the opposite direction and could overtake the double-parked delivery vehicle without stopping. This data is shown in Figure 1.

In order to identify the magnitude of the problem observed, we determine the number of vehicles in a period of time affected by the double-parked delivery vehicles. The data shown in Figure 2 present the total number of affected vehicles divided by the total time the delivery vehicles were double-parked in each period. In such a way the number of vehicles per hour affected by the double-parked delivery vehicles is obtained.

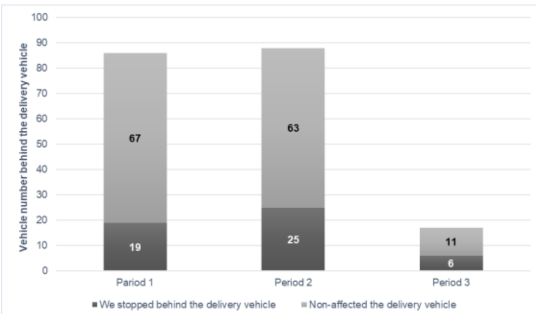

Figure 1. The delivery vehicle double-parking impact on two-lane two-way street

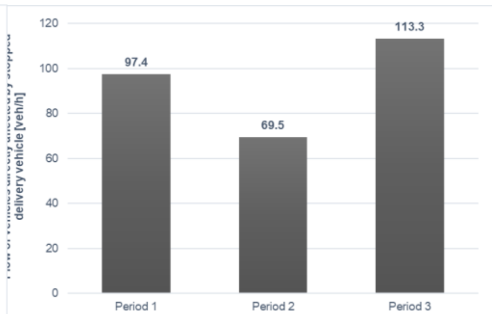

Figure 2. Affected vehicles per hour of double-parking on two-lane two-way street

4.2. The four-lane street analysis

In this case, the vehicles were also grouped into two categories: affected and non-affected vehicles. This data is shown in Figure 3.

The data shown on Figure 3 and Figure 4 are similar like the data on Figure 1 and Figure 2. The difference is that data shown on Figure 3 and Figure 4 are related to four-lane two-way street.

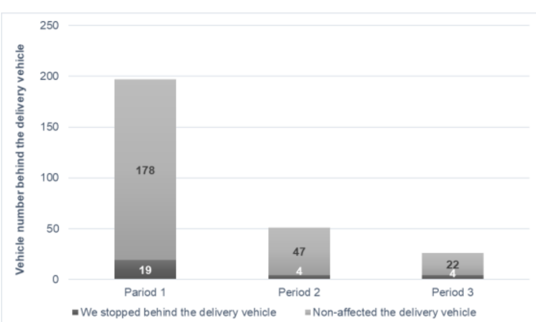

Figure 3. The delivery vehicle double-parking impact on four-lane two-way street

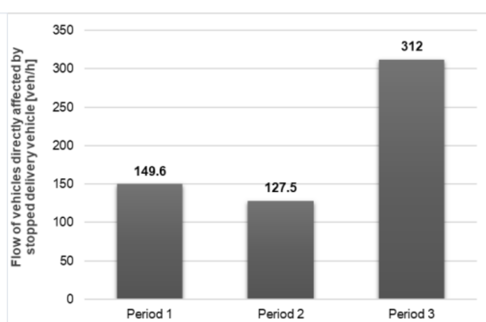

Figure 4. Affected vehicles per hour of double-parking on four-lane two-way street

4.3. Comparative analysis and forecasts

In order to analyze obtained results, comparative analysis is conducted for both survey locations. For each of the streets, the current situation and the situation in the planning period for 2029 are shown in Table 1. Predictions were obtained from source [7].

The symbols used in the Table 1 have the following meanings:

- total time lost by all vehicles per day (Td);
- the total additional distance that all vehicles could have traveled within a day without being affected by the delivery vehicle (Ld);
- total time lost by all vehicles observed for the whole year (Tg);
- the total additional distance that all vehicles could have traveled over a period of one year without being affected by the delivery vehicle (Lg).

Table 1. Parallel representation of the obtained results in the existing and forecasted state

Street name		**Danila Kiša**		**Novosadskog sajma**	
Observed condition		Current state	The future state	Current state	The future state
Peak hour flow [veh/h]		307	721	781	1477
AADT [veh/day]		2558	6011	6508	12308
Total daily	Td [h]	1,01	2,38	3,32	6,3
	Ld [km]	50,23	118,1	164,7	311,5
Total annualy	Tg [h]	264,4	621,2	866,5	1644,3
	Lg [km]	13110	30824,1	42987,8	81301,5

Based on this analysis, we can notice a significant increase in time loses both in two and four-lane streets. In two-lane street, all the forecasted losses are increased by a growth factor of 2.35, while in the four-lane street a smaller growth factor appears, but it is also very significant. In four-lane two-way street all the losses are increased by 1.9 times. This problem will create higher losses in the future, both in time and in the driving distance that is not realized.

When the loading/unloading time of the delivery vehicle is known, as well as the number of vehicles affected by each delivery vehicle, the impact of the delivery vehicle double-parking on the average time lost of the vehicles affected by the delivery vehicle can be determined. Table 2 shows time losses of the vehicles affected by the double-parked delivery vehicles.

Table 2. Impact of the duration of the delivery vehicles on the losses of other vehicles

Delivery vehicle double-parking time	Peak period	Off-peak period
< 1 min	–	0
1 – 3 min	15,43 sec	1,49 sec
3 – 5 min	22,11 sec	8,67 sec
5 – 10 min	17,5 sec	20,67 sec
> 10 min	37,2 sec	45,2 sec

The analysis confirmed that the time losses of other road users is related to the double-parking time of the delivery vehicle, i.e. the longer the double-parking of the delivery vehicle is, the time losses of the other road users are higher. When the retention of a delivering vehicle is longer than 5 minutes, a greater time loss occurring during the emergency period than during the peak period can be observed. In the extraordinary period there is a linear relationship between the retention time of the delivered vehicles and the resulting time losses, while in the peak period this is not the case.

When looking at two-lane two-way street, these time losses are about 265 hours per year in the current state, and according to projections of the future state for 2029 they will be about 135% higher. If we look at a four-lane two-way street, the total time losses occurring annually are about 865 hours, and by 2029 they are forecasted to be about 90% higher. At high-flow streets, these daily and annual time losses are expected to be much higher.

5. CONCLUSION

The impact of double-parked delivery vehicles on congestion, as one of the external effects of urban freight transport, was confirmed by using the case study of Novi Sad. This research has determined the magnitude of the problem on two-lane and four-lane urban streets in peak and off-peak periods. The results of the research give a good basis for modeling the impact of delivery vehicles on traffic congestion in urban areas. The results obtained can be useful for urban transport planners and city logistics researchers.

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BARRIERS TO THE DEVELOPMENT OF HUMANE CITY OF NOVI SAD

Key Words

Humane city;
Novi Sad;
Barriers;
AHP;
Ranking

Abstract

The purpose of this paper is to investigate empirically and identify barriers to the development of humane city of Novi Sad. In total, 16 barriers of humane city development divided into 4 barrier categories are explored. The Analytic Hierarchy Process (AHP) method is applied to prioritize the selected barriers. The obtained results show that high cost of IT infrastructure, lack of cooperation between institutions and growing population problems are the most important barriers for humane city of Novi Sad development.

1. INTRODUCTION

Smart city development and humane city orientation are gaining considerable attention during the last two decades. The 'smart city' context includes people, mobility, economy, natural environment, and public administration that are interconnected, organized, and controlled through the Information and Communication Technologies (ICT) infrastructure [1]. The 'humane city' context includes the various concepts by which the city has been transformed according to human needs. The transformation includes, among others, the following humane aspects: new mobility services (including public transport, walking, bikes, e-bikes etc.), new perspectives for urban freight and logistics development (environmental impact assessment, congestions, noise regulations etc.) and new ICT solutions (autonomous vehicles, data collection by sensors, various ITS applications etc.). According to some researchers, smart and humane can be sometimes opposing paradigms, but optimal situation is all that is smart is also humane-oriented and vice-versa [2].

This study aims to identify the key barriers that prevent the development of overall humane aspects of the city of Novi Sad. This is also the pilot research in the field which gathers representatives of university and city's policymakers in an attempt to identify, evaluate and rank the key barriers to the development of humane city of Novi Sad. In this paper, 16 barriers of humane city development divided into four categories are explored. Authors selected Analytic Hierarchy Process (AHP) to be applied as the research method.

The rest of the paper is organized as follows. First, categories and associated barriers to humane cities development are identified in the literature and adapted to be applied in the research. Second, the proposed research methodology and data collection are explained, followed by data analysis. The paper concludes with a discussion of the key findings, implications for further research and limitations of the study.

2. BARRIERS OF HUMANE CITIY OF NOVI SAD DEVELOPMENT

Based on [3] and [4], this paper included 12 potential barriers of humane city development divided into four categories: High IT costs, Low governance, Legal and Ethical issues and Environmental issues. Additional 4 barriers are added to complement the context of this research in the city of Novi Sad. The enumerated categories and associated barriers are presented in Table 1.

Table 1. Categories and associated barriers to humane cities development

Category	Label	Barrier	Reference
High IT costs (ITC)	ITC1	High costs of IT infrastructure	Authors
	ITC2	High training costs	[4]
	ITC3	High running and maintenance costs	[4]
	ITC4	High disposal costs of used IT infrastructure	Authors
Low governance (GOV)	GOV1	Lack of cooperation between institutions	[3]
	GOV2	Lack of transparency of processes	[3]
	GOV3	Lack of trust between government and people	[3]
	GOV4	Lack of public-private partnerships	[3]
Legal and ethical issues (L&E)	L&E1	Lack of laws, policies and directions	[3]
	L&E2	Lack of standardization	[3]
	L&E3	Lack of citizens' participation in processes	[3]
	L&E4	Lack of openness of data	[3]
Environmental issues (ENV)	ENV1	Growing population problems	[3]
	ENV2	Carbon emissions effect	[3]
	ENV3	Noise effect	Authors
	ENV4	Vandalism issues	Authors

3. RESEARCH METHODOLOGY AND DATA COLLECTION

The AHP is used as the research method in this work. The AHP starts by decomposing a complex, multi-criteria problem into a hierarchy where each level consists of a few manageable elements which are then decomposed into another set of elements. Later, these criteria are mutually compared to get the priority of each criterion in hierarchy. Finally, all alternatives are compared in relation to the set of criteria. In this paper, alternatives are not defined due to the different goal of this research. However, all criteria are evaluated and ranked.

The data were collected through a questionnaire survey. First, to validate literature based barriers the experts were asked to rate the listed barriers in humane city adoption on 5-point Likert scale (1 = not at all and 5 = very significant) through a questionnaire. The barriers with rating of 2 or mean value less than 2 were excluded from the analysis. Then, the refined humane city development barriers and their categories were evaluated by the experts to quantify their significance on 9-point Saaty scale. The research model containing the barriers to humane city of Novi Sad development (at Level-1), 4 categories of barriers (at Level-2) and 16 humane city related barriers (at Level-3) is shown on Figure 1.

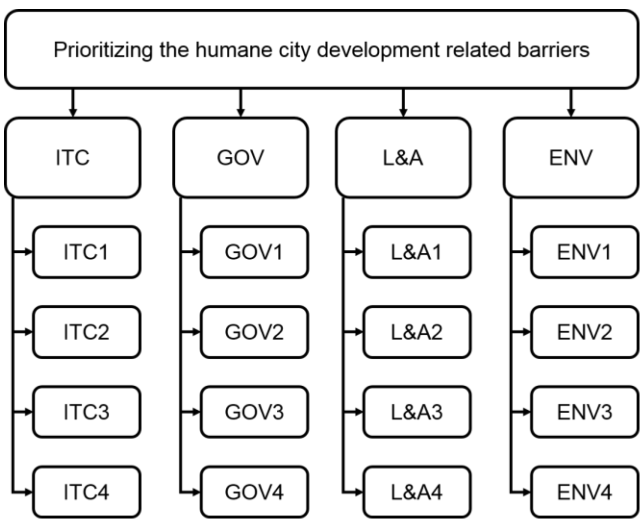

Figure 1. The research model

The data collection was performed between September 2019 and October 2019. Overall, 11 experts gave their contribution to this research. Six experts are from the Faculty of Technical Sciences in Novi Sad and five policymakers are from different institutions in Novi Sad: 3 from Provincial Secretariat for energy, construction and transport, 1 from City Council for traffic and roads and 1 from Bureau of Urbanism. The analysis is performed separately for both samples in order to highlight differences in how they perceive barriers to the development of humane city of Novi Sad.

4. DATA ANALYSIS AND RESULTS

The demographic summary of experts from the Faculty of Technical Sciences in Novi Sad and policymakers from different institutions in the city of Novi Sad is provided in Table 2. The full sampling frame was stratified by education qualification, work experience and size of organization.

Table 2. The characteristics of respondents (N=11)

		Experts from university (N=6)	Policymakers in Novi Sad (N=5)
Category	Classification	No. of experts	No. of experts
Education qualification	Master	2	5
	PhD	4	/
Work experience	< 5	/	1
	5-10	2	2
	11-15	1	/
	16-20	1	/
	> 20	2	2
Size of organization	50-250	/	1
	251-500	/	1
	1001-5000	6	3

In the first phase of analysis, the mean for all 16 factors is calculated for both groups of respondents. For one group of participants (experts from the Faculty of Technical Sciences in Novi Sad) one barrier – high disposal costs of used IT infrastructure obtained mean value less than 2, so it is excluded from further analysis for that sample. The remaining barriers have mean value greater than 2 for both samples, ranging from 2.4 to 4.33.

The preference weights and ranking for the categories of barriers for both samples is presented in Table 3. The final rank of specific barriers to humane city development for experts from the Faculty of Technical Sciences in Novi Sad and policymakers from different institutions in Novi Sad is presented in Table 4 and Table 5, respectively.

Table 3. Rank of categories of barriers to humane city development for both samples

	Experts from university (N=6)		Policymakers in Novi Sad (N=5)	
Categories of barriers	Preference weights (CR=0.0909)	Ranking	Preference weights (CR=0.0806)	Ranking
ITC	0.2592	2	0.4829	1
GOV	0.3975	1	0.2475	2
L&E	0.0996	4	0.0939	4
ENV	0.2438	3	0.1761	3

Table 4. Final rank of specific barriers to humane city development (experts from the Faculty of Technical Sciences in Novi Sad, N=6)

Category	Specific barrier	Relative preference weight	Relative ranking	Global preference weight	Global ranking
ITC (CR=0.0508)	ITC1	0.6330	1	0.1641	2
	ITC2	0.0627	3	0.0162	14
	ITC3	0.3043	2	0.0789	4
	ITC4	/	/	/	/
GOV (CR=0.0853)	GOV1	0.5403	1	0.2148	1
	GOV2	0.1825	2	0.0725	5
	GOV3	0.1754	3	0.0697	6
	GOV4	0.1018	4	0.0405	9
L&E (CR=0.0465)	L&E1	0.3852	1	0.0384	10
	L&E2	0.3641	2	0.0363	11
	L&E3	0.1636	3	0.0163	13
	L&E4	0.0871	4	0.0087	15
ENV (CR=0.0442)	ENV1	0.4520	1	0.1102	3
	ENV2	0.2349	2	0.0573	7
	ENV3	0.2166	3	0.0528	8
	ENV4	0.0966	4	0.0235	12

Table 5. Final rank of specific barriers to humane city development (policymakers from different institutions in the city of Novi Sad, N=5)

Category	Specific barrier	Relative preference weight	Relative ranking	Global preference weight	Global ranking
ITC (CR=0.0607)	ITC1	0.5101	1	0.2463	1
	ITC2	0.2366	2	0.1142	3
	ITC3	0.1817	3	0.0877	5
	ITC4	0.0716	4	0.0346	10
GOV (CR=0.0888)	GOV1	0.4654	1	0.1152	2
	GOV2	0.1515	3	0.0375	9
	GOV3	0.3160	2	0.0782	6
	GOV4	0.0672	4	0.0166	13
L&E (CR=0.0989)	L&E1	0.5769	1	0.0542	7
	L&E2	0.1807	2	0.0170	12
	L&E3	0.1161	4	0.0109	16
	L&E4	0.1263	3	0.0119	15
ENV (CR=0.0980)	ENV1	0.5231	1	0.0921	4
	ENV2	0.3003	2	0.0529	8
	ENV3	0.0782	4	0.0138	14
	ENV4	0.0984	3	0.0173	11

5. DISCUSSION

The obtained results imply that experts from the Faculty of Technical Sciences in Novi Sad and policymakers from various institutions in Novi Sad perceive barriers to the development of humane city of Novi Sad differently (Tables 3-5).

The similarities between two groups of respondents may be observed for two groups of factors: Legal and Ethical issues and Environmental issues. Experts from the Faculty of Technical Sciences in Novi Sad perceive Low governance as the strongest barrier, while policymakers from different institutions in Novi Sad perceive High IT costs as the strongest barrier. It can also be noticed that high cost of IT infrastructure, lack of cooperation between institutions and growing population problems are among the most important barriers for development of humane city of Novi Sad for both groups of respondents (Table 4 and Table 5).

Low governance is a key concern in developing an efficient humane city of Novi Sad. Within this category, barrier Lack of cooperation between institutions gains the highest priority. Therefore, there is a higher need for better cooperation between institutions in the city of Novi Sad. Long-term strategies, plans and initiatives can contribute to better cooperation between institutions in the city of Novi Sad.

High IT costs are also a strong concern in developing an efficient humane city of Novi Sad. Within this category, barrier High costs of IT infrastructure gains the highest priority. Therefore, there is a higher need for additional financial resources. Thus, policymakers in the city of Novi Sad need to provide greater investment in IT infrastructure in the future.

6. FINAL REMARKS AND LIMITATIONS

In developing countries, such as the Republic of Serbia, it is important that policymakers on different levels have good cooperation and communication with experts from universities and other institutions in order to define adequate measures, initiatives and strategies that can improve the concept of humane and/or smart city in the long run. One example of that kind of cooperation is a smart plan project for the city of Novi Sad [5]. However, this study reveals that cooperation between institutions should be improved as well as investments in IT infrastructure. These two aspects should be further explored.

The key limitations of this study are:

- A limited number of participants in the research. Although there is a limited number of surveyors, only experts from the field are included in the analysis. A further research could include more participants.
- A closed-ended questions in the questionnaire. A further research could introduce open-ended questions.
- A small number of factors in each group. A further research could be extended on larger number of factors in each group.

- Limitations of AHP method, such as a human bias and subjectivity in their judgments in forming pair-wise comparisons or consensus measure, if context is same and a group of experts has divergent priorities. A further research could be extended on some other techniques, such as Fuzzy AHP approach.

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SUMP FOR THE CITY OF BANJA LUKA

Key Words

Transportation planning;
Smart city;
Traffic forecast;
Land use study

Abstract

Sustainable Urban Mobility Plan - SUMP for the town of Banja Luka is conceived in accordance with spatial, economic, social characteristics and possible sources of financing. The proposed measures of traffic policy and the policy of land use, as well as the action plan of implementation and monitoring, are the result of the analysis of the specific conditions of implementation for the city and its surroundings. The plan was made for the period until the year of 2028.

1. INTRODUCTION

In the City of Banja Luka, the city centre (city core) is actually a functional urban space (FUA) for which the official data exist. The City consists of 57 smaller territories, in which one person is in charge of collecting the citizens' requests and bringing them to the headquarters of the town administration that contains all the city management services. The surface area of Banja Luka is large, but the majority of the population is located in the urban area. The implementation of strategic planning documents, such as the Urban Plan, had been interrupted due to war. Under such circumstances the problem occurred in the city, due to the fact that an increase in the number of motor vehicles was not followed by the construction and development of the infrastructure. Banja Luka is the main administrative centre of Republika Srpska, one of the two territorial units in Bosnia and Herzegovina. In the town centre there are almost all the Ministries of Republika Srpska, the Tax Administration, the Geodetic Authority, the city administration and authority, as well as a large number of public companies. In addition to administrative and business facilities, in the town centre there are most of secondary schools, banks, commercial and catering facilities. Trips to the town area can be conducted in three possible ways: by using passenger cars, as pedestrians and by using buses.

Sustainable Urban Mobility Plan - SUMP for the city of Banja Luka has been conceived in accordance with spatial, economic, social characteristics and possible sources of financing. The city of Banja Luka in the previous period has made a few serious steps which are in accordance with the goals of sustainable town development: signing the *Covenant of Europe Mayors*, creation of *SEAP (Sustainable Energy Action Plan)*, creation of *LEAP (Local Ecological Action Plan)* for Banja Luka. However, due to social surroundings and known situation after the breakup of Yugoslavia, there is an evident lack of spatial plan documentation and strategic plans for the development of the city traffic system, as well as the data base which are the basis for different measures analysis, defining and testing. For this reason, the first phase of SUMP creation was directed to spatial planning documentation collecting and uniting and the analysis of the current state. After this phase of the project, based on the research results, comprehensive goals of SUMP have been defined, and in accordance with them, the instruments and priorities of work.

2. ANALYSIS OF CURRENT STATE

Analysis of the number of registered vehicles demonstrates that there has been a rising trend in the number of passenger cars in recent years, thus in comparison to 1990, the number of passenger cars has almost doubled. An increase in the number of passenger cars and average age of passenger cars of more than 15 years is the major problem for traffic safety and environmental pollution.

The network of public transport lines is well developed and population from almost all parts of the city has a direct connection (without interchanges) with the central city area. All the suburban settlements have a connection with Banja Luka by bus lines.

The above mentioned indicators with daily migration of the surrounding regions' population towards Banja Luka indicate that continuation of the current development trend of traffic system in Banja Luka would have a negative impact on the development of the City in the next years, which would be manifested through the following aspects:

- Increase of the participation of passenger cars to meet the mobility needs,
- Increase of traffic congestion and crowded streets,
- Negative impact on the environment and economic activities,
- Insufficient quality of public transport,
- Reduction of the number of passengers in public transport,
- Insufficient number of parking space and problems related to parking,
- Bicycle traffic will be very poorly developed,

- The traffic safety will be very poor.

Unless the policies change and activities direct towards creating a sustainable transport system, Banja Luka will become a city of cars that have an advantage over people. Integrated and sustainable mobility will not exist, and the city will lose its attractiveness and comparative advantages for development that it currently possesses in comparison with other cities in wider region.

3. GOALS

SUMP for City of Banja Luka has following goals:

1. ***Active mobility and carless lifestyle*** - refers to Banja Luka citizens attitude on the mobility and its realization. Almost every movement in the city, except going to school, in the last 15 years, is done by car. In order to change attitudes and behavior of the citizens and to promote new lifestyle based on other transport means, following priorities are defined:
   - To increase public transport usage – first choice for movement in the city
   - To increase usage of bicycles
   - To increase number of pedestrians
   - To increase accessibility and better conditions for public transport usage to the specific groups: children, elderly people and people with disabilities.
2. The second comprehensive goal is to ***reduce the risk of traffic and traffic systems in order to increase the quality of life in Banja Luka and security***. The consequences of traffic, especially the traffic of passenger cars, are traffic accidents. Numerous examples have shown that the use of repressive, strict legal and regulatory measures, or interventions on the street network, cannot achieve the desired goals related to the number and structure of traffic measures in cities. Negative traffic products are emissions of pollutants, gases and substances that affect the increase of local and global pollution, as well as noise. To achieve this goal, the following priorities are defined:
   - To increase the level of traffic safety,
   - To reduce the emissions of pollutants,
   - To reduce the level of noise.
3. The third overall objective is ***to increase the efficiency*** that can be achieved above all through openness and accessibility. In order to increase efficiency and accessibility, the following priorities are defined:
   - The City of Banja Luka - good international accessibility,
   - Efficient mobility,
   - Increased accessibility to the city center and its regional capacities for all transport modes/means.

4. PROPOSED MEASURES AND INDICATORS

In accordance with the set goals and priorities of the development, various infrastructure and soft measures have been proposed for the creation of a sustainable traffic system in Banja Luka:

1. ***Creation of Urban City Plan and Transportation model by 2021*** - City Urban Plan represents a managerial policy of land use which directly influences the choice of non-motorized aspects of transport for the realization of journeys, thereby directly affects the realization of all project goals. Transportation model represents a set of relevant data (numeric, graphic and other), indicators, parameters and simulation models, in the way that in spatial coverage of the model and different time horizons, features and behaviour of the transportation system from the past can be reconstructed, certain regularities of transportation demands and offer can be determined on one hand, and on the other hand socioeconomic and spatial parameters. The current state of the transportation system has to be determined and estimated. Transportation system functioning has to be forecast and designed, or parts of it in the future, certain, existing or states defined by development scenarios have to be assessed by applying the elements of Transportation model.
2. ***Development of five zones of calm traffic by 2028***, which means the change of traffic regime by integrating all aspects of transport alongside the reconstruction of street profile.
3. A specialized site and printed publications for the promotion and informing in public transport, development of information centre, informing in real time at transportation stops and via mobile apps, that is, development of the functional informing system in the system of public transport in order to increase the use of public transport, especially for work journeys.
4. Data base, that is, a comprehensive base of socioeconomic characteristics on the area covered by transportation model, parameters and indicators of traffic demands and offers of the system and data on the land use and purpose.
5. Measures for the increase of public transportation participation in terms of modal distribution, defined through 3 special packages of measures in the field of public transportation, which will have a direct or indirect influence on the increase of public transportation participation in modal distribution, that is:
   5.1. Increase of number of buses
   5.2. Increase of the density and number of public transportation lines
   5.3.Increase of public transport accessibility
6. Construction of a system “park and ride“ (P&R system) by 2023, as an infrastructure measure, whose implementation would enable the use of public transport to the outer migrants for everyday journeys towards the central zone of Banja Luka.
7. Parking policy (regime and fares) in order to improve the accessibility to the central zone of the city for business and commercial purposes by 2020- regulative and economic measures in the field of parking which have the most

significant influence on the reduction of passenger cars use and all accompanying negative effects, that is, the increase of all aspects of traffic system sustainability.

8. The design of the project for the development of cycling traffic by 2021 - a useful instrument for the organization of measures which encourage cycling, with a general aim to increase the participation of bicycles in relation to other means of transport.
9. The construction of 5 multimodal bus stops by 2024, which will enable cyclists' leaving their bicycle in a secured space and continuing their journey by bus, as well as enabling passengers who came by bus to take a bicycle and continue their journey.
10. A specialized website for cyclists, which includes web services and information altogether with marketing measures, therefore it offers an interactive platform, both for user and planners.
11. The increase of the number of bike sharing stations from 4 to 14 by 2025 and the number of bicycles in the system to 100.
12. The construction of 30 cycling parking sites at attractive locations.
13. The increase of the length of cycling paths from 14 km to 30 km, in the way that the existing and planned cycling paths are connected into a functional network which will enable a safe approach by bicycle to most attraction zones in Banja Luka.
14. The construction of 1 regional cycling route by 2023, as the first international cycling route which would connect the area of Banja Luka with the existing routes in the surroundings.
15. Promotional activities, media and public campaign about the recommendations for the use of public transport, bicycles and walking. The predicted activities will include not only the citizens but also the decision makers and planners in the local authorities.
16. Enabling accessibility to all facilities of tourist attractions in the central zone, bordered by the streets Olimpijskih pobednika, Gundulićeva, Aleja Svetog Save, Vase Pelagića, Tržnička, Bulevar Cara Dušana, Kninska, Vidovdanska, and Krajiškog Korpusa Street.
17. Vehicles speed limit at 30 km/h in the zones which are primarily residential.
18. Reduction of pedestrian waiting time at traffic lights in order to decrease the number of irregular pedestrian street crossing, pedestrian traffic and pedestrians would be treated at pedestrian crossings of the signalized intersections in relation to vehicles in accordance with the principles of sustainable development.
19. Promotion of sustainable mobility in 10 schools by 2023, with the aim of promotion of the aims of sustainable mobility to the young, that is, in secondary schools.
20. Reconstruction of the central pedestrian zone, as one of the measures which affects the increase of the attraction of the central town zone, which apart from

the primary has also got a secondary role, which is related to the promotion of walking as the most natural and the healthiest way of moving.

21. The introduction of a new concept of public space using in residential zones, which would define the standards to be followed when new objects are constructed, then the necessity of the implementation of Traffic Impact Assessment Study when blocks of flats or offices are built.
22. Removal of all physical obstacles in the central zone for the disabled persons by 2022, in aim to adapt the existing facilities to the disabled in sense of accessibility increase, as well as the implementation of the concept Universal Design in creating traffic system and all its elements in the procedures of planning and designing.
23. Setting a display showing the vacant places in the central zone by 2022, which will affect the increase of the nearby facilities attraction, reduction of travel time and emission of harmful pollutants.
24. Traffic management centre, in the way that the centre should not exclusively work on the increase of level of service of motor vehicles traffic but it will be in the function of public transport, cyclists traffic and pedestrians, in order to exclude the possibility of stimulating the use of passenger cars through its activity.
25. Optimization of phase plans and implementation of measures for active management of signalized intersection functioning by 2023, which would react to the change in traffic demands at the intersection approaches.
26. The increase of funds for e-mobility from 70,000 KM to 200,000 KM by 2023, by the participation of the city in different international projects.
27. The increase of the number of stations for electrical vehicles charging from 2 to 3 by 2023, then keeping the leading position of the City of Banja Luka as one of the first cities in Bosnia and Herzegovina and one of the first in the region which financed the charging station for electrical vehicles.

5. CONCLUSIONS

Unlike conventional methods of traffic planning which are constituents of all traffic studies done on the territory of former Yugoslavia 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.

Due to the fact that the city of Banja Luka has not had strategic plans in the field of traffic yet and that there are not any systematic activities regarding data collecting and analyzing controlled by the city itself, a special attention of SUMP is directed to the measures which will enable the creation of the information basis, data basis and transportation model.

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TRANSPORTATION STUDY FOR THE CITY OF KRAGUJEVAC

Key Words
Transportation planning;
Smart city;
Traffic forecast;
Land use study

Abstract
The research study of traffic in Kragujevac belongs to a group of expertise documentation made or which is being made, as an analytical basis for the design of General Urban Plan of Kragujevac by the year of 2025. The article shows the basic results of the research carried out during the study, as well as the proposed measures for the advancement of traffic in Kragujevac.

1. INTRODUCTION

The main reason for the creation of the research study of traffic in Kragujevac was to determine the current state and development of the primary road and street network of Kragujevac, as a necessary constituent of General Urban Plan of

Kragujevac by the year of 2025. The spatial coverage of the research study is the area of General Urban Plan, including state roads of the first and second category on the above mentioned territory. The railway infrastructure and facilities, since within the planned period there are not any planned changes in spatial terms,they are not specially considered and in the planned period they are kept in the current state. The zone system of the study contains 104 traffic zones out of which five represent the so called outer zones and 99 are within the borders of the General Urban Plan - local zones. The borders of the local zones are based on statistical division (statistical circles), within the borders of local communities, and the centroids of the outer zones are located on intersection of state roads of the first and second category and the borders of General Urban Plan.

Information basis of the study consists of three groups of data:

1. Socioeconomic data (households, population, employment,...)
2. Characteristics of road and street network (categorization, capacity, regime...)
3. Data on traffic determined through research studies (surveys, traffic counting, speed reduction...)

2. ANALYSIS OF CURRENT STATE

Information basis of the study of traffic in Kragujevac consists of five basic data groups:

1. Characteristics of the basic road and street network,
2. Intensity and structure of traffic on the basic road and street network
3. Travel characteristics of Kragujevac residents, and
4. Socioeconomic characteristics of residents and indicators of economy development
5. Spatial distribution of the basic components of land use on the territory of General Urban Plan.

The existing data sources from the documentation of General Urban Plan were used for forming the information basis. The data were complemented by data obtained in the research through traffic counting and speed reduction on the basic road and street network, and through the survey conducted among the traffic participants, carried out by the method of home interviewing.

All data of the information basis were sorted by certain indicators and shown in numerical-table and graph form.

For the needs of forming information basis the area of the General Urban Plan was divided into local communities within which the division into traffic zones was carried out. The borders of the traffic zones were determined by grouping statistical circles within each local community on the territory of the General Urban Plan, which enabled the data use from the official statistics (through statistical circles) and simultaneously their aggregation to a higher spatial level: traffic zones and local communities.

In total, 104 traffic zones were determined, out of which the zones from 001 to 099, the so called local zones, which are the basic spatial carrier of the information about demographic and economic characteristics of the residents and their travel attributes, as well as the indicators of the intensity of land use. Traffic zones, numerated from 101 to 105 are the so called outer zones and with the aggregated data on traffic on state roads of the first and second priority on the territory of the City of Kragujevac. Traffic zones 101 – 105 are located on the intersection of roads of the first and second category with the border of General Urban Plan of Kragujevac.

2.1. Surveys

For the needs of the study, the following surveys were conducted:

1. Traffic counting on the road and street network

Traffic counting on the street network of the city of Kragujevac was conducted at totally 27 positions, out of which there are 20 intersections, 1 interchange and 6 sections . Traffic at the intersections was counted in the period 06:00-09:00 and 14:00-17:00, and at the sections in the continuity from 06:00 to 18:00.

2. Survey in households

Surveys in households were conducted in local communities on the territory of General Urban Plan of Kragujevac. It had been planned that the survey is carried out on the sample of 1% of the households in 38 local communities, that is, in totally around 500 households..

3. Determining basic demographic and economic characteristics
4. Survey on the external cordon
5. Velocity measuring on the basic road and street network of Kragujevac

2.2. Travel characteristics

For the needs of the analysis of the current state and travel characteristics, the analysis of exploitation characteristics of the existing network in peak hours was carried out. Analyzing the capacity and the level of service at intersections where the traffic counting was carried out, the following data were obtained.

Travel with original and target zones within the borders of the general plan represent the so called inner-city travel. The travel within the city territory, depending on the motive, the distance, that is travel time, can be carried out by all traffic means existing in the given conditions, including walking.

The average mobility of inhabitants of Kragujevac determined in the survey in the households is 2.21 units of travel a day by all transport means, which, if applied to the number of residents in Kragujevac, which is around 152,400 residents, results in 336,750 units of travel a day.

Table 1. Peak hour LOS

Intersection	**LOS**	***Intersection***	**LOS**
R1	C	*R11*	**F**
R2	C	*R12*	C
R3	**F**	*R13*	**F**
R4	D	*R14*	D
R5	**F**	*R15*	**F**
R6	E	*R16*	E
R7	D	*R17*	C
R8	C	*R18*	**F**
R9	C	*R19*	D
R10	**F**	*R21*	C

Table 2. Modal split

Method	On foot	Bicycle	Private car driver	Private car passenger	Private car	JPP	Other	total
Travel number	138,070	6,060	86,210	31,650	117,860	70,380	4,380	336,750
(%)	41.0	1.8	25.6	9.4	35.0	20.9	1.3	100.0

Table 3. Travel by purpose

purpose motive	Going to work	schooling	shopping	Returning to flat/house	Other	total
Travel number	55,227	24,583	42,767	153,221	60,950	336,750
(%)	16.4	7.3	12.7	45.5	18.1	100.0

Table 5. Traffic on the external cordon

Road name and label	Traffic zone	Target traffic	Original traffic.	totally I-C	Transit	total	Transit (%)
Kragujevac-Batočina IB 24	101	3,204	3,207	6,411	557	6,968	8.0
Kragujevac-Topola IB 25	102	3,163	2,937	6,100	272	6,372	4.3
Kragujevac- G. Milanovac IIA 177	103	2,672	2,418	5,090	216	5,306	4.0
Kragujevac-Kraljevo IB 24	104	2,712	2,310	5,022	514	5,536	9.3
Kragujevac-Rekovac II A 183	105	1,282	1,098	2,380	122	2,502	4.9
total		13,033	11,970	25,003	1,681	26,684	6.3

2.3. Calibration of transport model

Calibration of the model was carried out on the level of vehicles counting at the most important intersections and sections, which has been shown in the following figure:

Figure 1. Counting positions for traffic counting and model calibration

The model was calibrated on the base year 2017 with totally 96 links. Mean relative mistake of 7% and correlation coefficient R2 of 0.97 were achieved with the calibration, as shown in the following figure.

Based on the above, it can be seen that the estimated (e.g. modeled) flows correspond to the observed flows (counted). This implies that the model corresponds to the purpose and it can be freely used in the development of traffic forecasts in Kragujevac, as it can be seen in the following figure:

Figure 2. Calibrated model

3. PROPOSED MEASURES AND ACTION PLAN

Within the proposed measures for the improvement of traffic flow conditions on the territory of the city of Kragujevac, altogether 12 proposed measures have been analyzed, further explained:

- Small scale intersection with a roundabout.
- The end of the street Braće Petković on the section from Interchange Centralna Radionica to Kneza Mihaila Street
- The construction of Pozorišna Street from Daničićeva Street to Lepenički Boulevard
- The completion of the construction of Petrovačka highway to the road for Topola.
- The completion of the construction of the second roadway lane of Kneza Miloša Street from Male Vaga to Grad Sirena Street and further to Petrovačka highway
- The completion of construction of Dragojla Dudića Street to the intersection with Gornji Milanovac Road, as to connect the direction to Gornji Milanovac and Kraljevo
- Analysis of validity (from the aspect of service level) of the roundabout construction at the intersection number 3 “Crva na Aerodromu“ (“Worms at the Airport”)
- The construction of 4 lanes in the street Miodraga Vlajića Šuke from Save Kovačevića Street to Beogradska Street.
- Simulation of transit with the completion of the first phase of the construction of the south bypass to the interchange “Korićani“
- The construction of the street Đure Pucara Starog and Dragana Panića Street from Save Kovačevića Street to Milentija Popovića Street (Direction of the state road towards Topola)
- Simulation of the transit with the completion of the first phase of the north bypass construction from the intersection Petrovački highway and the road towards Topola and state road to Kraljevo
- Roundabout at the intersection number number 16 at Medical School.

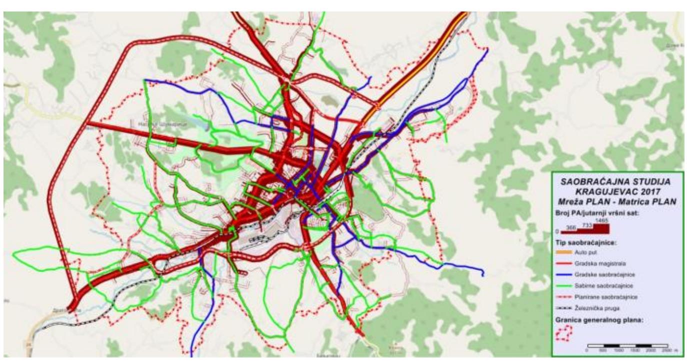

Figure 3. Traffic volumes with proposed measures

On the basis of the analysis of the proposed measures, from a traffic point of view, the following has been concluded:

- The proposal number 12,i.e., the roundabout at the intersection number 16 at Medical School has no validity since the land use of the roundabout planned in this way is over 109%.
- The proposal number 11 (Northern bypass) has no validity since there is going to be less than 250 PA/h in the peak hour by one downstream and the capacity utilization is going to be less than 20%,
- The proposal 10 (Direction of the state road towards Topola) has no validity since there is going to be less than 250 PA/h in the peak hour in one downstream and the utilization is going to be less than 20%,
- The proposal 6 (Dragojla Dudića - Connection Gornji Milanovac - Kraljevo) also has no validity since there is going to be less than 250 PA/h in the peak hour in one downstream and the capacity utilization is going to be less than 20%.

On the other hand, the measures which are justified and which are to be implemented as soon as possible are:

- Proposal number 1 should be realized as soon as possible, that is, the existing intersection "Mala vaga" should be reconstructed into a roundabout,
- Proposal 7 (to reconstruct the intersection number 3),
- Proposal 8 (Miodraga Vlajića Šuke Street),
- Proposal 4 (Petrovačka highway)
- Proposal 5 (Kneza Miloša Street)
- Proposal 9 (the first phase of the southern bypass - Kraljevačkog Bataljona Street)
- Proposal 2 (Braće Petković)
- Proposal 3 (Pozorišna Street).

4. CONCLUSIONS

The research study of traffic in Kragujevac has been carried out as an analytical and graphical basis for General Urban Plan "Kragujevac 2025." This research study was preceded by corresponding research and documentation collecting which were the basis for the analysis of the current state and for the proposed measures for interventions in the short-termed period. The forecast of the expected traffic has been done by models based on indicators of the current state and the expected demographic and economic development of Kragujevac, and based on the data from the documentation and specialist studies made for the needs of General Urban Plan. In the study there are proposed measures for the improvement of the conditions of passenger traffic by enlarging pedestrian zones in the centre and the reduction of street and surface parking by constructing public garages, as well as the recommendations for the development of cycling traffic, as an element of the concept of sustainable urban mobility. These measures mean building cycling infrastructure in the city and suburban territory of the city of Kragujevac.

Apart from that, the recommendations were given that alongside the plan and project documentation, by priorities previously stated, there should be a research study related to the validity of northern and southern bypass, which will take into consideration not only the traffic -economic effects, but also the benefits which will be achieved in ecological and social plan, with the removal of the transit and freight traffic from the centre to the peripheral parts of the city area.

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THE CITY OF BANJA LUKA – CHALLENGES OF SUSTAINABLE MOBILITY

Key Words

Sustainable mobility; Sustainable development; Mobility

Abstract

The increasing problems caused by modern traffic, and apparently a contradictory need to continue development of such traffic, have posed the following question as a challenge to the whole society: How to increase mobility and at the same time reduce traffic congestion, traffic accidents and level of pollution? In accordance with the concept of sustainable development, the idea of sustainable mobility is defined as "the ability to meet the needs of all members of the community to move freely, have access to all activities, communicate, trade and build relationships without sacrificing or endangering other human and environmental values of the present or future generations. " If we compare this statement with the evident consequences of urban traffic, we can easily conclude that the largest number of urban traffic systems has "failed" the sustainability test. In the past three years, the City of Banja Luka has carried out a number of activities, which are just the beginning, but show a clear commitment of the city to develop in compliance with the principles of sustainable activity.

1. INTRODUCTION

All papers will be reviewed by International Program Committee. For text originality, quality and accuracy of data and results responsibility lies sole on authors. It is understood that paper has not been previously published and that authors have employer permission to present the results.

Sustainable mobility as a goal of urban traffic planning, due to the obvious causes of the problem, imposes the need to define a city's transport policy that would reduce negative effects of car use, while increasing accessibility to all urban subdivisions. By applying different transport and land-use policy mechanisms, it is necessary to reduce the need for passenger car travel, encourage redistribution of car travel to environmentally friendly travel modes, reduce distances and improve efficiency of the transport system (Banister, 2008).

Sustainable mobility should meet the mobility needs of the present time without compromising the ability of future generations to meet those needs (Zietsman & Rilett, 2002).

The implementation of a single urban mobility management measure cannot solve urban traffic problems (Vieira, Moura, & Viegas, 2007). A large number of different measures, most commonly fall into the following three categories:

1. Technology innovations
2. Land use policy measures
3. Transport policy measures

How the application of individual instruments has an impact on the demand for travel by various modes of transport and on the reduction of negative effects of transport on the environment has been the subject of the years of research by experts worldwide.

The number of passenger cars in the European cities has increased dramatically since accession to the EU, primarily as a result of rising income levels (Roberts and Taylor 2004). A similar trend of increasing passenger cars in the countries of Serbia, Eastern and Southern Europe was pointed out by many authors even 10 years ago (Bojković et al. 2011; Dargay 2002). Based on the analysis of the number of registered vehicles in Banja Luka, it can be concluded that the number of passenger cars has increased in recent years, so that the number of passenger vehicles has almost doubled compared to 1990.

2. CURRENT STATE

Sustainable and prosperous development requires planning and strategic documents defining spatial development schemes, land use and, in general, development strategies for all areas and systems in the city. Banja Luka is the main administrative center and the most important city in one of the constituent entities of Bosnia and Herzegovina, Republika Srpska. The Presidency of Republika Srpska, the seat of Government and Ministries, the Assembly and the headquarters of many institutions and public companies are located in the central zone of Banja Luka. The spontaneous increase in population, the construction of new settlements, changes in land use, changes in activities and the emergence of new attractions, have all led to very significant changes in the transport system and to the changes in mobility behavior of the residents.

In the last few years, Banja Luka has solved some long-term infrastructure problems by constructing modern, high-capacity roads and intersections, especially on the Western and Eastern transit routes, but in some parts of the city it is impossible to carry out infrastructure interventions due to property issues, as well as cultural heritage and the environment. In addition, the experiences of other cities in the region, Europe and the world show that problems in the transport system cannot be solved solely by building new capacities for motor vehicles. As well as the problems in the transport system directly affect citizens who travel longer and more uncomfortably, these problems have negative effects on the environment, as well as on the development and utilization of the city's potential. Sustainable urban mobility, which is a product of a sustainable transport system, is a priority of all global strategic documents for sustainable development.

With the analysis of the number of registered vehicles, it can be concluded that in the last years there has been a trend of increase in the number of passenger cars, so in comparison with the year 1990, the number of passenger vehicles has almost doubled (Figure 1). Increasing number of passenger cars and the average age of passenger cars over 15 years is a major problem for traffic safety and environmental pollution.

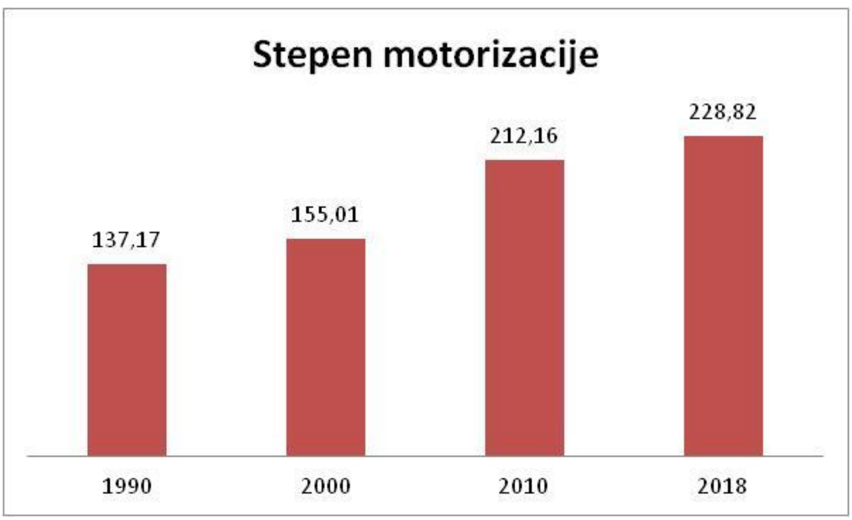

Figure 1. Level of motorization in Banja Luka in PA/1000 population

Traffic load of the street network, in addition to the increase in the degree of motorization in the city, is influenced by the daily migration of the population of the surrounding areas towards Banja Luka, as the main administrative, economic, educational, sports and cultural center of the Republika Srpska. In addition to daily migrations, the traffic on the street network is also affected by transit traffic, since the main roads pass through Banja Luka, especially from the South and West, connecting the Banja Luka region on the motorway, further to Gradiška border crossing and the European road network.

3. ACTIVITIES

In the last few years, a number of activities have been carried out related to changing the way of travel, ie transport planning is carried out in such a way that it is no longer oriented only towards infrastructure but towards meeting the needs of people in terms of faster, safer, healthier way of life, thus improving the overall quality of life in the city.

Traditional urban traffic planning	Sustainable urban traffic planning
The main goal is infrastructure	Infrastructure is one way to achieve the desired goals
Project planning Strategic and goal planning	Project planning Strategic and goal planning
Non-transparent decision-making	Transparent decision-making and public involvement
The main goals are traffic flow and speed	The main goals are accessibility and quality of life
Focusing on cars	Focusing on people
Meeting traffic demand	Regulating traffic demand
Focusing on large and expensive projects	Focusing on effective and gradual improvement
The task of traffic engineers	Interdisciplinary involvement of the mobility, environment and spatial sectors
Intensive investment planning	Rational investment planning

3.1. "Bike sharing system"

In the spring of 2018, a "Bike sharing system" (Figure 2) was implemented in the city, called "BL bike" with 4 terminals for automatic bike rental and a total of 30 bicycles. In 2019, the system has been expanded by 1 new terminal and 6 bicycles. The tariff system includes three types of tickets:

- Annual €10 – 30 minutes daily (cumulatively) is free of charge, each subsequent start time is € 0.75, and the amount paid as a membership fee can be used by the user,
- Monthly € 5 - 30 minutes daily (cumulatively) is free of charge, each subsequent start time is € 0.75, and the amount paid as a membership fee can be used by the user,
- One-off – €1 is for one hour, there no free minutes.

The largest number of bicycle rentals, ie use of bicycles, is in the period 07-08 and 16-17 hours, which is a confirmation that a certain number of residents have opted to use a bicycle to commute to and from work.

The current number of active users is 1200.

Figure 2. "BL bike" - "Bike sharing system" Banja Luke

3.2. Chargers for electric vehicles

Chargers for electric vehicles have been installed at two locations, each with 3 chargers (2 universal and 1 for Tesla engines) at each location.

Figure 3. Chargers for electrical vehicles

3.3. Time limited parking

Tariff system in the stationary traffic has been modified in such a way that in addition to the first and second parking zones, a "zero" parking zone has been formed in which the parking time of the vehicle is limited to a maximum of two bound hours. This zone comprises the busiest central city parking lots.

3.4. Mini tourist bus

In the summer period, on weekdays from 15-19h, and on weekends from 9-19h, transport to the famous city outing site to the Banj Hill is organized. On a monthly basis, the number of transported tourists is over 3000, and this year the tourist mini-panoramic bus (Figure 4) is equipped with a ramp, so that the excursion site is accessible for disabled persons and mothers with baby strollers.

Figure 4. Tourist mini panoramic bus

3.5. Main street becomes pedestrian zone during summer period

In the Summer on Saturdays and Sundays, the main city street Kralja Petra I Karadjordjevica (Figure 6) closes for four-wheel vehicles and turns into a pedestrian zone, where pedestrians and children play freely, and where different sports, cultural contents and manifestations are organized.

Figure 6. Main street transformed into pedestrian zone

3.6. Reconstruction of the pedestrian zone

3.7. Construction of pedestrain and cycling infrastructure

When constructing infrastructure projects, special attention is paid to pedestrian and cycling infrastructure (Figure 7). The aim is to form a network of cycle paths and lanes in the coming period.

Figure 7. Construction of cycling infrastructure

3.8. Mobility week

The celebration of the European Mobility Week is organized in such a way that at least one event or activity promoting sustainable mobility is organized each day of the week: distribution of membership cards for "Bike sharing", organization of lectures on sustainable mobility, cycling (Figure 8), rollerblading, sports competitions on the main street, walking to the Banj Hill, awarding promotional prizes, setting up bicycle parking, etc.

Figure 8. Bicycle Race

3.9. Sump

The SUMP defines the following general and / or comprehensive goals:

- Active mobility and a car-free lifestyle,
- Ecological and safe city
- Efficient city

and, in line with these goals, various infrastructure and soft measures were proposed to create a sustainable traffic system in Banja Luka.

3.10. Application "BL BUS"

The "BL BUS" application for smartphones and tablets (Figure 9), provides users, passengers with real-time information necessary for using public passenger transport and is one way to make public transport more attractive and of better quality. The application is designed for the Android and IOS platform and is a step towards improving the public transportation system in the City of Banja Luka.

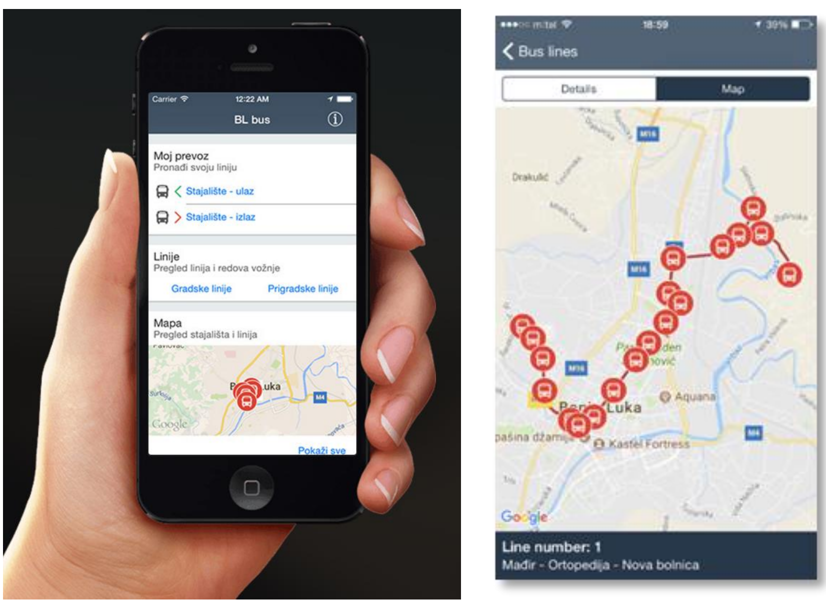

Figure 9. Applicaitn "BL BUS"

3.11. Round table

As a member of the "CIVINET Slovenia-Croatia-Southeast Europe" network, Banja Luka hosted a roundtable on sustainable mobility (Figure 10), which brought together a large number of experts from Southeast Europe.

Figure 10. Round Table organized by the City of Banja Luka

4. CONCLUSION

In 2018, in the European Urban Mobility Week, Banja Luka won 1st prize in the category City in Transformation, organized by the CIVITAS Forum Conference, held in Umea, Sweden. Banja Luka, as the only local community from BiH that is a member of the Civitas Network, has been recognized as a city that has implemented a number of different measures in a very short period of time to promote urban mobility. In doing so, it demonstrated its commitment to sustainable development, as well as to improving the environment and quality of life in the city.


CIVITAS
Cleaner and better transport in cities
AWARD 2018
Europe's highest awards for clean urban transport
TRANSFORMATION
This is to recognise the city of
Banja Luka
for its exceptional achievement in the field of urban transport and recent implementation of an integrated set of mobility measures that demonstrate wholesale transformation and progress towards a liveable and smarter city. In this way, the city has proved itself to be a paradigm of excellence, inspiring and serving as a model to guide and stimulate the further development of sustainable mobility initiatives in Europe.
As the **winner** in the CIVITAS award **"Category IV"**, the European Commission acknowledges the city as one of Europe's best in making a real difference to the welfare of European citizens.

The award showed that Banja Luka is on the right track, and it is an acknowledgment of past activities and an encouragement for further work.

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SMART PLAN NOVI SAD

- Invited lecture -

Key Words

Smart city;
Smart mobility;

Abstract

During the year of 2017 Novi Sad started the processes related to the realization of the project Smart City. The activities of the project SMART PLAN were primarily directed

Sustainable mobility	to smart mobility, which represents one of six basic characteristics of the smart city. Within the first phase of the project, many research studies were conducted resulting in data on mobility, public transport system, traffic conditions, parking and traffic safety. After the research results processing, data bases were formed which were the starting point for further steps in the project realization. By means of the comparative analysis of different data from the formed bases, different indicators were determined to be the basis for the assessment of the current state and travel matrices were formed. Based on the results of the first phase of the project, taking into consideration spatial, social, economic and demographic characteristics, the travel model on the territory of the town of Novi Sad was formed. The basis of the new traffic model was the previously formed transport model within the project NOSTRAM, which was done by the town of Novi Sad in the previous decade. The formed transport model served for testing all planned infrastructure interventions and activities in the street network, defined within the existing planning documentations, as well as other proposed measures of traffic policy in short-termed, mid-termed and long-termed period, after the year of 2017. After the conducted analyses, the action plan was proposed for conducting the proposed activities on the realization of plans and measures in all areas, which would contribute to Novi Sad traffic system advancing in the spirit of sustainable mobility and smart city.

1. INTRODUCTION

Sustainable and smart mobility is according to all relevant sources one of six fields which characterizes a smart city [1,2]. Smart mobility is always the result of smart traffic system which apart form the use of information technologies also means new models which enable a unique policy, correlation and integration with smart management, economy, environment, people and way of life. All stated fields represent basic characteristics of smart relationship, that is (SMART) city.

Novi Sad has a long and rich tradition in traffic system development planning, which, among others, influenced on becoming one of the most successful and beautiful cities in the region. Deviation from the heritage and planning policy of traffic development in accordance with the principles of sustainable development, would affect generation of the problems which can degrade traditional values and recognizability of Novi Sad as a spatial and comfortable, cosmopolitan, central European city. In order to preserve the identity of Novi Sad, attractiveness and quality of life, it is necessary to plan the development of traffic system in the following period, but also to correct as many as possible mistakes occurred as a consequence of a turbulent period, that is, the process and changes happened in our region at the end of the twentieth century.

Novi Sad was among the first cities in the region which developed the traffic model NOSTRAM [3] in 2009 (**NO**vi **S**ad **T**raffic **TRA**nsport **M**odel). This model enables a great precision outcomes analyses of variant solutions, that is, positive and negative consequences of their application, in the spirit of sustainable mobility and principles of a smart city. In order to have a functional model, it is necessary to update data bases periodically which refers to mobility characteristics, traffic flow, parking, public transport, traffic security, etc.

Activities related to the data collecting and their analysis in the form adapted to the model has been conducted within project SMART PLAN - THE FIRST PHASE [4]. Within the second phase of the project, SMART PLAN - THE SECOND PHASE [5] , on the basis of the formed data bases, movement matrices have been defined, necessary for the functioning of NOSTRAM in accordance with the real state on the network and hypothesis of city development (population, construction development, etc.), based on the analyses the solution proposals related to all means of transport have been tested. In accordance with contemporary planning principles, the outcome of planner's procedure are the proposals of action plans with whose application sustainable development goals would be achieved.

The basic goals of the smart city project in the field of traffic and mobility are based on general goals of city sustainable development and smart city. The policy goals of sustainable and smart mobility are based on giving priority to non-motorized transport means, as well as to public transport, in relation to passenger cars. All policies of sustainable mobility and smart city are directed to the application of stimulative measures for non-motorized movement and public transport and restriction of the use of passenger cars by applying different non-stimulative measures of traffic policy (access restriction on certain parts of street network, increase of parking price, charging taxes for entering certain city zones, tax increase, etc.).

2. DATABASE FORMING

Databases formed in the previous project phase SMART PLAN - THE FIRST PHASE on the basis of different research studies represented the base for the creation of the second phase of the project SMART PLAN. Within the first phase of the project, databases were formed as well as the reports on:

- Mobility,
- Traffic conditions characteristics,
- Public transport of passengers,
- Parking,
- Traffic safety.

Within the mobility characteristics determination, the following research studies have been conducted:

- Surveys in households,
- Survey and outer passengers counting,
- Survey and counting on the outer cordon.

Research results processing was used for forming travel matrices which have been added with the report on mobility.

Within the traffic conditions characteristics determining, the following research studies have been conducted:

- Traffic counting on the street network and traffic flow characteristics determining regarding all vehicles categories and pedestrians,
- Velocity characteristics determining on the street network,
- Level of service determining at key intersections and sections in the city.

The research on public transport characteristics included:

- Technical-exploitation characteristics of all public transport lines in the city,
- All day passenger counting on all public transport lines,
- Survey of public transport passengers.

The research in the field of parking conducted at all locations, that is, all parking spaces with parking charging, that is:

- Available surfaces for parking and parking regimes,
- Parking characteristics (duration, accumulation, turnover),
- Parking samples.

In the field of traffic safety , the following have been researched:

- Absolute indicators of traffic safety,
- Attitudes of traffic participants about the risks,
- Behaviour indicators.

This study methodology has been shown in the figure 1 and it generally consists of two phases. In the first phase, the research was conducted and necessary data for the study creation were collected. After the first phase, forecasts were made and the model in the program package VISUM was formed. The formed model enabled all proposed measures testing, regardless of the predicted time period of their realization, that is, regardless of the fact whether it is about short-termed, mid-termed or long-termed measures.

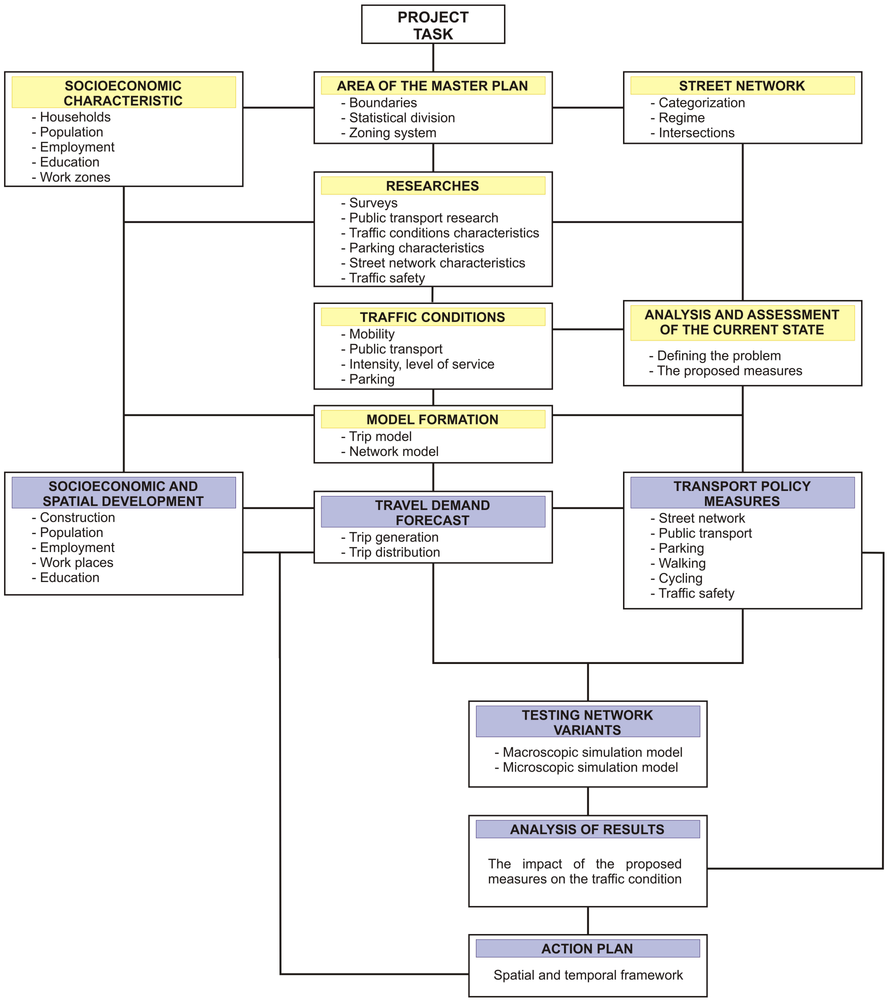

Figure 1. Methodology and the flow of the study creation

3. MODEL FORMING

In order to define development plans which refer to the City, updating and calibration of the Transport model of Novi Sad NOSTRAM were conducted. The forecast of the traffic demand, that is, the number of journeys, and then the number of vehicles on the basic road and street network of Novi Sad, was made for the year 2027, for the planned period longer than General Plan. The basic data on which the forecast of the expected traffic is based are the rates of travel generating determined in the survey in households, the outer traffic increase rate and indicators from earlier demographic and economic research studies in Novi Sad, which are related to planned development indicators in Novi Sad.

3.1. The model of flow distribution on the existing road and street network

Transport model of Novi Sad NOSTRAM has been developed within the software package "VISUM" and it consists of two key elements: computerized display of traffic network and traffic demand matrices.

On the basis of the data from the conducted research studies from the first phase of the plan creation (survey in households, survey of outer passengers and the survey on the outer cordon) and socioeconomic data by traffic zones and districts (number of residents, number of flats, surface of residential area, surface of the business property area) matrices on public transport journeys and journeys by passenger cars were formed.

The model calibration was done in two steps. The first step was related to passenger cars calibration, and the second to the calibration of the passenger transported in public transport.

The model calibration of passenger cars was conducted on the level of vehicles counting at the most significant intersection and sections. The model was calibrated on the base year of 2017 on totally 152 links. With the calibration, the mean relative mistake of 9% was achieved and the correlation coefficient R2 of 0.95. It has been determined that the assessed (modeled) flows correspond to the observed flows (determined by counting). This implies that the model corresponds to real traffic demand and it can be reliably used in the development of traffic forecasts in Novi Sad. The result of passenger cars flows distribution on the existing road and street network of Novi Sad, that is, the results of model simulation have been shown in the following figure.

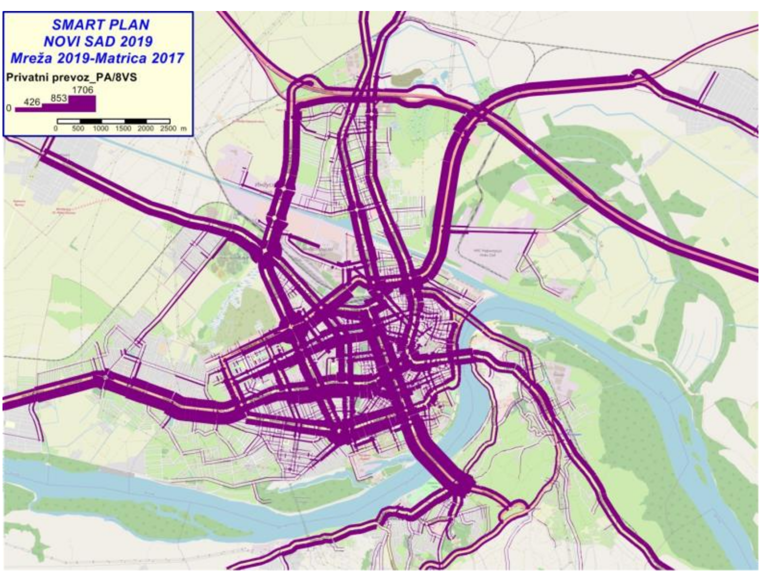

Figure 2. The current traffic load with passenger cars in the morning peak hour

The model calibration on the level of passengers public transport has been done in the way that the network of state was “burdened” by calibrated public transport travel matrix in 3 steps:

1st step: public transport system level;

2nd step - level of suburban corridors;

3rd step -level of input-output corridors into the city centre

The model was calibrated on the base year of 2017 on totally 16 links. With the calibration the mean relative mistake of 2% was achieved and the correlation coefficient R2 of 0.99. The obtained calibration results completely confirm the correctness of the methodological procedure, since the differences are negligibly small, which means that the model represents the state of the public transport system from 2017, when system passengers counting was conducted. The passenger number calibration results have been shown in the following figure.

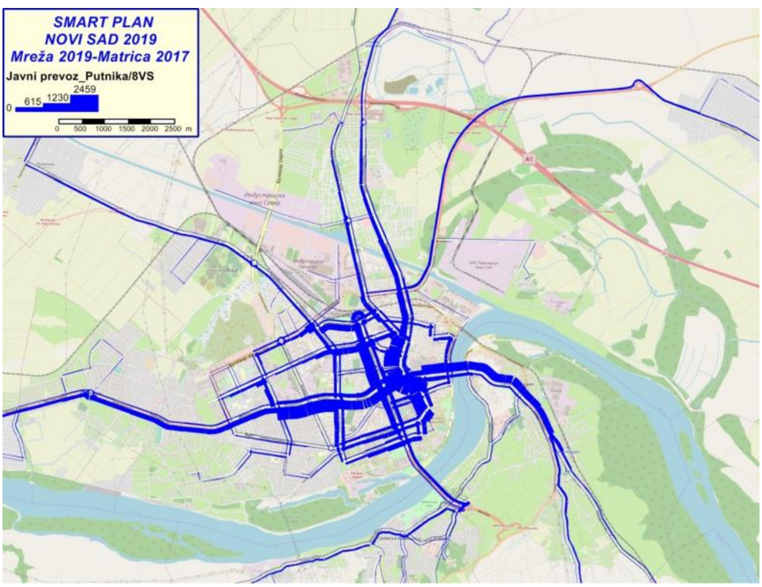

Figure 3. The existing number of passengers in public transport in the morning peak hour

3.2. Traffic demand trends and forecast

In order to test different development variants, the obligations inherited through basic plan documents (General Plan of Novi Sad by 2021, Spatial Plan of the City of Novi Sad and measures proposed in 2009 through the traffic study NOSTRAM) were analyzed.

For the needs of this study the total number of origin and destination journeys (production and attraction) of every zone was calculated on the basis of the travel generating rate achieved in traffic research (for each traffic zone and district) and expected changes in the number of passengers and work positions of every traffic zone of the research area. The distribution of journeys ends obtained in the previous model group (travel generating models) was conducted by combining the application of two models of spatial distribution for the period of morning peak hour: synthetic method (Gravity model) and the method of increase factor (Fratar model). The results have been shown by origin-destination matrix O-D or demand matrix in which each of the elements represents the number of journeys from the origin zone “o” into the destination zone “d” (o,d= 1,2,...n; n- number of traffic zones of the city for which the analysis is done).

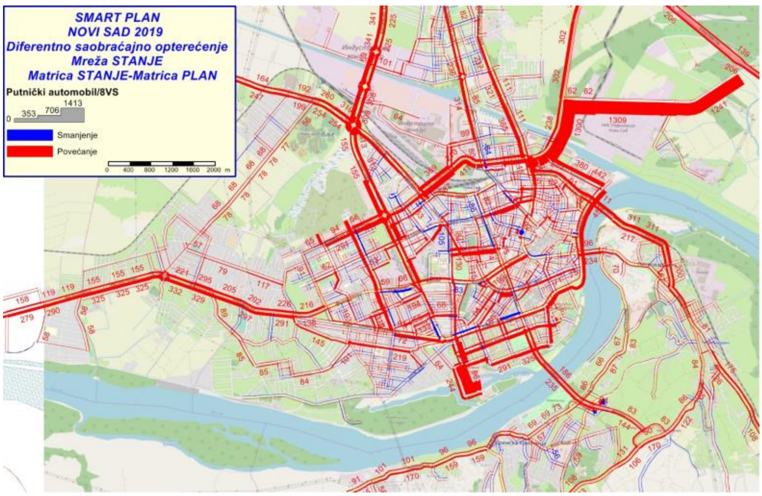

Figure 4. Different traffic load of the planned matrix in relation to the matrix of state in the existing traffic

The basic indicator which served for mutual variant evaluation is the percentage of capacity utilization on the planned links in the planned traffic.

Analysis of the percentage of capacity utilization of the existing traffic network burdened by the existing traffic showed that the existing traffic network of Novi Sad is satisfactory. Also, in case when the existing network of capacity utilization with the planned load on a large number of sections exceeds 90%. In accordance, modelling of the future traffic network has been made, which was proposed in the plan documentation which has been made so far. The obtained results of traffic load and the percentage of capacity utilization of the planned traffic network have been shown in the following figures.

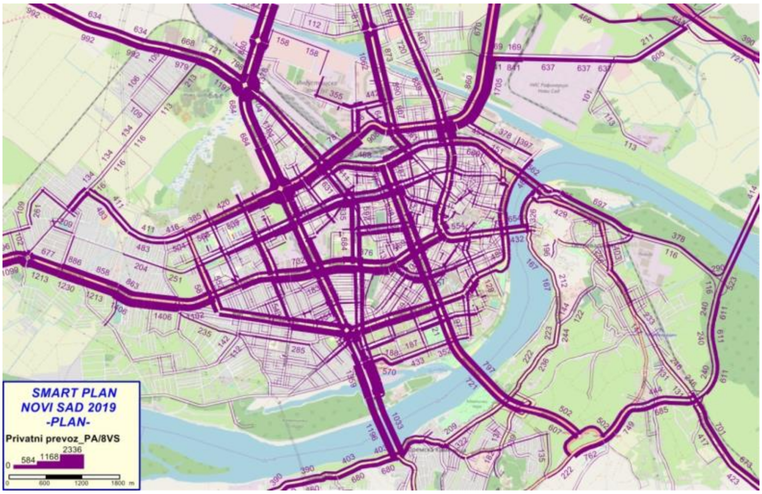

Figure 5. Expected traffic load of the planned traffic network burdened by planned traffic in the morning peak hour

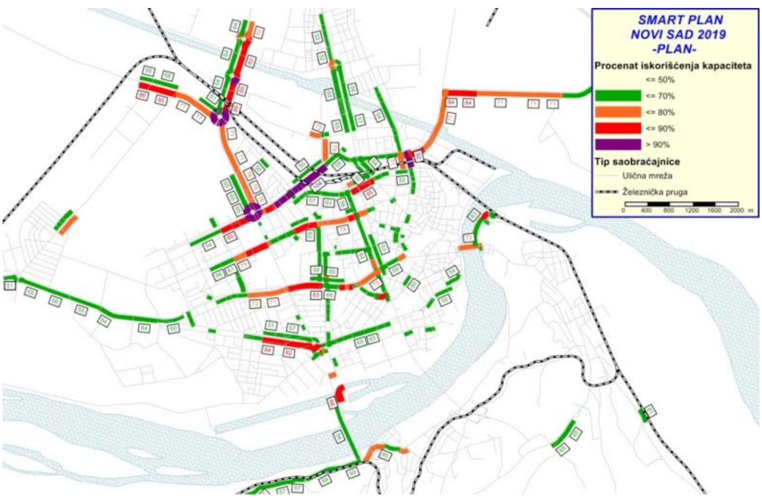

Figure 6. Percentage of capacity utilization of the planned traffic network burdened by planned traffic in the morning peak hour

On the basis of these analyses the priorities for the advancement of road and street network in Novi Sad have been defined, and at the same time the priorities and construction order. Interventions and building on the traffic network of the city are to comply with the priorities defined in the study, so as to achieve an acceptable level of service in the street network.

4. STATE ASSESSMENT

On the basis of the collected and analyzed data, the state has been assessed in the form of tables with the indicators describing advantages and disadvantages of the traffic system in the field of public transport, parking and cycling and pedestrian traffic. In the following table the method of the state assessment has been shown on the example of the public transport.

Table 1. List of indicators describing advantages and disadvantages of public transport system

Advantages (+)		Disadvantages (-)	
INDICATOR	**VALUE**	**INDICATOR**	**VALUE**
Coverage of the area of Traffic Master Plan	Participation of the area of Plan within izo line of 300 м around the bus stop	Passenger loss in a longer time interval	% of the decrease in passenger number in the period 2012 - 2018
	Participation of the area of Plan within izo line of 500m around the bus stop	Low average vehicle velocity	Average vehicle velocity in a day /peak hour
Availability of passenger public transport system	Participation of work positions within izo line of 500m around the bus stop in relation to the total number of work positions	Zone system characteristics	Number of fare zones
	Participation of work positions within izo line of 500m around the bus stop in relation to the total number of work positions	Number of fare items	Total number of fare items
Acceptability of transport fare for the users	A monthly expenditure for public transport for a three-member family does not exceed 8% of monthly incomes	Relationship City- Carrier	type of relationship
		Existence of the bus stops of low utilization	Total participation of the bus with the volume of entrances and exists lower than 200 passengers a day
		Quality of the bus fleet in the context of the environment protection	Participation of drive units (vehicles): Diesel of EU4 norm and higher; natural gas or hybrid or electric drive. totally - less than 50%
		Easiness of entering /leaving vehicles	Participation of low-floor buses in the total number by types: not lower than 60% by each type
		Easiness of entering / leaving vehicles for the disabled	Participation of buses equipped with ramps in the total number: - solo– min. 50% - articulated - min. 50% - midi-bus - min. 50%

5. ACTION PLANS

Strategic and special goals defining for all fields of traffic system of Novi Sad, defined in accordance with general goals of sustainable and smart city.

5.1. Strategic goals in the field of public transport

On the basis of the system current state analysis the following strategic goals have been defined:

A. Short-term (by 2021)

- Carry out the rationalization of the zone system by enlarging, that is, reducing the number of zones. Introduce a zone system on the territory of city and in the suburban area.
- Regulate the relationship of the City and Public Carrier by Public Service Contract.
- Introduce a contemporary public transport management system and form the Control Management Centre,
- Introduce a contemporary system of charging based on e-tickets. This goal is connected with the previous.
- On parts of the street network where general traffic influences the velocity of public transport vehicles. Introduce special lanes with a video monitoring. Gradually introduce the priority to public transport vehicles at critical intersections,
- Renew the bus fleet,
- Increase inspection activities for the suppression of illegal transport.

B. Mid-term (by 2027)

Continually increase the participation of vehicles with environmentally friendly aggregates (Euro 6, CNG; electric drive),

- Prepare Public Carrier for switching to electric vehicles (install the system for vehicle maintenance, choose the line network segments where these vehicles will run and equip them with necessary infrastructure).
- Continue the reorganization of line network (new lines, alternative directions for the existing lines - connected with the construction of street network, reduction of number of bus stops with a very low number of inputs/outputs, reduction of the number of departures with the most burdened terminus by dislocating to less burdened terminus).

C. Long-term (after 2027)

- Return the volume of transportation service from 2012. This goal demands a longer period since its realization is connected with all the goals above mentioned.

- Continue the preparation for the introduction of the system with high/mid capacity based on rail vehicles. This goal is connected with the overall development of Novi Sad (city territory expanding, increase residential density at the existing locations,etc.).
- When it is necessary, open public transport market for other carriers as well.

5.2. Strategic goals in the field of parking

The following strategic goals have been formulated on the basis of system state analysis:

A. Short-term (by 2021)

- Corrections of the existing parking regime. Proposal of the parking for “an extra zone”, as well as pre-defining of certain parking spaces with the currently valid into another parking zone. Parking space within the campus to become a “white” parking zone.
- Corrections in the field of fare policy. Parking price correction in accordance with the trend of increase of the number of registered passenger vehicles in Novi Sad, average gross income and the price of an individual ticket in JGSP (Public transport carrier) Novi Sad in the first zone. A higher amount for the privileged ticket for the second car in the family.
- The change of the city Decision on determining fees for land development by which investors for the unbuilt parking places pay a symbolic amount to the city budget.
- Forming a special city earmarked fund from which money could be used for investing into the construction of parking garages and other off-street car park capacities.
- Removal of unregistered and damaged vehicles from the existing car parks
- Horizontal marking of parking lots would increase available space for parking, that is, the available parking surface would be most rationally used.
- A more active participation of communal police in detection and sanctioning of parking in green surfaces and other areas where it is not allowed.
- Zero tolerance to usurpation of parking places designated to the disabled.
- Possibility of reporting irregular and haughty parking by citizens via MMS messages or other multimedia services.

B. Mid-term (by 2027)

- Parking garages building at more locations in the inner and wider central zone.

- Construction of close (safe) bicycle parking garages.
- Application of information technology and “smart” solutions in the field of parking.
- Regulation of delivery vehicles parking and stopping in the street network.

C. Long-term (after 2027)

- Construction of collective parking terminals (“P+R“ terminals) with organized transport of parking users towards the city and backwards.

5.3. Strategic goals in the field of pedestrian and cycling traffic

Based on the analysis of the system state regarding cycling and pedestrian traffic on the territory of the city of Novi Sad, the following strategic goals have been defined:

A. Short-term (by 2021)

- Increase of the safety level of pedestrians and cyclists on the street network of the city of Novi Sad.
- Remediation, reconstruction and modernization of the existing pedestrian and cycling infrastructure.
- Application of the basic parameters of design and cycling infrastructure which are in accordance with the contemporary manuals for cycling traffic design and planning.
- Application of contemporary solutions in the field of cycling and pedestrian traffic regulation.
- Development of the system for offering services in cycling traffic.
- Expanding services intended for cyclists.
- Promotions, education and campaigns conducting related to pedestrian and cycling traffic.

B. Mid-term (by 2027)

- Construction of new cycling lanes in accordance with the proposed network for a better coherence of the cycling network.
- Traffic calming in order to improve the conditions of pedestrian and cycling traffic.
- Improving the accessibility of the street network for pedestrian and cycling traffic
- Integration of cycling transport and the system of passenger public transport
- Advancement and expending of “bike sharing“ system.
- Construction of open and closed (safe) parking places for bicycles

- Traffic policy integration.
- Creation of strategic plans in the field of pedestrian traffic planning.
- Creation of strategic plans in the field of cycling traffic planning.
- Institutionalization of cycling planning and promotion in the local self-government bodies.

C. Long-term (after 2027)

- To close Beogradska Street in the suburbs of Petrovaradin fortress
- Expanding of the pedestrian zone in the city
- Construction of new cycling corridors on the territory of Novi Sad.
- Construction of pedestrian-cycling connection between Novi Sad and Sremska Kamenica.
- Connecting of the city cycling paths with the suburban network of cycling paths and international network of cycling routes.

Plan of activities is essentially the output result of every strategy. In accordance with the above mentioned goals, within the study SMART PLAN - THE SECOND PHASE, a plan of activities was stated in the field of public transport, parking and cycling and pedestrian traffic. For each activity in the stated fields a short description has been given and the purpose, that is, the expected result of the initiative. In the plan the existence / non-existence of the necessary plan and technical documentation has been analyzed, as well as the existence /non-existence of the study or the analyses of justification. The activities were shown in detail by phases and implementation deadlines, as well as the estimated means for the initiative realization.

For each activity, action plan and the assessment of the means necessary for the realization have been defined. Plan of activities includes the description, purpose and expected results. For a number of the proposed activities the need for justification analysis was estimated (or its existence has been stated), documentation necessary for the implementation of the activities, dynamics and the estimated implementation time, activities operators and the assessment of the means necessary for the realization of the proposed measure.

In the following table there is an example of the action plan for the correction of fare policy in the field of parking.

Activity:	Correction in the field of fare policy
Short description:	Low prices of parking compared to the prices in the nearby cities, price of services of JGSP (Public city transport carrier), etc. It is necessary to increase the basic parking charging and abolish privileged tickets for more cars in one household.
Purpose/ Expected result:	With the increase of parking price, non-stimulation of a number of users from everyday use of passenger cars can be expected, with simultaneous increase of the number of journeys by public city transport, by bicycle or on foot. Tightening criteria for privileged resident tickets issuing could affect relinquishing possessing the second or the third car.
Necessary documentation:	-
There is a study/ justification analysis:	Smart plan – the second phase
Phases and estimated implementation time:	Phase 1 – proposal of new parking prices Phase 2 – administrative procedure (Decision creation) Phase 3 – Decision adopting,placing new additional boards with new prices of parking service Duration: Phase 1: around 1 month Phase 2: around 2 months Phase 3: around 3 months
Operator:	City Administration Public utility company “Parking Service Novi Sad”
Estimated realization fund	Replacement of the existing additional boards (there are about 195 parking areas within “extra”, red, blue and white colour) - minimal expenses in the amount of around 3,700,000 dinars

6. CONCLUSION

The basic goals of the study SMART PLAN have been decided on the basis of strategic goals of sustainable development of traffic system and smart city. In accordance with the general goals, within the study SMART PLAN, research has been conducted as well as the analyses of complete traffic system of Novi Sad, which included:

- Proposals and conclusions about the existing plan and project documentation,
- Characteristics of traffic, road and street network,

- Characteristics of residential mobility and land purpose,
- Characteristics of passenger public transport system,
- Parking characteristics,
- Characteristics of pedestrian and cycling traffic.

The conducted research studies were the basis for updating the Transport model NOSTRAM. After the calibration, the transport model was completely accorded with the state of transport demand of Novi Sad from 2017. As a platform for the model development, the program package “VISUM” was used.

On the basis of the conducted analyses in further procedure, by methods of comparative analyses and synthesis, with the use of application software packages for the processing of the data collected in the research, the assessment of the traffic system state was done. The advantages and disadvantages were analyzed in the field of mobility, public transport, parking and cycling and pedestrian traffic.

The general conclusion is that there are negative trends which primarily appear in ever higher use of passenger car for meeting the needs of mobility and lower use of public transport, which is one of the key factors for the fulfillment of strategic goals of sustainable and smart city.

In order to assess the influence of the proposed measures on the behaviour of traffic system, demand forecasts were made, based on the known City development plans and plan horizon of the study, by 2027. The demand was interpreted by appropriate journey matrices used for network burdening (of general and public traffic).

In order to stop negative trends, short-term measures have been proposed by 2021, mid-term by 2027 and long-term after 2027, for the improvement of the state of traffic system of Novi Sad. For the field of public transport, parking, pedestrian and cycling traffic, action plans have been proposed, which included system changes, necessary decisions and activities which should be done the city administration, traffic-regulative and infrastructure measures.

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GROUP OF ARTICLES 2
New mobility services, technologies and tools

7th INTERNATIONAL CONFERENCE
''TOWARDS A HUMANE CITY"
Environmentally Friendly Mobility
Novi Sad 6th and 7th December 2019

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INFORMAL PARK-AND-RIDE BEHAVIOUR

Key Words

Transport demand management; Park-and-Ride; Parking management; Travel behaviour

Abstract

As a response to sustainability requests, transport management aims to reduce car use encouraging modal shift to public transport and non-motorized modes. Therefore, parking management in central urban areas typically involves implementation of restrictive measures (time limits and parking charge) in order to enable parking to "priority users" while discouraging others to park there. Users who, as a reaction to parking measures, give up parking in the central area look for an adequate travel option. Some of them self-initiatively found a way not to completely give up driving: they travel by car in one part of the trip, then park the car and reach the destination by public transport. This travel pattern is known as "informal Park-and-Ride" (PnR). If such behaviour does not lead to parking problem spill-over from central to peripheral areas, it should be estimated as a relatively positive, because even though it partly involves driving, the critical "last mile" is travelled by public transport. Therefore, as PnR demand grows and reaches the significant level, policy-makers should consider its formalisation and integration into the urban transport policy. The aim of this paper is to identify informal PnR users and to investigate their motives, requests and preferences towards this option. The findings should be of importance when planning and developing formal PnR sites, which effectiveness can largely increase user willingness to accept restrictive parking measures in the city central area, i.e. to adopt more sustainable travel behaviour. Necessary data were collected by surveys at informal PnR sites in Belgrade.

1. INTRODUCTION

Almost a century of intensive car-oriented development has left many populated areas with strong uncertainties about future progress and quality of life. Cities are now searching for different programs, policies, solutions and innovations that can help sustainability efforts. As a response to sustainability requests, Transport Demand Management (TDM) is an emerging concept and a general term for policies and measures that could increase overall urban transport system efficiency and effectiveness. Essence of this are measures oriented towards modal shift from single-occupant vehicle use to more environmentally friendly and healthier modes of transport – public transport and non-motorised modes

Parking is often seen as a key transport issue while parking problems in city centres are tackled by restrictive parking measures such as time limits and parking charges. Some users, as a response to these measures, give up parking in the central area and look for an alternative travel option. In this situation, some of them change their parking location and park outside the restricted areas, often near public transport stops. Restrictive zoning and tariff policies in urban parking management often leads to the emergence of informal park-and-ride (PnR) locations created on users' own initiative.

Informal PnR is an alternative trip choice to solely driving to the city centre and cruising and paying for parking there. One of its negative side-effects could be urban chaos and local nuisance probably in peripheral low-density zones and neighbourhood streets. But if such behaviour does not lead to parking problem spill-over from central to peripheral areas, it should be estimated as a relatively positive, because even though it partly involves car use, the perceived critical "last mile" is travelled by public transport. Appearance of this impromptu parking locations calls for the research of its users as the first step towards implementation of the effective formal PnR transport policy in one city, which increases user willingness to accept restrictive parking measures in city centre, i.e. to adopt more sustainable travel behaviour.

To the best of our knowledge, the behaviour of informal PnR users has been rarely investigated so far. The exceptions are studies of Bullard and Christiansen (1983) and Picket and Gray (1993) which are of older date.

The aim of this paper is to identify informal PnR users and to investigate their motives, requests and preferences towards this option. The findings should be of importance when planning and developing formal PnR sites, which effectiveness can largely increase user willingness to accept restrictive parking measures in the city central area, i.e. to adopt more sustainable travel behaviour.

2. PARKING MANAGEMENT IN BELGRADE

As in other cities and towns in Serbia, most of public parking supply in central area of Belgrade is located on the streets, about 80%. Since 2003, on-street parking has been time-limited and charged. The area of parking regime and its attributes have been changed several times over time. Currently, there are four parking zones:

purple, where parking is time-limited to ½ hour and costs 100 RSD; red, where first hour of parking costs 56 RSD and following ½ hours costs 100 RSD; yellow, where first two hours cost 48 RSD/h and the third 180 RSD; and finally, green zone, where first three hours of parking cost 41 RSD/h and the fourth hour cost 140 RSD. Regime is valid every working day from 7 am to 9 pm and on Saturdays from 7 am to 2 pm. Residents are entitled to purchase Parking Permit (PP) at a price of 457 RSD/month, which enables them to park without time limitation. The same right have businesses with headquarters within the area, but at much higher prices (4.106 – 9.130 RSD/month depending on parking zone). Resident may purchase a maximum two while business three PP, out of which maximum one can be for a vehicle owned by an individual employee. There is also a possibility of reserving parking space. On-street parking state is such that almost all parking spaces are occupied during the whole day and illegal parking is common thing, which makes it difficult to find a vacant parking space.

Parking at public off-street parking lots and garages is charged non-stop, and the price varies from 60 to 120 RSD/h, with 100 RSD/h as the most common value. There is also possibility for residents and businesses to purchase different types of monthly parking tickets, but they are more expensive than the ones for on-street parking spaces. Unlike on-street parking, a vacant parking space can be easily found at any off-street parking lot and garage anytime.

Discouraged or enabled to park in the central area by its restrictive parking policy, many users decided to change their travel behaviour, typically by shifting to another transport mode. This is especially the case for work trips, where changing the trip destination is unlikely an option. In this sense, the most acceptable solution for many of them was to travel by car in one part of the trip, then to park the car and reach the destination by public transport, i.e. to use (in)formal PnR system (Simićević et al., 2012).

In 2008 City Administration – Secretariat for Transport initiated and financed Feasibility study with preliminary design for Park and Ride system implementation (Milosavljević et al., 2008). However, to date only one site has been dedicated to this purpose. It is off-street parking lot at Vladimir Popović Street with 292 parking spaces. Tariff system at this parking lot enables its use by both PnR users and others. The former are provided with parking free of charge with a monthly ticket for public transport and previous registration at PUC “Parking Servis”. The price of monthly public transport ticket depends on user category and zone. For employees it costs from 2.990 to 4.990 RSD. Other users pay parking at prices 31 RSD/h or 150 RSD/day. Recent research (Molan and Simićević, 2019) has shown that about 500 users park their cars at this location daily, out of which about 200 are PnR users. Parking capacity is insufficient to accommodate total demand, especially from 10 am to 3 pm when there are no vacant parking spaces. This caused parking spill-over to adjacent parking lot where parking is free.

In addition to the described PnR site, it was concluded based on previous research (Milosavljević et al., 2008) and expert assessment that numerous locations are informally used for this purpose. It is they, i.e. users who use them for this purpose, that are the subject of this research.

3. METHODOLOGY OF SURVEY

The aim of this survey was to identify informal PnR users and to collect necessary data for assessing their behaviour, motives and requests towards this option.

Since we intended to compare the results with that obtained at the formal PnR location (Molan and Simićević, 2019), the survey methodology was compliant with the one conducted there.

The area of survey included a sample of locations previously determined to be (partly) used for informal PnR purposes. These include: *Despot Stefan Boulevard* (illegal on-street parking), *Fire brigade* (illegal on-street parking), *Brankov bridge* (on-street parking), *Sava Centre* (regulated parking near main city's motorway) and *Mostar interchange* (off-street parking lot). We selected locations close to the parking regime zone, as it is expected that users drive as close to the trip destination as possible. Parking at all locations is free of charge and all locations are well served by public transport, Figure 1.

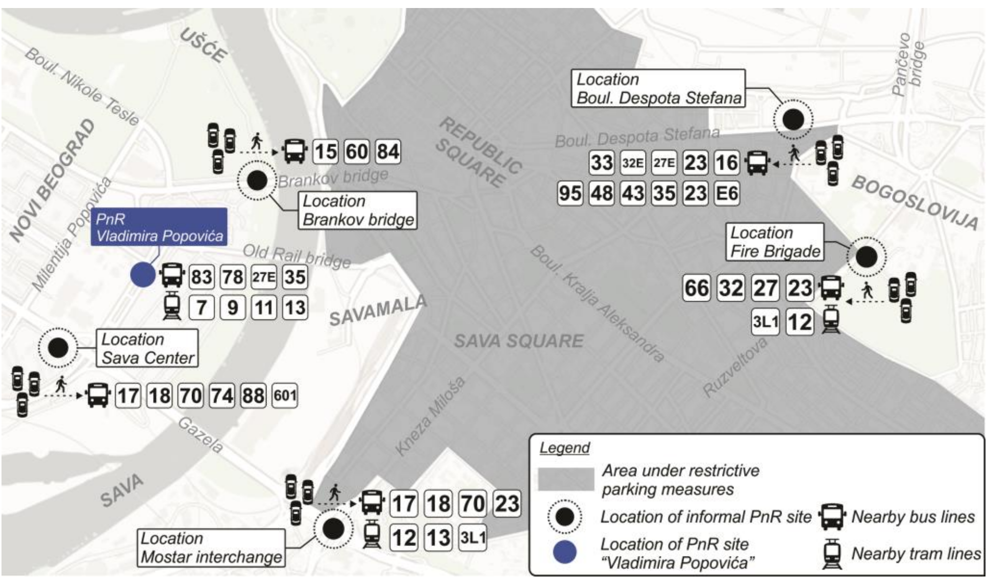

Figure 1. Area of survey

The survey was conducted on 03., 08. and 10.10.2019. from 6am to 7 pm.

Face-to-face interview of users was performed to identify informal PnR users, and to collect data on their travel and demographic characterises afterwards. This includes: trip origin and destination, parking purpose and frequency, user behaviour and preferences relating to (in)formal PnR option. Additionally, we collected data on driver gender and age. Above mentioned parameters proved to be important for studying informal PnR behaviour (Bullard and Christiansen, 1983; Picket and Gray, 1993).

4. RESULTS AND DISCUSSION

Although the survey was conducted at several locations in the city (Section 3), only 26 informal PnR users were identified and interviewed. We believe the reason for relatively small sample is not that these users are rare in Belgrade, but that their paring locations are widespread throughout the city as a consequence of unregulated PnR system.

The main travel purpose of informal PnR users is “work”, even though its share is smaller than at the formal PnR location (77% vs. 88%). To a smaller extent there are travels with purposes of “private business” (12%), as well as “shopping”, “leisure” and “business” (with 4% each). In line with travel purposes, an average parking duration amounts almost 8 hours and most of users travel every day (56%) or several times a week (20%).

From total number of respondents, 42% travels to the central area, while 58% travels to other parts of the city, suburbs and nearby towns. Average travel length by car is 6.4 km and by public transport 6.1 km. Although recommendations from European countries for efficient PnR system state that the length of travel by bus from PnR site to the final destination should not exceed 5 km (Dublin Transportation Office, 2012), 28% users travel longer distances. In addition, 23% of users have to change the line of public transport they use.

Survey results show that the number of new informal PnR users increases: 48% of respondents started to use this travel option in the last year. Before that, users travelled solely by car (52%), solely by public transport (43%) or used employer transport (5%). Informal PnR did not lead to an increase in mobility, while findings from literature indicate that formal PnR system generates new trips (Meek et al., 2007). Users with travel destination in the central area gave up travelling by car more often than others (70% vs. 38%). The main reason for abandoning car trips are restrictive parking measures at the travel destination: parking charge (54%) and/or time limitation (23%), as well as the parking state at the destination: 15% of users said that a vacant parking space was difficult to find. Only 8% of users gave up travelling by car because this way they reach their destination more quickly, even though on the way to destination 50% of users uses public transport lines with partially or completely yellow lanes and 92% do not have to change the line. On the other hand, the reasons for abandoning travel by public transport are shorter travel time (56%) and higher comfort (44%). It is interesting to note that these results are almost the same as those obtained at the formal site (Molan and Simićević, 2019).

Expected impacts of PnR formalisation at the surveyed locations were also investigated. By formalisation we mean that the same tariff system as the one at formal location would be applied, i.e. that users with a monthly public transport ticket would be allowed to park free of charge. In this case, 50% of users would continue to park at the same place and to use (then formal) PnR system. This data is quite in line with the number of users who travel every day (56%), therefore it is assumed that they poses a monthly public transport ticket. On the other hand, the rest 50% of users would change their behaviour as such tariff system would not suit them. As a response, 23% would continue to use (informal) PnR system, but they would change parking location, which could lead to parking spill-over. Other users would change transport mode, mostly returning to the mode they originally used: 15% would travel by car and 12% by public transport. However, none of the users travelling to the central area would shift to a car, because they have been already discouraged by parking policy. If we observe trips to the central area only, 64% of users would not change their behaviour, 18% would change parking location and 18% would shift to public transport.

Given that the issues of equality and inclusion are necessary in the development of sustainable transport, the gender and age structure of informal PnR users was finally analysed and it was compared with the social structure of users who travel as drivers in Belgrade. The share of female informal PnR users is very high (48%) and the similar data was obtained at the formal location, 41% of female users (Molan and Simićević, 2019). Taking into account that in total number of car trips in Belgrade female drivers represent 21% (FTTE and CEP, 2015), it can be concluded that females are more willing to change their travel behaviour and to accept alternative transport options. With regards to the age structure, the most users aged between 30 and 45 years. Their share at the formal location was 63% and in all car trips in the city 42%.

5. CONCLUSION

Informal PnR option is used for travelling both to the central area (42%) and elsewhere (58%). Even though PnR system introduction is primarily expected to mitigate traffic congestion and parking problems in city central areas, such impact outside the central area should be also seen as positive.

Before using informal PnR option, 43% of users travelled by public transport. Shifting to driving, at least at one part of the trip, should be considered negative. Since the reasons for modal shift from public transport to informal PnR are faster and easier travelling, it can be assumed that this percent could be reduced by implementing measures which increase public transport quality of service.

On average users are willing to travel by public transport 6.1 km and the majority of users (77%) do not accept to change the line. This should be of importance for transport planners when selecting locations which could be used as PnR lots.

48% of users started this travel option in the last year. Out of new users who gave up driving to the central area, everyone stated that the reason for changing travel behaviour was high parking price in the central area. Since all of them are long-term parkers and on-street parking time limits do not suit them, it is expected that the change of behaviour was a reaction to the increase in parking price at garages which occurred in 2018, when prices increased by 10-30 RSD/h.

And generally, users who gave up travelling by car in 77% of cases did so because of restrictive parking measures at the destination. All mentioned leads to the conclusion that PnR system introduction should be preceded by parking regulation and control in the central area. Only 8% of users gave up travelling by car because this way they reach their destination more quickly, even though on the way to destination 50% of users uses public transport lines with partially or completely yellow lanes and 92% do not change the line. The greater impact of restrictive measures than shorter travel times by public transport confirms literature findings that push measures are more effective in managing modal split than pull measures. This certainly does not mean that pull measures should not be applied as a support and contribution to a higher quality of service to users.

The share of users with purpose “work” is bigger at the formal (88%) than at the informal locations (77%). The reason could be the implemented tariff system at the formal location which suits the daily users more. This means that when defining PnR tariff system the needs of other users should be also taken into account. Otherwise, according to the survey results, negative impacts to transport system could occur. Namely, if the same tariff system which is applied at the formal PnR lot were applied at the surveyed locations, 23% would change parking location which could lead to parking spill-over. In addition, 15% of users would shift to car use solely, which would adversely impact the realisation of targeted modal split.

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TINNGO: CHALLENGING GENDER INEQUALITY IN SMART MOBILITY

- Invited lecture -

Key Words

TInnGO;
Gender;
Inclusivity;
Smart mobility

Abstract

The European transport sector is marked by a strong, persistent unconscious bias, which produces gendered inequalities which permeate all aspects of the domain from design, modelling, implementation, education, employment and usage. TInnGO will create a framework and mechanisms for sustainable change in gender and diversity mobility through the development of a Pan European TInnGO observatory which will lead, coordinate, and be fed by hubs across EU (UK, France, Germany, Greece, Spain, Portugal, Romania, Baltic states, Denmark/Sweden, Italy) providing international and national leadership, innovation and critical reviews of smart mobility innovations. The ambition is to become a template for other observatories to address barriers to women's mobility through gendered, culturally sensitive smart mobility innovations. Written during the first year of a 3-year project, the paper provides an overview of the concept and initial results.

1. INTRODUCTION

It has long been recognised that women (and other groups) are significantly marginalised in transport. Without research in this area, smart mobility will continue to exclude these groups (e.g. the elderly, those from lower income backgrounds, with mobility, cognitive, sensory and communication difficulties). For example:

- Commuting journeys are privileged by transport systems, over those related to home and social and health care.
- The complex, multilegged journeys by women and those in lower socio-economic groups are not modelled, therefore future systems will perpetuate the same inequalities.
- In Europe over 70% of the transport workforce are male. If unchecked this may limit the opportunities for women's and other marginalized groups' employment and education in this field, and the inclusivity of Smart Transport innovations.
- Since 1945, only 7% of the transport ministers in TInnGO countries have been female. This is further reflected in research committees which have significant gender gaps and imbalances [1], these pose democratic problems and barriers to developing equitable innovative future transport systems.
- Gendered and non-inclusive discourses are being used to promote smart mobility.
- Informal workplace interactions reproduce stereotypical associations of the transport sector as a place for 'masculine' work
- A gender gap has already been recognised in the Smart Transport sector in the UK as well as in the Nordic regions [2].
- Women face higher risks and burdens than men in transport [3]. Additionally, some may be subjected to entrenched social and cultural norms which limit their mobility.
- The lack of awareness of gendered imbalances means that gender inequality persists and that there is practically no progress in gender smart mobility options.

The TInnGO project builds on and extends existing European gender and transport projects, notably the Transgen project [1] which outlined gender gaps, the usefulness of GM in transport systems, transport labour market, and the gendered character of transport -related media: the EIGE report [4] substantiated transport and sustainability as a vital part of the European responses to the Beijing Platform of Action and equality gaps; the DGMove report [5] which documented the different travel patterns and concerns of male and female transport users, the limited attention placed in developing gender-specific policies, programmes, and mandates, the evolution of intersectional issues such as employment trends, reduction in traditional gender divisions around household roles and responsibilities and 'mobility of care' as a concept to explain trip chaining

Unfortunately, despite the vast body of knowledge and numerous policy recommendations [1, 6] groundbreaking changes in European transport priorities or policies [7] have not been found. The TInnGO project seeks to address this by building on previous studies focusing on intersectional perspectives – related to socio cultural categories such as class, ethnicity, and age particularly in relation to smart and sustainable mobility, by creating gender and diversity awareness and action plans which can be translated into different cultural contexts to develop gender and diversity sensitive smart mobility as a fundamental component of a smart city.

2. APPROACH

TInnGO aims to promote a sustainable game change in the European transport by creating a new observatory, conceived as a one stop shop for analysis and solutions on the inequalities women face in the transport sector. It takes a three-pronged approach looking at gender and diversity issues in transport usage, employment and education. This will include:

1. The creation of a **Pan European observatory** for gender smart transport innovation in the Smart Mobility sector, providing a nexus for data collection, analysis and dissemination of gender mainstreaming tools and open innovation. The observatory will collect existing resources to become the reference portal for those wishing to address gender and diversity sensitive smart mobility. It will provide best practices, case studies, guidelines, tools, methodologies, training, policy documents and videos. Specific sections will allow users to participate in open innovation, share content and collaborate.
2. The central observatory will be fed by **10 national hubs and laboratories** (Baltic States, Italy, Greece, Norway/Sweden, UK Midlands, France, Romania, Germany, Spain and Portugal) each specialising in a local issue relating to gender and inclusivity (e.g. safety, needs of women from minority groups, entrepreneurship). The hubs will:
    a. use project outputs (such as gender action plans and gender mainstreaming tools) to address local issues in Transport Business Ecosystem (TBE) (such as gendered workplaces, inclusive consultation, entrepreneurship and education).
    b. provide national data relating to the (TBE) for example through standardised surveys on women's mobility
    c. act as beacon for women's engagement in the smart mobility sector
    d. provide '**living labs**' drawing on citizen science and participatory design to create gender and diversity-sensitive smart mobility solutions,
3. Development of an **Open Data Repository** – a one stop shop for sharing transport related gender datasets with standardised templates, tools and GDPR compliant data management processes.

Proposed impacts will be in areas of education and R&I(gender and role equality in STE(A)M, engineering & design); employment (gender bias in opportunities and workplace);mobility (increased awareness and use of 'hidden' journeys);datasets (standardise, create and merge datasets enabling better data analytics on women's mobility);entrepreneurship (document and transfer best practice);policy at local, national & international level (more accurate mobility information, integrated planning & diversity in policy making bodies); practice (increase equality in consultation, decision making and employment practices); new knowledge (about intersectionality and gender transport poverty); creation of inclusive smart mobility solutions putting people first; smart mobility discourses (critical analysis and development of new scripts.

3. METHODOLOGY

TInnGO is underpinned by key concepts and tools related to intersectionality, gender transport poverty, gendered discourses, scripts and agent-based modelling. It uses and advances gender mainstreaming (GM) which has proven useful in the promotion of gender equal transport with its duel focus on just and accessible transport and in achieving gender equality in the transport labour market. GM consists of tools to identify imbalances and inequalities in processes where gender has been invisible or regarded as unimportant [8]. It has been suggested as a tool for mobilization and participation and for addressing gender and diversity in new ways [9,10]. TInnGO will advance GM into diversity mainstreaming exploring influences on travel and transportation needs [9-12].

Given the project's scope, a mixed method, pragmatic approach has been developed (Table 1). Many of these, such as the use of intersectional analysis, co-design and citizen science are innovative in the field of gender and transport.

Table 1. Overview of Methods to be used in TInnGO

Method	Description
Gender and diversity Smart Mainstreaming	TInnGO will further develop and employ models of gender mainstreaming in transport
Mixed methods	Quantitative and qualitative methods will provide thick explanations and new hypotheses for gendering and diversifying key notions and gendered/genderless stereotypes such as user, passenger, safety, smart mobility
Qualitative research methods (feminist social psychology methods + Personal Construct Psychology+citizen social science tools and methods	Feminist research acknowledges the centrality of female/gendered knowledge and experience and the social construction of meaning, with emphasis on the role of language as the primary vehicle to enhance criticality of thinking, broaden research scope providing an extra dimension by adding to understanding of women's daily lives.
Quantitative methods	Development of an interrogatable and standardised open access and open data repository combining historic and real-time data sets for use with intersectional analysis to uncover new and significant mobility patterns. These will be modelled to evaluate and inform existing policies, operational issues, transport infrastructure and innovation.
Big data analytics and Agent Based Modelling (ABM)	ABM entails the sampling of the quantitative data collections into a larger data scenario perspective. This will be used for enhancing data and strategies; geographical comparisons; advancing GM; validation of qualitative data; consciousness raising and new

	policy recommendations
Digitalized and visual methods	Media and visual analysis will be combined with textual and visual methodologies to understand how future scenarios of smart mobilities are embedded in existing and emerging gendered discourses. Themed discourse analysis will provide a knowledge based comparative analysis of various gender diversity and transport discourses throughout Europe, using national media archives as data material and together with a visual analysis of marketing material a knowledge-based analysis of smart mobilities.
Case studies	Giving a multi-perspective analysis to develop theory, evaluation and interventions.
HUBs as living labs/mini publics	The TInnGO Hubs (each having a specific area of interest based on local concerns, e.g. safety, bicycling, design) will function as living labs, according to principles of deliberate and participatory democracy, user-centred design and open-innovation to inform practice, policy and act as a collection point for issues relating to women’s mobility.

4. WHAT HAS HAPPENED TO GENDER MAINSTREAMING (GM)?

[13] performed a desktop review on current methods and tools on gender and diversity mainstreaming tools in the transport sector in TInnGO's participating countries - Denmark, France, Germany, Greece, Italy, Lithuania, Portugal, Romania, Spain, Sweden, and United Kingdom.

Although variations were found between countries – both regarding gender and diversity mainstreaming and in the availability of published material, none of the eleven countries have sufficiently developed and applied methods for gender and diversity mainstreaming in the transport sector and they seem to lack overall strategies on national level. More considered approaches were found in some local Authorities and funded applied research projects. Examples of best practice (as shown in Table 2) were identified by [13] from ongoing work in Germany, UK, Spain (Valencia), Italy, Denmark and Sweden which could form the basis of a toolbox and disseminated through the observatory.

Table 2. Examples of best practice in GM

Country	Practice
Germany	Handbuch Gender Mainstreaming in der Stadtplanung und Stadtentwicklung" - awareness-raising handbook for gender-sensitive issues in interdisciplinary planning.

Sweden	1) Manual on gender impact assessment for transport planning (Halling, Faith-Ell & Levin 2016) provided examples, analysis questions and indicators for each national gender equality objective. 2) “Gender mainstreaming with intersectional perspective” (Almén 2016) providing a basic introduction to intersectionality
Denmark	Handbook on gender equality and transport: “Bæredygtig & Ligestillet Transport" (Breengaard 2008) presents challenges in relation to knowledge about women's and men's transport needs
UK	Regional/local examples of publications, initiatives and guidance e.g. the Transport for London’s (TfL) “Manual for the streets” (2007) and “Streetscape Guidance” (2019)
Spain	1) Equal Opportunities Strategic Plan sets out priority measures and objectives for removing gender-based discrimination to attain equal opportunities. 2) Madrid Social Policy and Family Regional Ministry - Women's General Directorate have developed a strategy for gender equality which includes measures related to transport.3) In Valencia GM is being incorporated into public policy and support manuals/handbooks exist in relation to this. The SUMP has inclusivity objectives
Italy	Regional initiatives directed at women in public transport and car parking and car-sharing; eg “pink passes”, reduced off-peak travel rates in public transport; “pink parking”, parking spaces or free parking for pregnant women or women with babies in certain places.

5. SUMMARY AND CONCLUSIONS

TInnGO is taking a multifaceted, ground -up and bottom-down approach, providing both tools and methods to encourage the use of GM in transport an smart mobility. The hubs will act as touch points across Europe disseminating good practice and encouraging the development of diversity sensitive smart mobility solutions to local problems. We hope, in this way that we can increase the inclusivity of smart transport for all.

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THE ROLE OF ITS ARCHITECTURE IN THE DIGITIZATION OF TRANSPORT IN SMART CITY

Key Words
Intelligent transport systems; Smart city; Digitization; Transport

Abstract

The development of the smart city concept requires digital transport infrastructure and the deployment of intelligent transportation systems. Successful development of the smart city concept requires ITS architecture. The ITS architecture creates a technical and technological framework for the development and implementation of ITS services that support the smart city's digitized environment.

1. INTRODUCTION

The smart city concept includes digital transport infrastructure. The new mobility paradigm focuses on user needs, their priorities, data flows and dynamic responses. Digital transport infrastructure includes information and communication systems and associated equipment used to store, generate and transmit information related to human and freight transport processes.

ITS systems must be open, offering on the one hand the application of different technologies of interactive and multimedia features, and on the other hand, must ensure that they operate in a specific geographical area from micro-locations, cities to regions, countries and continent [2]. Intelligent transportation systems play an important role in the development of a smart city. The ITS architecture is a framework for the successful development and implementation of an ITS system. It is not possible to integrate the transportation system with other smart city features without ITS architecture. The ITS architecture provides opportunities to develop new innovative customer-oriented transportation services and sustainable mobility as one of the important functions of a smart city.

2. DIGITAL MOBILITY TRANSFORMATION

Intelligent mobility is a new way of solving the problem of moving people, cargo and information, from starting point to destination, using all modes of transport. The transport service in the ITS environment should be a personalized, flexible service tailored to customer requirements. It integrates all types of mobility and offers them to the user in a fully integrated way [4]. Mobility as a Service is an innovative operational model that generates passenger mobility and customer-oriented freight services based on an unobtrusive, cooperative and sustainable transportation system. Mobility will increasingly be viewed through the timeliness of services and less through the ownership of assets (vehicles).

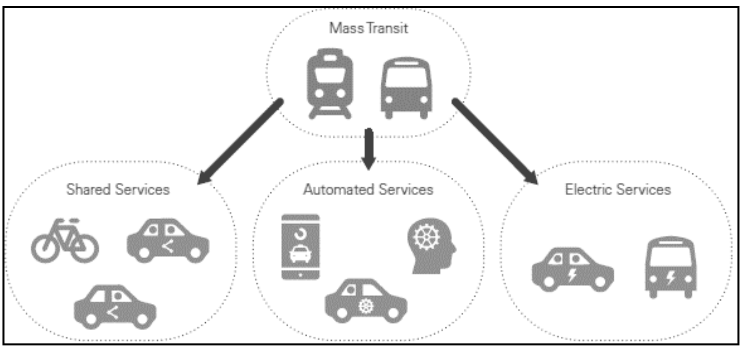

Figure 1. The concept of mobility as a service [3]

The availability of information throughout the transport network in the ITS environment opens up new possibilities for using the transport network in an efficient and user-oriented way. The new approach to mobility as a service in smart cities will depend on ITS services that enable integrated travel planning, integrated billing systems and the development of new mobility business models such as car sharing and on-demand mobility services.

Digitalized transport systems will have the following features:

- mass networking characterized by pervasive connectivity throughout the Transport system through the interaction of vehicles with V2V vehicles, V2I vehicles and infrastructure, and infrastructure with I2V vehicles.
- customer orientation is a paradigm focused on user needs, their priorities, data flows and dynamic responses to changes in system behavior.
- dynamic tariffs that contribute to balancing supply and demand
- integration of processes aimed at easily moving from point of departure to destination regardless of transport mode, service provider and service time

- new models of public-private partnership in the transport system.

Customers are looking for multiple integrated ITS solutions that will meet their communication needs through a single device (smartphone, trip computer) with intermodal terminals and connected networks.

3. BASIC GOALS FOR THE DEVELOPMENT OF INTELLIGENT TRANSPORT SYSTEMS

The development of modern society is accompanied by a steady increase in the demand for transport, which has resulted in the congestion of the transport network, a decrease in safety and an increase in adverse environmental impacts.

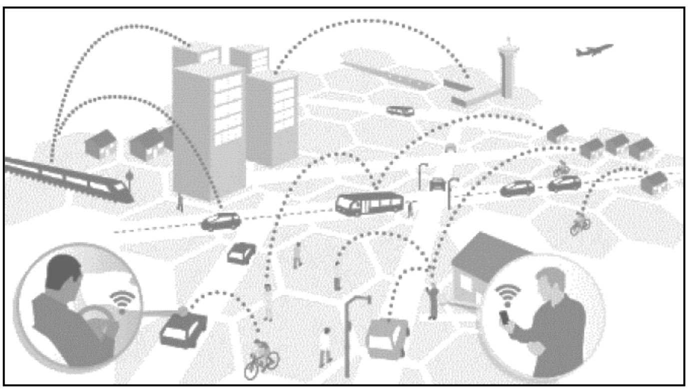

Figure 2. Functionalities of ITS services in a smart city [2]

The growing demand for transport is accompanied by customer demands for an increase in the level of service (safety, comfort, travel time), which are often contrary to the requirements of the transport and transport network operators for sustainable mobility and better use of the existing network. New approaches and new solutions are needed to ensure sustainable mobility and meet customer demands.

Intelligent Transportation Systems have been recognized as a new concept that will enable improvements in the transportation and transportation systems, but also ensure sustainable mobility. **Intelligent transport systems are the application of information, communication and management technologies, artificial intelligence and transport and transportation engineering methods to better plan, design, operate and use the transport and transportation system to enable safer, more secure, efficient, economical and environmentally friendly movement of people , freight and information on the transport and traffic** networks [3]. New solutions are needed to enable the transport of people and freight in an efficient, secure, efficient, environmentally friendly and sustainable manner to ensure a more efficient use of existing infrastructure.

4. DEVELOPING THE CONCEPT OF A SMART CITY

A smart city is a new concept for the development of an urban structure whose citizens are influenced by its changes to be effective, interactive, attractive and adaptable. It differs from the existing monofunctional and conventional cities of a monolithic structure.

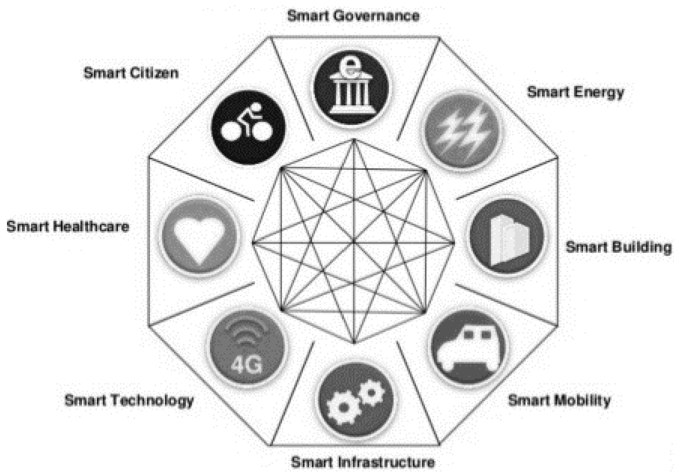

Figure 3. Smart city concept [3]

Although there is no single definition of smart city, it implies the application of ICT that enable better management of systems that improve living conditions and facilitate urban problem solving. The concept of a smart city includes the transport system that will enable the movement of people and cargo in an efficient (efficient), safe (protected), effective (efficient), environmentally friendly and sustainable way.

The differences between the dynamic structure of a smart city and a traditional city are reflected in the following:

- smart cities use an intelligent infrastructure that includes devices and equipment to collect data from the environment
- smart cities use new analytical tools that enable the analysis of large amounts of data and tools that encourage citizens to connect and change their behavior
- smart cities, through intelligent infrastructure and programmable systems, enable efficient management in a dynamic environment.

Improving the traditional transportation and transport infrastructure in the urban area enables it to evolve from a passive to an intelligent, self-monitoring and self-managed infrastructure. The smart city's intelligent infrastructure components, connected via the Internet, allow the collection of data from a variety of sources and contexts and the execution of integrated functions.

5. THE ROLE OF ITS ARCHITECTURE IN THE DEVELOPMENT OF INTELLIGENT TRANSPORT SYSTEMS

The ITS architecture is a conceptual framework that defines the structure and behavior of an ITS system. ITS architecture can be defined as a basic system organisation consisting of crucial components, their relations and connections to environment, as well as principles for system design and development during the whole lifecycle [1]. The ITS architecture describes the functionalities of the ITS subsystems and the ways in which they are interconnected at the functional (logical) and physical levels used to plan, develop and deploy ITS applications [5].

In order to harmonize the development of ITS, the European Union has developed The European ITS Framework Architecture is designed for use as the starting point for the development of National ITS Architectures. The European ITS Framework Architecture defines and describes what needs to be included in ITS that can fulfil the requirements of the European ITS User Needs. A Functional Architecture defines and describes what functionality needs to be included in ITS.A Physical Architecture defines and describes how the functionality created in the European ITS Functional Architecture can be grouped to form Systems that can be produced. A Communication Architecture defines and describes what kind of communication links needs to be used in a System in order to support its physical data flows. **National ITS Architecture** is developed to cover the application of ITS within a EU Member States. It can be based on those parts of the European ITS User Needs that are relevant to the EU Member States and be developed from the European ITS Framework Architecture (figure 4.).

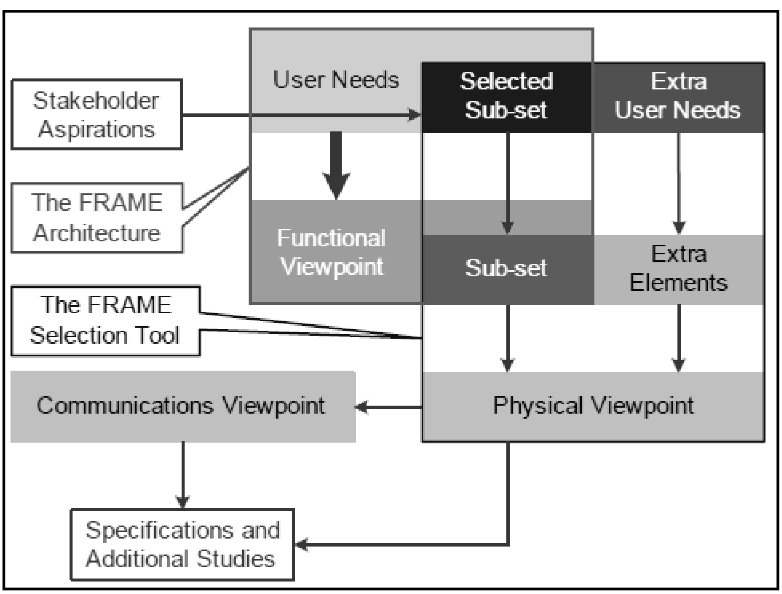

Figure 4. Creating a national ITS architecture based on the European ITS Framework Architecture [6]

The European ITS Framework Architecture is designed to provide a flexible framework that individual countries can tailor to their own requirements. National ITS Architecture projects based on the European ITS Framework Architecture, have a common approach and methodology, but each Country can able to focus on the aspects of local importance and develop them in more detail.

Some Southeast European countries (Slovenia, Hungary, Croatia, Greece) have made significant strides in developing national ITS architectures, while other countries (BiH, Serbia, Montenegro, Macedonia, Kosovo, Albania) are conducting preparatory research that will result in the development of national ITS architectures. Harmonizing the development of ITS in Southeast Europe would significantly reduce ITS implementation costs, create a larger ITS services market and ensure interoperability. This would create a stable framework for digitizing transport and developing smart cities in this part of Europe.

6. CONCLUSION

The development of the Smart City concept entails the digitization of the transportation system. The development of intelligent transportation systems is a complex long-term process. The ITS architecture creates a framework for the stable development of the transport system and the successful application of new information and communication technologies in the transport system and the successful integration of the transport system with the digitized environment. To ensure the interoperability of ITS services, standardization of solutions through the development of the ITS architecture is required.

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SUSTAINABLE STRATEGIES FOR DEVELOPING BANJA LUKA AS A CITY FOR PEDESTRIANS AND CYCLISTS

Key Words

Cycling;
Walking;
Urban mobility;
Sustainability

Abstract

Due to the unstoppable trend of urbanization and expansion of motorized traffic, during the 20th century, cities were confronted with great and often negative changes in the urban tissue. Recent shift of focus in urban planning toward pedestrians and cyclists is a result of contemporary tendency to revive the lost human dimension of cities. Paper consist of two parts. First part analyse basic and contemporary concepts of sustainable urban mobility (SUM) with focus on walking and cycling and overall human city dimension. Research deals with how process of stimulating non-motorized transport can contribute to sustainable urban mobility and whether it can become a strategy for development and sustainability.Second part is application of analysed concepts and theories on urban matrix of city of Banja Luka. By reviewing local policies and actions, research seeks to determine whether sustainable transport problems are identified and to what extent they are being addressed.

1. INTRODUCTION

For more than half a century, most countries have experienced rapid growth, which has brought with it an increase in population density, urban sprawl and overuse of motor vehicles. All mentioned has caused a number of environmental, social and economic consequences. Due to the oncoming traffic spree, the city space is occupied by streets and large parking areas [1]. Solutions that tried to reduce traffic jam by building new traffic infrastructure and improving car traffic conditions have caused even more traffic congestion. Lack of public urban space, obstacles, noise, pollution, impaired security and disruption of citizen participation in urban life are just some of the consequences of the growth of modern cities. The focus has shifted from social interaction in public urban spaces to meeting the needs of individuals.

The modern concept of sustainability has contributed to the awakening of awareness of the lost human dimension in the city and enabled transport to be no longer an end in itself, but rather a means to enable people to obtain all that they need. Traffic congestion solutions are sought in increasing the attractiveness of alternative modes of transportation, in changing parking policies and behavior of road users, as well as in the more rational use of urban land. The Danish architect Jan Gehl, whose work focuses on improving the quality of urban life, argues that "a sustainable city is, in principle, possible if most of its transport system is based on green mobility, which involves walking, cycling or using public transport" [1]. Based on this statement, the paper examines current strategies for achieving sustainable urban mobility in the city of Banja Luka.

2. METHOD

The first part of the paper presents the concept of sustainable urban mobility and the tendencies that occur in traffic planning. The research involves the application of a content analysis method, analysis of available literature within the subject area in order to present relevant data and to form a theoretical research background.

The second part of the paper focuses on the study of the local context - the analysis of the case study of the city of Banja Luka. The analysis of the current situation of urban mobility is presented in a descriptive and graphical way in order to define the guidelines for the development of urban mobility, based on theoretical research. The review of local policies and actions, as well as the planning documentation, seeks to determine whether the problems of unsustainable traffic are identified and to what extent they are being addressed.

The final part of the paper provides recommendations and guidelines for the development of Banja Luka as a city of pedestrians and cyclists.

3. SUSTAINABLE URBAN MOBILITY CONCEPT

After sustainable development became relevant in all spheres of society, the concept of conventional traffic planning was abandoned. The need for systematic traffic planning, which will eliminate the shortcomings of traditional, linear planning, has emerged, [2]. Sustainable planning uses the principle which says that any form of transportation can be useful in creating a balanced system. A large number of cities are employing strategies that favor non-motorized modes of transportation, public transportation, and disincentives for car use in congested urban areas.

Pedestrians and cyclists are given priority over motor vehicles, and comfort and safety are of primary importance in relation to speed [3].

Usually mobility is viewed through three groups: slow (walking and cycling), shared and private transport [4]. What begs the question is which of these modes of transport can contribute most to the creation of sustainable urban mobility. Naturally, cycling and walking are the only low energy solutions that take up the least space [4]. Slower modes of transport have low requirements for transport infrastructure, are safe and environmentally friendly. What the slower modes of transport do not live up to are the expectations and the habit of traveling fast and long. Due to these limitations in the practice of sustainable urban mobility, walking and cycling are part of multimodal transport and are combined with public, road and similar modes of transport.

Planning for sustainable urban mobility in European countries, as of 2014, is taking place according to a new planning concept, which is realized through the development of a Sustainable urban mobility plan (SUMP). This new concept calls for the involvement of citizens and relevant actors, for coordination between different levels of government and for a cross-sectoral approach to planning. The sectors requiring coordination within the plan are: transport, land use, environment, economic development, social policy, health and energy [5]. SUMP is a strategic document that builds on existing traffic planning practices and takes into account integration, participatory and evaluation principles to meet existing and future residents' mobility needs and to ensure better quality of life in cities and their surrounding areas [2].

Also, the United Nations report Mobilizing Sustainable Transportation for Development is moving away from the principle of mobility on the basis of individual motorized traffic and increasing traffic speeds, and is moving towards ideas of accessibility, where people and their quality of life are prioritized with a focus on safety and social equality. The concept of access is realized through enabling people to access everything they need: sustainable livelihoods, food, health, safe communities and spaces, thus creating the opportunity for economic prosperity, social needs, personal and intellectual development [6]. In most successful implementations, a single policy has not been introduced but rather a package of measures, which allows the mixing of different policies that at first glance seem insignificant to individual users but promote the overall well-being of society as a whole [7]. In all of this, mobility drives development, connects people, connects local communities, builds markets and facilitates trade.

4. BANJA LUKA CASE STUDY

In recent years, Banja Luka has gradually entered the era of new urbanization. The increasing population, as a result of the migration of residents from small towns and villages to the capital of Republika Srpska (one of the two entities of the Bosnia and Herzegovina), has forced cars, as a necessary means of transportation, to be drawn into most families. With the increase in the number of urban cars (49,795 registered vehicles in 2008 and 73,341 in 2018) (Republika

Srpska Institute of Statistics) [8], traffic congestion has become a bottleneck in urban development. Also, poorly developed, expensive and slow public transport is one of the reasons why citizens use private cars more often. In order to critically address these issues and to determine the research space of their socio-ecological implications, a study is presented the analysis of urban mobility in Banja Luka and the possibilities of its reorganization in order to mitigate traffic challenges, increase urban public spaces, and increase the quality of the environment and of the life of the city inhabitants.

The Urbanization Plan for Banja Luka (1975) (a valid urban plan) also indicated the expansion of individual motor traffic. By 1965, bicycle traffic, in addition to pedestrian traffic, was a major form of communication in the city. According to the estimate at the time, every second resident owned a bicycle. The increase in the number of motor vehicles has dramatically reduced the participation of pedestrian traffic and cycling as streets have become dangerous for them [9]. What is worrying is that the Banja Luka Urban Plan Proposal 2008-2020. which has never been adopted, is not adequately treating pedestrians and cyclists. The priority in traffic planning is the construction of city roads, in order to increase the capacity of the street network. Pedestrian and bicycle traffic are not brought into the context of mobility and are not treated as modes of transport [10]. Also, it is clear from the comparative scheme of the Planned Bicycle Network of the 1975 Urban Plan and the 2006 Bicycle Trail Network in Banja Luka that there is no progress in the development of cycling traffic over a thirty year period (Figure 1).

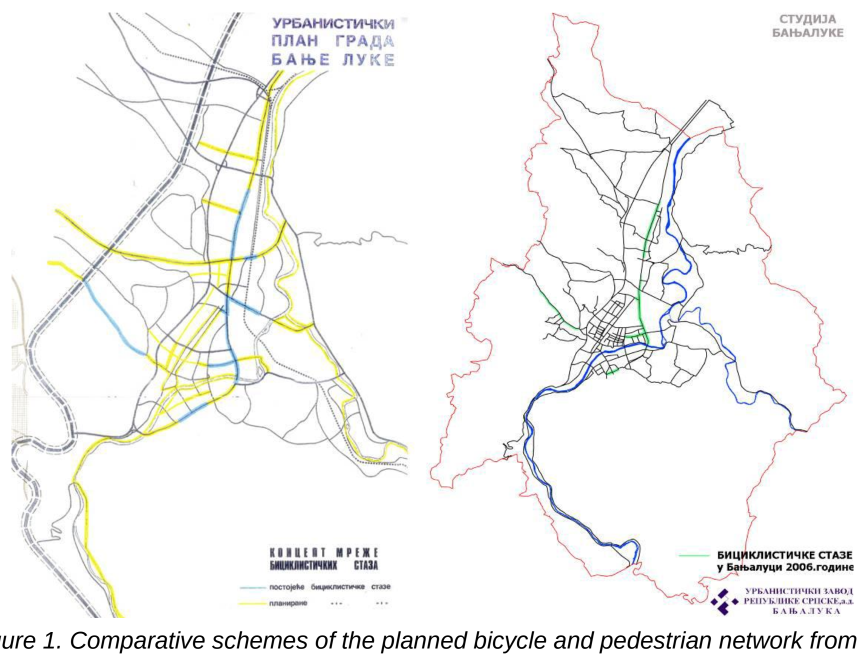

Figure 1. Comparative schemes of the planned bicycle and pedestrian network from the 1975 Urban Plan and the network of cycling trails in Banja Luka from 2006 (Source: Draft of Urbanization Plan for Banja Luka 2008-2020, 2009)

The current situation map of the cycling trail network (Figure 2) indicates some progress compared to the situation recorded in 2006. In the past year, 2,200 m of new pedestrian and 2,200 m of new cycle trails have been built, while 800 m of new cycle paths are currently under construction. The newly constructed bike lanes are not integrated into the street infrastructure. They are slowed down and diverted at intersections, clearly prioritizing cars in traffic. The map of the current situation of the cycle path network has been supplemented by other sustainable mobility measures implemented in the city of Banja Luka, relating to the bike sharing system, the introduction of a mini-bus for the Banja Luka Recreation Area (Banj brdo) with access for the disabled, construction of trim trails along the Vrbas river coast, changing the purpose of Kralj Petar I Karadjordjevic Street into the pedestrian street on weekends in summer [11].

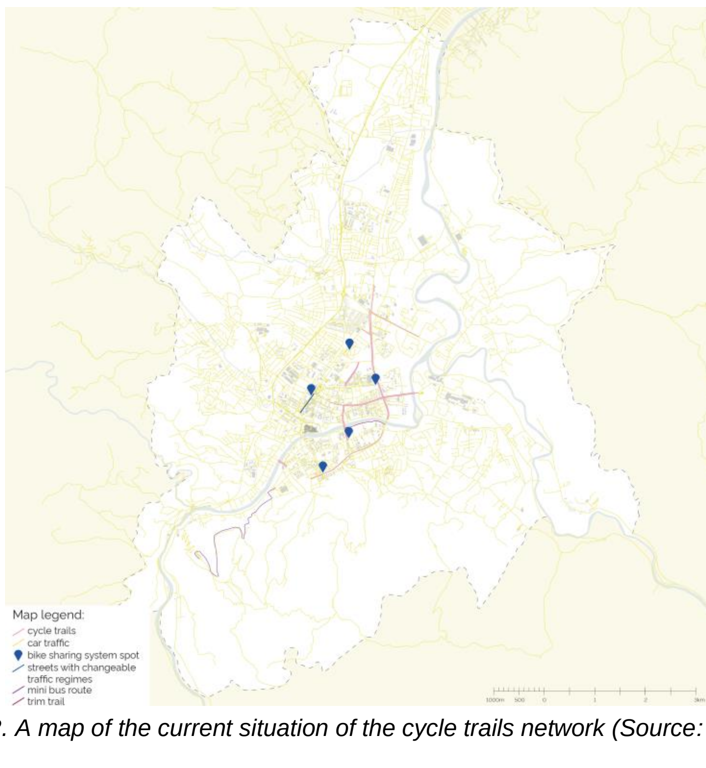

Figure 2. A map of the current situation of the cycle trails network (Source: Authors)

In the context of sustainable urban mobility planning, there is still no adequate legal basis or governance policies in the Republic of Srpska that recognize sustainability. Integral planning has been declaratively present in legal acts as one of the planning principles, but through legal solutions, planning methodology and institutional support has not been realized [12]. The problem of sustainable transport in Banja Luka is in itself an extraordinary and complex challenge. What can be pointed out is that there is still no sustainable urban mobility plan (currently under development) in the city through which strategic and systematic approaches of planning, that take into account social, economic and environmental aspects, can be established. However, there have been initiatives in the city for many years aimed at sustainable urban mobility.

Since 2002, Banja Luka has been participating in a campaign called European Mobility Week, within which the city's first cycling cycle was organized [13]. European Mobility Week is organized each year in more than 2,500 cities around the world and ends with the celebration of World Car Free Day, 22 September. Banja Luka, with the support of city authorities, Deutsche Gesellschaft für internationale zusammenarbeit (GIZ) and the Open Regional Fund for South-East Europe - Energy Efficiency (ORF-EE), has become a gold participant in the European Mobility Week 2018 and the only city in BiH with this status [14]. The actions organized in the city have a good turnout of citizens, as evidenced by about 600 participants of the 16th Banja Luka's bicycle fair "Two wheels are enough" held in 2017. The organization named Banja Luka's Critical Mass, made up of citizens of Banja Luka, guests, tourists and bicycle lovers, is responsible for organized bicycle rides on a monthly basis.

The National Coordinator of the European Mobility Week is the organization Center for the Environment and since 2002 has been implementing a transport program aimed at "promoting sustainable modes of transport and changing habits of people in populated areas" [13]. The City of Banja Luka is part of the CIVINET Slovenia-Croatia-SEE network of cities, with the aim "to transfer knowledge and good practices and to design joint projects that will finance future sustainable transport activities and better mobility" [15]. Organized by this network, a roundtable on sustainable urban mobility planning was held in May 2018 in order to discuss sustainable urban mobility plans [16]. At this roundtable, the city authorities and the Department of Transport and Roads presented the Mobility Plan of the City of Banja Luka for the period 2018-2020. [17]. It is emphasized that the following has now been realized so far: sistem of public bike renting stations, public transport mobile phone application, electric vehicle chargers, a zero parking zone, the redesign of the central pedestrian zone and the change of use of the main street into the pedestrian zone on weekends.

5. CONCLUSION

In the case of Banja Luka, there is a clear lack of implementation of sustainable transport planning measures, as well as a lack of strategic planning approach guided by integrative, participatory and evaluation principles. The paper highlights the problems of sustainable urban mobility in Banja Luka that deserve special attention and additional research. Cycling and walking can become strategic commitments in order to achieve sustainable urban mobility, but research shows that they have not yet become one. Various initiatives, roundtables and actions are a good indicator of raising the awareness of citizens and authorities about urban mobility. In the coming period, it is necessary to focus even more on the development of sustainable modes of transport, through education, new actions and projects. Introducing a sustainable urban mobility plan and working on legal and institutional support are necessary instruments to integrate sustainable urban mobility systems into the environmental context, while paying attention to the economic and social aspects of sustainability.

Walking and biking opportunities should be understood and viewed as a comprehensive investment in improving living conditions and developing sustainable transportation systems, in order to reduce environmental pollution and traffic risks.

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OPEN SOURCE TICKETING ENHANCING MOBILITY AS A SERVICE SCHEMES

Key Words
Public transport;
Ticketing;
Open source;
MaaS

Abstract
Public transport users need innovative, multi-applicative, multi-functional, safe and secure ticketing systems, easy to use. Operators, on the other hand, need systems which offer all requirements from passengers but financial sustainable. To achieve balance and provide sustainable and useful public transport services, traditional public transport needs to be improved with new innovative mobility solutions. Ticketing is the key to the making mobility services work together. Data from services using public transport must be public for the benefit of citizens and city planners. Concept of Mobility as a Service (MaaS) as an integration of various forms of transport services into a single mobility service accessible on demand is a new way of thinking about public transport. This paper focuses particularly on open source as a main driver for enhancing Mobility as a Service schemes.

1. INTRODUCTION

Today, transport operators wish to deliver the best services and simplify people's daily lives. Future tools may help them in reaching that goal. NFC phones will certainly become more widely used and stand out as the inevitable multi applicative media. Meanwhile contactless USB keys may increase home usage services, such as the reloading of transport rights. Among the different ticketing systems available on the market, Calypso technology ranks as an attractive and innovative solution, made for transport operators and driven by transport operators [1]. Calypso technology can accept new challenges. A generic applet is already available, fully compliant with the GlobalPlatform API specifications, and is today widely used by SIM providers and bank card manufacturers. The applet is downloadable onto a Secure Element based on the Java Card environment and implemented in an NFC mobile phone or a contactless USB key. This enables new facilities for customers and retailers. Rolling out an electronic ticketing project over time requires the ability to integrate new upgrade and technological capabilities on an ongoing basis.

Modern urban living is rapidly changing with new technological innovations, one of which is the possibility to integrate different electronic “on demand” services into one single medium. Therefore, different applications can be brought together into one single device for the citizens of tomorrow in Europe or elsewhere: the "Urban Pass", will have the ability to integrate mobility and banking applications, local authority and public administration service access. Calypso security technology and memory storage are tailored to meet multi-functional requirements. A transport application and a dedicated city application may, for example, safely reside on the same Secure Element of a portable object; moreover, they may live alongside third party applications, opening the road to the ideal urban pass [1].

Beyond its original function of collecting revenues from transport, ticketing is now considered as the backbone of Mobility as a Service (MaaS). Ticketing must enable mobility services to be combined and offer passengers a seamless, end-to-end, easily accessible transport offer.

2. MOBILITY AS A SERVICE

Mobility as a Service (MaaS) represents a new way of thinking about transport. It has the potential to be the most significant innovation in transport since the advent of the automobile. MaaS is the integration of various forms of transport services into a single mobility service accessible on demand. To meet a customer’s request, a MaaS operator facilitates a diverse menu of transport options, be they public transport, ride- sharing, car- sharing or bike-sharing, taxi or car rental/lease, or a combination thereof. For the user, MaaS can offer added value through use of a single application to provide access to mobility, with a single payment channel instead of multiple ticketing and payment operations. For its users, MaaS should be the best value proposition, by helping them meet their mobility needs and solve the inconvenient parts of individual journeys as well as the entire system of mobility services [2].

The term Mobility as a Service (MaaS) was coined in Finland in 2014. Then defined as ‘a system, in which a comprehensive range of mobility services are provided to customers by mobility operators’, MaaS has more recently been described as an integrative concept that bundles different transport modalities into joint, seamless service offerings, in order to provide tailored mobility solutions that cater for users' travel needs [3].

A successful MaaS service also brings new business models and ways to organise and operate the various transport options, with advantages for transport operators including access to improved user and demand information and new opportunities to serve unmet demand (Figure 1). The aim of MaaS is to provide an alternative to the use of the private car that may be as convenient, more sustainable, help to reduce congestion and constraints in transport capacity, and can be even cheaper [4].

Figure 1. MaaS advantages [5]

Some examples of recent implementation and/or planning for MaaS schemes in a number of countries are MOBIB in Brussels, HANNOVERmobil, EMMA in Montpellier, SMILE7 in Vienna, Moovel in Germany, etc [6].

MaaS is a still a very young concept, and the amount of MaaS-focused research is rapidly increasing, which is also visible in scientific publications, the amount of which has increased strongly in 2017 and 2018. The early scientific findings related to Mobility as a Service, and the wider scale impacts on mobility and transport system of MaaS, according to [7] are:

• MaaS makes the transport system more efficient and helps to recognize and choose the daily mobility options

• Personalized services enable seamless trip chains by integrating different transport modes

• Popularity of private cars is expected to reduce as flexible choices such as car-sharing and on-demand ride-sharing services become more common. Overall, MaaS seems to increase use of sustainable transport modes

• Sustainable transport modes are expected to become more popular albeit there is not much discussion of the role of cycling in the MaaS literature.

• New flexible transport modes force conventional public transport to adapt to a more service-oriented system

• MaaS trials enable great possibilities to get to know and try out new mobility services

• Public sector has a key role as an enabler of MaaS e.g. by supportive Legislation

The popularity of MaaS has spread to become a global phenomenon. For instance, outside Europe, scholars have also considered MaaS developments in North America Asia and Oceania [3].

3. OPEN SOURCE TICKETING

Data from services using public infrastructure such as roads must be public for the benefit of citizens and city planners. It is highly recommended that transport operators use available standards and open specifications (incl. security, data model, transmission, etc.) as much as possible to avoid costly implementations of proprietary and non-compatible systems, which make interoperability impossible. In this context, an open platform is composed of hardware and software components that adhere to common standards and are non-proprietary such that multiple vendors can supply these components interchangeably. In an open platform, components from multiple vendors using different technological approaches may be assembled and interoperability across products can be ensured. The objective of an open platform is to achieve vendor independence and allow easy transition to emerging technologies [8].

For the Mobility-as-a-Service dream to come true at a reasonable cost, the ecosystem must be based on standards, APIs and open technologies as much as possible. This opening has been a reality for several years in the field of passenger information services and has given rise to a wealth of attractive applications, thanks in particular to open data. To allow ticketing to follow that path of opening initiatives, Calypso Networks Association has provided the first fully open source ticketing API free of charge Eclipse – Keyple. Keyple offers a concrete and operational answer to two key issues: mastering ticketing systems and providing a simple and fast access to Calypso technology, especially as part of MaaS schemes. It will become easier to develop connected and interoperable services combining all forms of mobility: metro, train, tramways, buses, park & rides, bike-sharing, car-sharing, car-pooling, e-scooter-sharing, etc. Keyple aims at accelerating the integration and development of high-performance ticketing applications. It will enable mobility stakeholders, event organisers, sports, cultural and leisure infrastructure managers to easily and economically implement ticketing systems based on a common, open and modular platform, whilst keeping Calypso's fundamental characteristics of reliability, security and interoperability. Technically, it is a library of functions, available in Java and C++ that allows developing ticketing applications to communicate securely with Calypso media (NFC smartphones or cards). It provides developers with a generic interface that automatically manages Calypso transactions. It is available in several OS environments (Windows, Linux, Android etc.) and can interface with standard readers (PCSC) and proprietary environments linked to specific hardware. Keyple can be used in both card-centric ticketing architecture schemes and server-centric schemes (account-based ticketing), where customer rights are stored on back-office servers. Using Keyple thus considerably reduces development time, avoiding both implementations specific to each environment and the need to master Calypso's complex secure session mechanisms.

Keyple project is hosted by the Eclipse Foundation, which guarantees strict compliance with open source rules. It is therefore accessible to everyone free of charge with the only condition that any modification of the source code must made available to the community. This allows a documented access to the source code, and therefore everyone can optimise its use in specific contexts. Developers can interact with the Keyple user community and contribute to product improvements. Keyple offers the highest guarantee of technical and financial efficiency, full control of its ticketing system and a real independence from equipment suppliers. As public transport operators, RATP and SNCF are committed to ensuring that future MaaS platforms are as open and inclusive as possible, so as not to be locked into a few large private players [9].

4. DISCUSSION

Seamless travel, e-Mobility, ease of access to the city, passenger information, guidance, smart and flexible ticketing are key points to ensure a real attractiveness of public transport. More and more these new digital services are both integrating transport in the city thanks to the deployment of urban multi-application solutions (banking, parking, leisure, event management, etc.) and linking cities between them thanks to interoperable schemes.

Successful adoption of technology is one of the key elements to sustainable economic development and growth. In addition, intelligent solutions are a driving force to modernise society. With urban transport at the core of future mobility patterns we see the need of intelligent solutions that will allow users to benefit from integrated services. Only by becoming part of lifestyle services public transport will create the necessary positive image and allow increased ridership on the long term. Customers want to be informed about the services they use and everything that relates to them. Matching these expectations means that numerous services need to be integrated with smart ticketing such as real-time information, guidance, events information etc. Internet 2.0 has started to educate users to perceive their environment this way and urban transport needs to adapt to this new societal paradigm.

For more than two decades now Calypso technology has contributed to many significant developments in the frame of smart ticketing. To manage successfully the upcoming mobility challenges the ability to offer a standardized and interoperable transport application, matching the needs of transport operators irrespective of what customer medium they run on, is essential. To better enhance developments the technical specification has been opened. By matching the philosophy of open source to ticketing a new dimension within the world of developers has been reached. Only by having open APIs and ticketing specifications it will be possible to act as a connector for mobility services. The availability and accessibility of technology through “Open Sources” means a significant broadening of the perimeter of the potential technology deployment and it widens in parallel the current eco system to meet the future challenges of mobility by guaranteeing a high level of security of transactions.

To be prepared to the new challenges of ticketing, the Calypso community has initiated one year ago this path towards Open Source. This means that over the coming years a switch to a model oriented on the parameters of an Open Source approaches will be made. Consequently, a significant broadening of the perimeter of technology will open to new business models. With higher service orientation, the competitiveness of Calypso will increase the value for its users and generate new streams of revenue. The Open Source SDK that will be provided by CAN, the association managing the Calypso technology) through the Open Source Platform ECCLIPSE will allow local suppliers to implement Calypso ticketing systems without having to be linked to big traditional ticketing integrators. This strategy will allow the creation of local added value and work force by integrating every player of the ticketing eco system without any discrimination.

5. CONCLUSION

As the ticketing system typically lasts for up to 20 years, its implementation represents an important investment. Therefore, ticketing system must enable evolutions and upgrades throughout its life. Whilst ticketing was initially a mere fare collection tool, it is now considered as an essential enabler of MaaS which has given back to ticketing a major role as the gateway to mobility for all, after having often been wrongly perceived as just a means of paying for transport. Sustainable door-to-door mobility need innovative mobility solutions complement with traditional public transport and useful transport services. This has driven the need to connect pt services together to provide a coherent mobility offer, which is the principle that guides the concept of Mobility as a Service. In conclusion, ticketing is the key to the making mobility services work together, as it should facilitate the transition from one form of mobility to another seamlessly and contribute to the attractiveness of services through an adapted fare offer.

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THE VERTICAL URBAN FACTORY CONCEPT AND SUSTAINABLE TRANSPORT – PROTOTYPES FOR EUROPEAN CITIES

Key Words
Urban freight logistics;
Urban transport;
Sustainable transport;
Productive city;
Smart city

Abstract

The Vertical Urban Factory concept reclaims production in multi-storey buildings as part of the cityscape. Today, factories are mostly located in monofunctional industrial areas outside of cities due to high land prices and restrictions on motorised individual transport. However, production must be taken into account as a necessary element of lively and mixed urban structures. New urban development concepts are therefore in demand for efficient and space-saving use of commercial and industrial space. We analysed how multi-storey production can be reintegrated in European cities and developed five prototypes considering urban structure and logistics concepts. The prototypes show that multi-storey construction is indeed a realisable alternative for limited space resources. While integrating individual production facilities in densely built-up areas fulfils the current transport policy objectives best, the greatest potential of vertical production is located in mixed commercial areas. The vertical urban factory concept promotes sustainability goals on many levels and we therefore recommend it to cities. In this paper, we focus on the transportation aspects and present three of the five prototypes.

1. INTRODUCTION

Production plants in backyards and multi-storey buildings integrated into the street front have been part of the cityscape since industrialisation. Today, they are mostly relocated to monofunctional industrial areas. Mass motorization and the availability of cheap raw materials have massively changed the form of economy and production. The catchment area of raw materials for further use and processing could be expanded as well as the space for a possible sales market. Economies of scale enabled economic and production-specific concentration processes to take place while at the same time providing an extensive sales market [1].

The mixture of residential and working areas contributes significantly to energy-efficient urban development and the achievement of ambitious smart city goals. The potential contribution of urban factories to the sustainable development goals has been analysed in [2]. However, urban commercial properties are scarce in many places and are not affordable for manufacturing companies with correspondingly large space requirements. In addition, there is the pressure to develop new locations for residential construction due to increased immigration into cities. In Vienna, for example, since 2001 the space for manufacturing companies has declined by 16.5%, in pure industrial areas the decline is even 30% [7].

The decline in the number of business premises, and thus in many cases of urban workplaces, requires measures to be taken to prevent the spatial segregation of living and working areas. The consequences of this spatial decoupling are not only opposing energy spatial planning objectives, but also synergy potentials cannot be used sustainably (such as the use of energy/waste heat, closed-loop and cascade management, urban value creation, microeconomic local networks). New urban development concepts are therefore in demand for efficient and space-saving use of commercial and industrial space.

Alternative concepts to make production in the city attractive again for companies are currently still the exception. While the digital transformation of industrial production is preparing the return of urban industry to mixed-use neighbourhoods (cf. [3]), there are considerable obstacles on the other side. While digital production can either be bundled spatially efficient or organized in small decentralized areas, there are challenges for integration into city-compatible logistics systems and intelligent transport and traffic concepts. New driving technologies and flexible transport containers offer the possibility of making freight transport more compatible with urban conditions. Nevertheless, elements of an urban freight transport are still predominantly designed for the distribution of goods. How the system has to be designed in order to offer flexible and acceptable conditions for production processes inside the city has so far received little attention. The role of logistics is becoming increasingly important in the globally networked economic process based on the division of labour. Based on the spatial distribution and separation of production and consumption, huge distribution centres are emerging outside cities, so-called "logistics landscapes" (see [4] and [5]), with enormous effects on traffic volume and energy consumption. The integration of this link into the urban fabric is a central challenge. Various European cities, such as Berlin, have adopted an area protection concept ("Berlin Integrated Commercial Transport Concept" [6]). Vienna has developed the "Productive City" concept [7] for this purpose.

This study was part of the research project “Vertical Urban Factory” [8] that assessed architectural, legal and transportation parameters for vertical production in cities. For the project, we built on the concept of the vertical urban factory [3]. The objective was to assess the possibility of reintegrating multi-storey production in European cities. To this end, we took Vienna as an example of a typical European city and developed five prototypes of “vertical urban factories” considering the existing urban structure, legal restrictions, global and local objectives, production needs and urban freight logistics. In this paper, we focus on the transportation aspects and present three of the five prototypes.

2. METHODS

Firstly, we analysed the existing urban structure of Vienna (which is similar to those of other historic European cities) in the context of land use and transportation. This included the assessment of building density and height as well as the accessibility by walking, cycling, public transport (PT) and private motorized vehicles. Simultaneously, we visited existing production facilities with vertical concepts. Secondly, we carried out a multi-criteria analysis by comparing the needs of factories, spatial and legal restrictions of cities and global to local objectives in terms of land use and transportation. As a third step, we developed prototypes of vertical urban factories reflecting the considered criteria (one prototype for each type of area). The prototypes are 3D models showing the size, rough floorplans and transportation concept of the schematic factories. In addition, we specified the relation of the building with its surroundings, such as the transport system and land use of adjoining buildings.

3. RESULTS

3.1. Urban structure

For the purpose of this study, the urban structure of Vienna can be divided into three major different types of areas for production facilities: *integrated individual production facility, mixed commercial area* and *industrial-commercial area.* These types correspond to the areas defined in the city's thematic concept "productive city" [7]. The *integrated individual production facility* is a single factory, embedded in a dense urban structure with mainly residential use. Existing factories of this type are usually historic ones that were built in an industrial area where residential buildings have approached with city expansion. *Mixed commercial areas* combine residential, commercial and industrial use. Such areas have generally been densified more recently and still show lower building density. *Industrial-commercial areas* can be found usually on the outskirts of the city. They have no residential buildings, mostly hall constructions and spacious traffic areas. Table 1 gives an overview of how the three types correspond to transportation parameters that are relevant for production.

Table 1. Three types of areas for production facilities and their transportation parameters

Transportation parameters	**Integrated individual production facility**	**Mixed commercial area**	**Industrial-commercial area**
Logistics area	Densely built-up; limited logistics area	Variable availability of logistics area	Generally high availability of logistics area
Parking area	Mixed use and densely built-up; limited parking area	Rather sufficient parking area	Sufficient parking area
Accessibility (public transport, walking and cycling)	High accessibility, short distances	Medium quality of accessibility; acceptable access by public transport	Insufficient accessibility
Accessibility (motorised vehicles)	Limited accessibility	Good accessibility	Very good accessibility
Delivery restrictions	Strict restrictions	Restrictions are important	Little restrictions

3.2. Multi Criteria Analysis

Objectives that are relevant for urban production reach from global (such as the UN Sustainable Development Goals [9] or the Paris Agreement [10]) to national (e.g. climate and energy strategy of Austrian government [11]) to local (e.g. urban development plan of Vienna [12]). The current overall goal is decarbonisation. This demands restrictions for private motorized transport, better conditions for alternative modes of transportation including more density and mixed use to support short trips. Fortunately, these measures also promote sustainability and liveability in cities and align with the local city objectives. The concept of the vertical urban factory promotes the goals in shortening trips for freight, employees and customers, adding to the density of the city and providing mixed use.

Nevertheless, there are also challenges for incorporating vertical factories in cities. Neighbours can be disturbed by delivery traffic and production itself. Population growth puts pressure on administrations to construct residential buildings instead of preserving old production facilities and constructing new ones. Public space is limited in denser areas. This can result in conflicts of interest for that space. Figure 1 shows the relations between transportation parameters of cities and production parameters of factories. Interdependencies between transportation parameters are indicated with two-sided arrows.

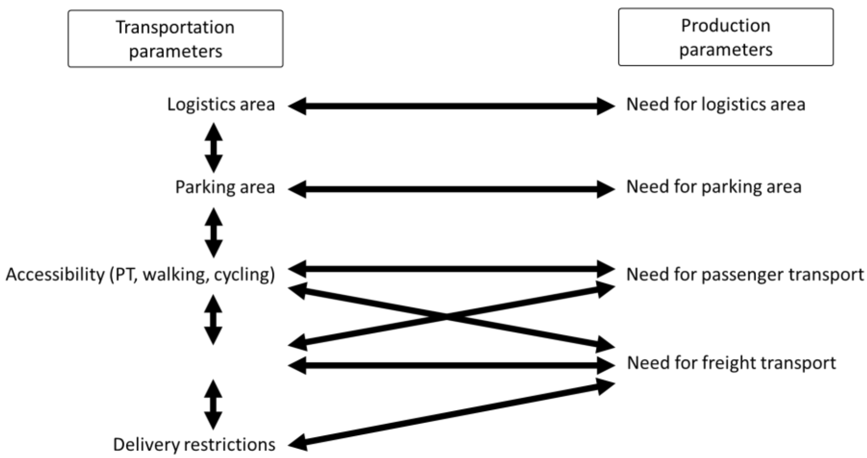

Figure 1. Relations between transportation parameters of cities and production parameters of factories

We identified that the production parameters that correspond to the transportation parameters are depending more on the scale of production and less on the type of industry. The scale of production determines the frequency of deliveries and size of transport vehicles. Therefore, the prototypes are not assigned to specific industry types but to production scales. Unsurprisingly, in the current state, small scale productions best fit the area type *integrated individual production facility* while big scale productions are best suited for *industrial-commercial areas*. This is mainly due to the fact that in *industrial-commercial areas*, there are no delivery restrictions, better accessibility for motorised vehicles and more available area for parking and logistics.

On the other hand, considering the global and local objectives, *integrated individual production facilities* fit the objectives best. They offer very good accessibility for non-motorised modes of transportation and mixed use. Nevertheless, the highest potential for vertical urban factories can be found in *mixed use areas*. There, accessibility for motorised as well as non-motorised modes of transportation is acceptable and there is still space available for densification. If we consider the needs for production facilities and sustainable transportation in future planning of densification and land use, good conditions for vertical urban factories can be achieved. *Industrial-commercial areas* can also be a use case for vertical factories in the process of densification. However, for now, they have rather poor accessibility and monofunctional land use and are therefore less attractive for applying the concept.

3.3. Prototypes

We present three different prototypes of vertical urban factories, one for each type of area. They reflect common challenges according to the type of area as well as suitable solutions. Certain principles of transport planning are part of all the prototypes. These include priority access by public transport, walking and cycling and bicycle parking close to the entrance. Yellow shaded areas inside the buildings are “access cores” featuring logistics areas, elevators and staircases.

Underground parking in the basement floors of the buildings was included to account for existing laws requiring car parking (e.g. WGarG 2008 in Vienna). At this point, we would like to note that on-site parking is not in line with global and city objectives to reduce private car use. It creates an advantage for the use of private cars compared to public transport, since walking distance to the parking place is shorter than to the public transport stop. The effect of parking distance on mode choice was shown for example in [13] and [14].

Integrated individual production facility

The challenge for this prototype is primarily the conflict of space in the densely built environment. Solutions for this are for example sharing concepts that are part of the typology. The courtyard serves as a shared logistics and meeting area. Large delivery trucks can access the courtyard in a one-way manner, though use of smaller vehicles such as cargo bikes is encouraged by designated cargo bike parking. Outside the building, in public space, is a “multifunctional lane” which can serve as delivery zone, parking space or seating area depending on the time of day and year. Figure 2 to Figure 4 show the 3D visualization, material and people flows and transportation concept of the prototype.

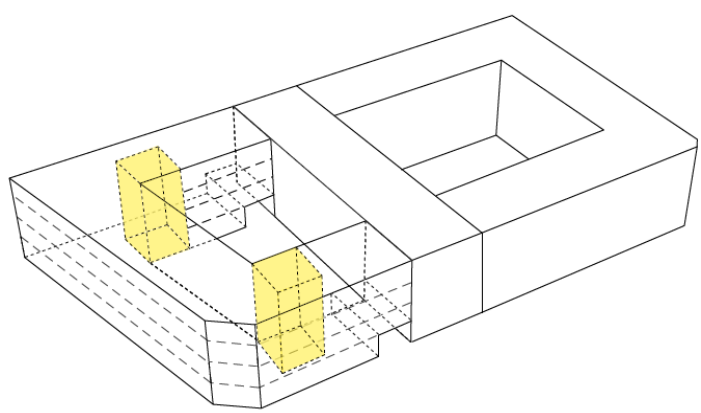

Figure 2. 3D visualization prototype integrated individual production facility

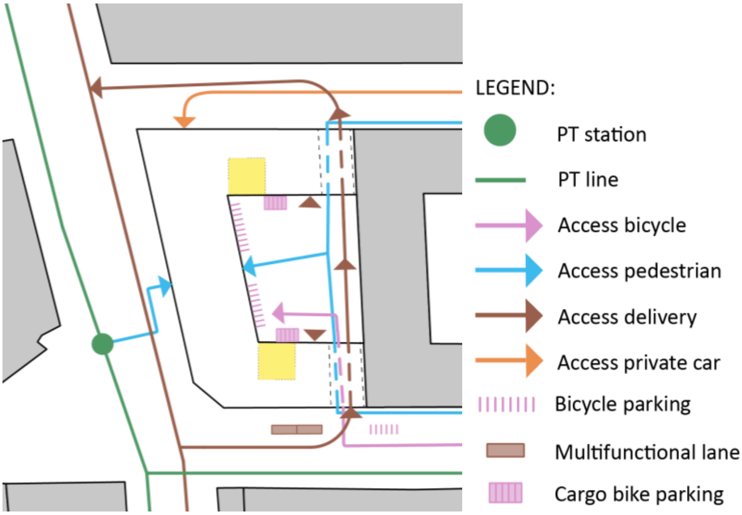

Figure 3. Transportation concept integrated individual production facility

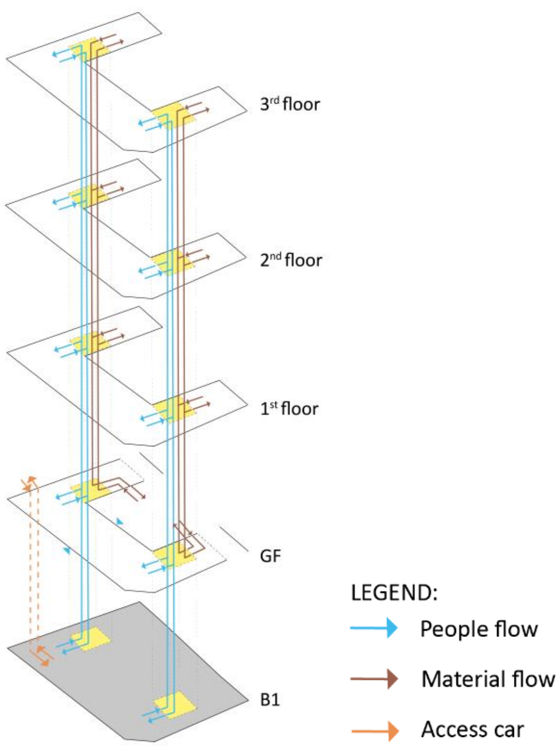

Figure 4. People and material flow integrated individual production facility GF…Ground floor, B…Basement

Mixed commercial area

For the *mixed commercial area*, we developed a concept where the building serves as a buffer between a high-ranked transportation axis (e.g. a busy road or a railway line) and a residential area. This shields residents from noise and exhausts while providing access for delivery vehicles. The access for people to the building is located on the backside at a lane closed for motorized vehicles. At the side facing the transportation axis, delivery trucks can access and exit the delivery area. This design creates a protected area at the backside that serves simultaneously as a pleasant pathway and meeting area for employees and residents, making a positive contribution to the neighbourhood. The prototype for *mixed commercial areas* is shown in Figure 5 to Figure 7.

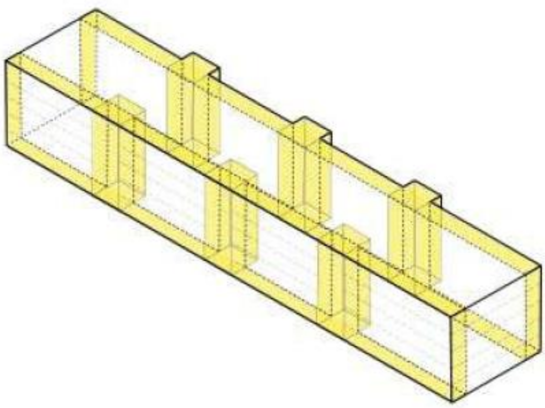

Figure 5. 3D visualization prototype mixed commercial area

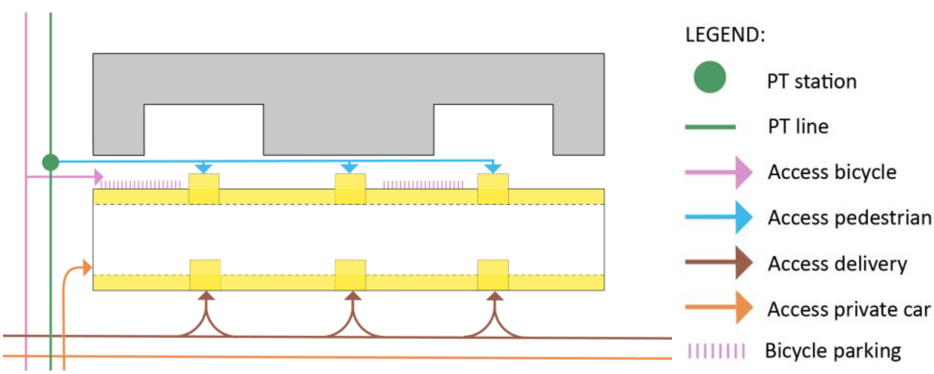

Figure 6. Transportation concept mixed commercial area

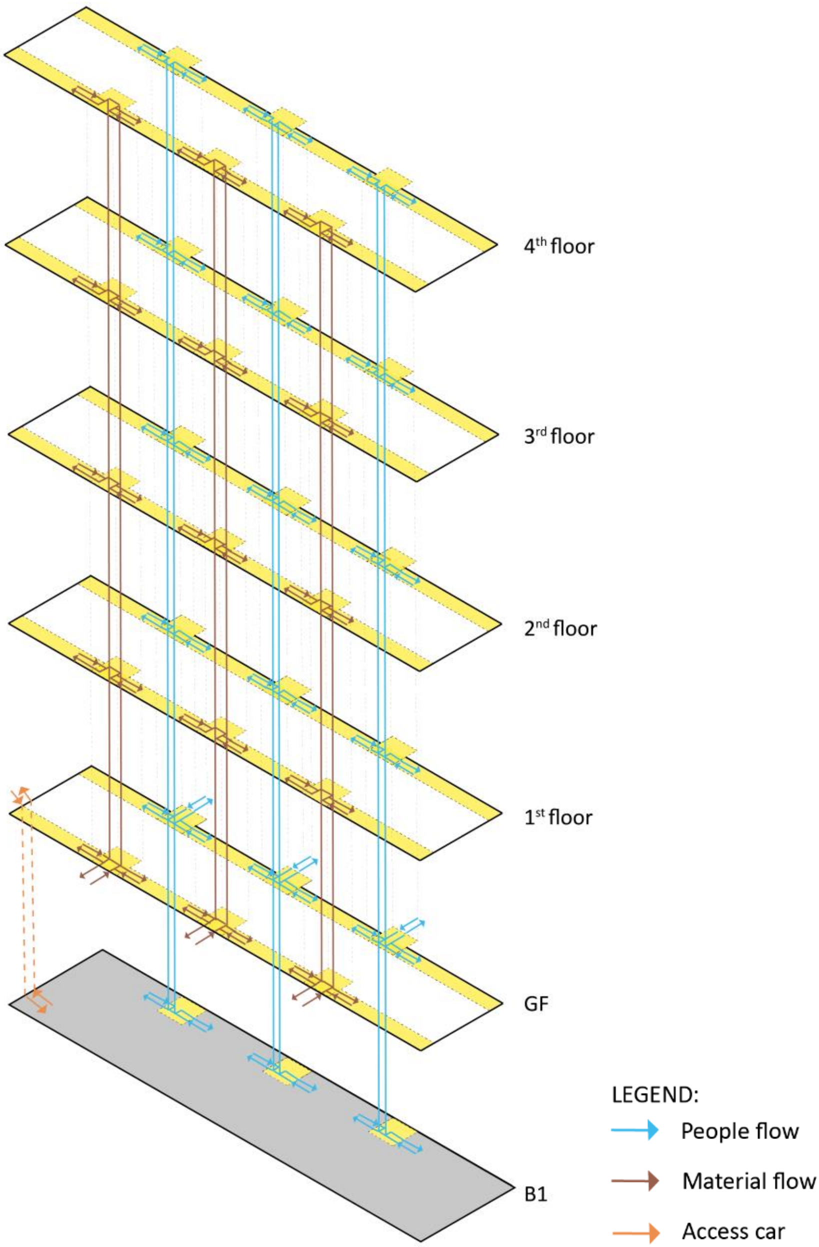

Figure 7. People and material flow mixed commercial area
GF…Ground floor, B…Basement

Industrial-commercial area

The prototype for industrial-commercial areas is based on a common hall construction, expanded by two multi-storey buildings. It shows how an industrial area dominated by single-storey buildings can be densified. Delivery and people accesses are separated. At the street-side, people can access the building from a PT stop, by walking or cycling. The large area in front of the hall features customer parking, a logistics area and bicycle parking close to the entrance but can also be used for events and as a meeting area. Access for delivery trucks is located at the other side of the building. Figure 8 to Figure 10 show the *Industrial-commercial area* prototype.

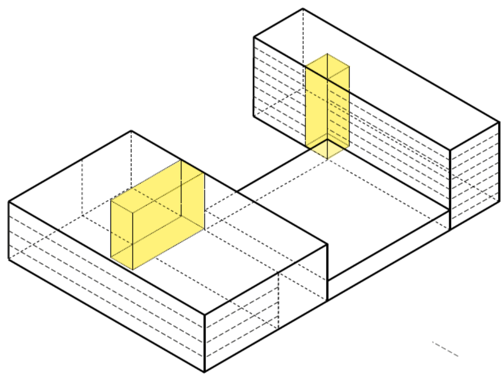

Figure 8. 3D visualization prototype industrial-commercial area

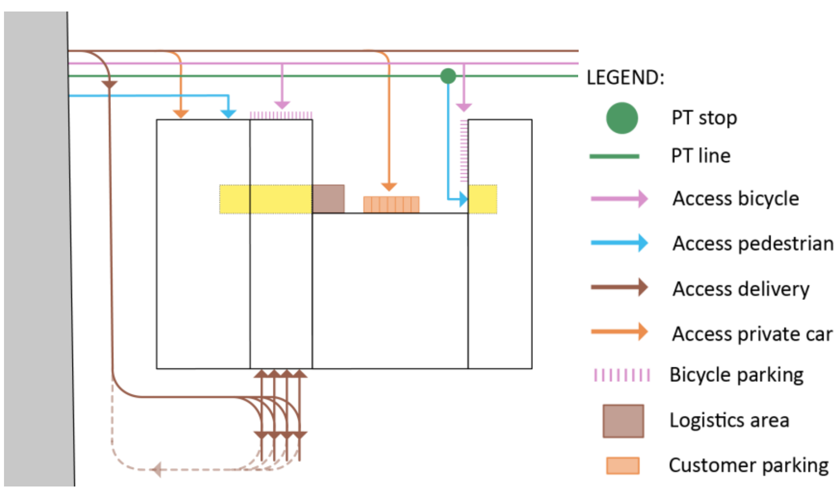

Figure 9. Transportation concept industrial-commercial area

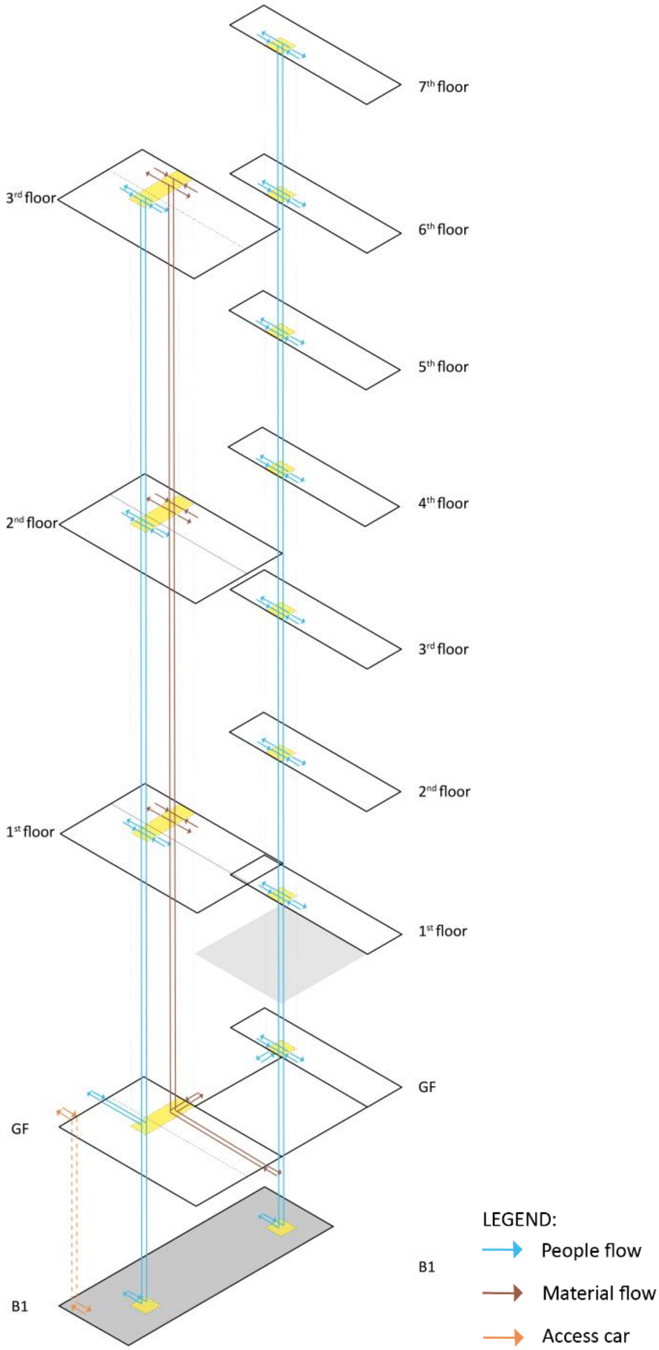

Figure 10. People and material flow integrated individual production facility GF…Ground floor, B…Basement

4. DISCUSSION

Our prototypes show that it is possible to reintegrate vertical urban factories in typical European urban structures, in terms of transport systems and available space. However, there are also legal issues that have to be considered. One of the reasons companies choose to relocate production sites outside of cities is the legal situation that favours residents' rights. While it is necessary to shield residents from dangerous emissions, even factories that have been built long before neighbouring housing units can be forced to shut down due to complaints. This aspect is not part of our study but should be addressed by cities if they choose to encourage urban production.

Another limitation of our study is the consideration of single handicraft facilities. While they are an important part of cities and should be promoted, such facilities are not subject of this study. Instead, we focused on larger factories that comprise at least one building.

Regarding such larger factories, new and rediscovered technologies can be of aid to overcome current challenges. Production techniques such as 3D printing, computer numerical control milling and laser cutting make it possible to produce decentralized on a low scale down to lot size one. This enables the use of smaller factories with lower transport volumes per site. Smaller vehicles and alternative engines help in making the logistics of urban factories more compatible with traffic calming measures and objectives of reduced CO_2 emissions. Cargo bikes could play a major role in future urban logistics. Demand for and production of cargo bikes are on the rise again [15]. A German study calculated that already 23% of all commercial trips can be substituted with cargo bikes [16]. Vehicle manufacturers are working on traditional delivery vehicles with electric engines as well as new types of vehicles that are smaller and more efficient in urban environments. Sharing concepts further facilitate the incorporation of production facilities in densely built areas. Concepts such as multifunctional lanes and shared loading yards are already in use in different cities (e.g. [7], [17]). This multi-use of private and public space can help relieve tensions due to limited space and conflicting interests. Therefore, our prototypes include such concepts, e.g. in the form of parking places for cargo bikes or multi-use areas. Many solutions already exist; they only have to be incorporated by city administrations, planners, developers and companies.

5. CONCLUSION

We conclude that multi-storey construction represents indeed a realisable alternative for limited space resources and urban production. Depending on the type of area, type of development or infrastructural conditions, very different space-saving concepts are possible, which can be adapted to company-specific requirements.

The *integrated individual production facility* best fulfils the transport policy objectives with regard to traffic influencing factors. Although there are restrictions for motorised individual transport (e.g. number of parking spaces) and higher costs due to logistics, these production locations are easily accessible with the public transport system. However, the greatest potentials for vertical factories are located in *mixed commercial areas*, which have been developed as a result of urban densification and in the sense of busy urban spaces with mixed use.

Vertical urban factories promote sustainability goals on several levels. They can shorten trips for freight, employees and customers and help strengthening local economic cycles. They add to the density of the city and provide mixed-use areas. We recommend to cities to promote vertical production. For this, it is necessary to include production land use in city codes and reserve space for logistics. Additionally, cities should provide a legal framework that enables factories to stay in cities whilst protecting residents from harmful emissions.

Future research on vertical urban factories could analyse quantitatively the impact of these on economic and sustainability indicators or analyse how our prototypes can be transferred to other cities. Real world applications should be encouraged and existing vertical factories should be supported by cities. They can further serve as case studies to deepen the knowledge about vertical factories and their integration to existing urban structures.

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OVERVIEW OF THE IMPLEMENTATION OF ACTIVITY-BASED MODELS IN CITY PLANNING

Key Words

Transportation planning; Population activity; Sustainable mobility; Disaggregate approach

Abstract

Transport system planning and modelling traffic demand in cities and / or urban areas oriented to the needs of the population are key to create and implement a safe, efficient, environmentally friendly and sustainable transport system. The trend of population growth in urban areas also carries with it an increase in the number of activities resulting in more trips made. By grouping population activities, it is possible to predict future transport demand. The classic approach to transport planning uses a four-step aggregate travel demand model. With the development of information and communication technologies, the possibilities for increasing the mobility of the population are further expanded. Due to the complexity of this problem, the classical approach does not provide the optimal solution. The new approach based on population activity allows for a more detailed and accurate representation of the habits of the population during different periods of the day and thus influences the number, type and characteristics of their travels. This paper will provide an overview of current research on predicting transport demand in urban areas, based on population activity through a disaggregated approach. The methodology, discussion of the topic, evaluation of future research on the subject matter and conclusion will also be presented.

1. INTRODUCTION

Transport planning, as part of spatial planning in cities that are urbanized centres, areas or regions, is a core activity of the transport profession and science in detecting population needs for mobility in urban areas and cities. The constant migration of residents from rural areas to urban areas and cities increases the need to build additional capacity for economic, social, health and educational activities. Increasing population and their mobility within cities and urban areas has caused a lack of free and public space and various negative effects such as increased energy consumption, increased noise levels, environmental pollution by emissions of harmful exhaust gases, etc. Four-step transport modelling is a globally acceptable process for creating mobility and flows of goods in a specific area that has been in use since the 1970s around the world. Limitations of the Traditional Four-Step Traffic Modelling Process has resulted in the need to define measures and solutions that are tailored to human lifestyles, their attitudes and thinking. Traffic modelling methodologies based on travel tours and population activities have shown improvements in the areas of transport policy implementation and solutions based on traffic demand management. A process based on population activity describes a set of processes that influence the decision-making process of a population during a trip, through the choice of destination location, travel time, mode of travel, purpose of travel, etc. Improvements can be justified through the disaggregation of the population according to certain characteristics affecting activity and mobility and a more detailed elaboration of the choice of travel and route.

2. THEORETICAL BASIS OF THE ACTIVITY-BASED MODEL CONCEPT

An approach to traffic demand modelling based on population activity began to develop during the 1970s [1]. The basis for the development of such an approach in traffic modelling is the ability of computerized data processing, simulation of traffic demand, and the availability of multiple data sets. Aggregated data relies on demographic data through traffic analysis zones (TAZ) [2]. The use of aggregated data allows a general assessment of traffic flows on a network but does not describe the behaviour of the population when traveling according to time, space and other types of constraints. The activity-based concept is based on disaggregated data in relation to the classic four-step concept of the traffic modelling process [3][4][5]. Research [6][7][8][9] has shown certain advantages of applying this approach over the classic Four-Step approach. The four-step approach shows "rigidity" and the methodology defines exactly four steps that need to be carried out in a specific sequence in order to generate relevant data [10]. The disaggregated data used in the activity-based traffic modelling process allows the assessment of the population's behaviour when planning and carrying out trips, it also identifies when certain elements of the transport system or other external elements affect its behaviour.

The structure of the concept based on population activity in traffic modeling is as follows:

- Population synthesis [11];
- Long-term definition of population decisions (location of living, car ownership, etc.);
- Mid-term definition of population decisions (job location, education location, etc.);
- Short-term definition of population decisions (daily activity, tours, distribution of trips);
- Assigning travel [12].

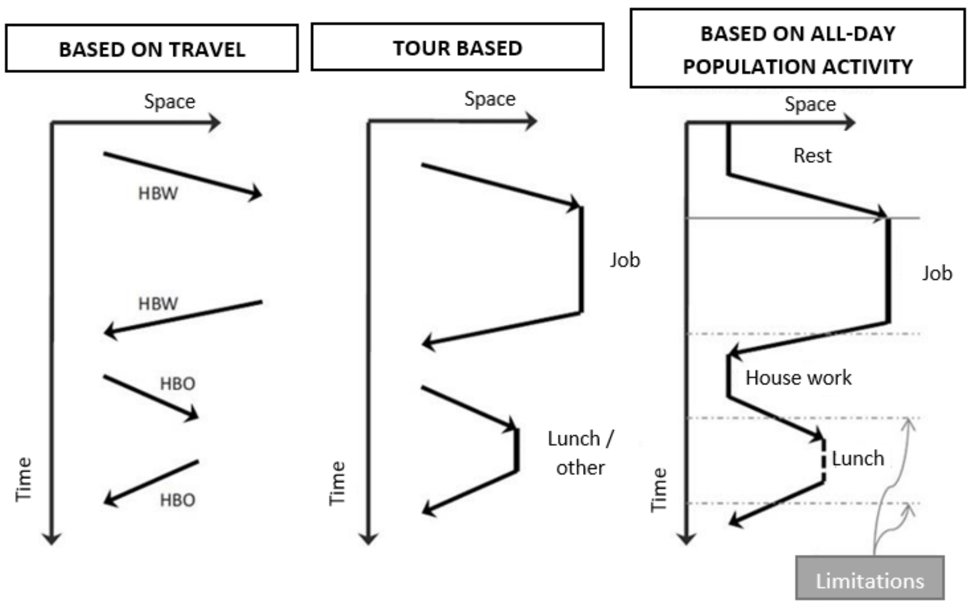

Figure 11. Comparison of individual travel, tours and day-long activities [12]

3. OVERVIEW OF CURRENT SITUATION IN TRAFFIC PLANNING AND MODELING FROM THE ASPECT OF THE ACTIVITY-BASED CONCEPT

The current situation in transport planning is based on multidisciplinary where a set of multiple professions and scientific branches are involved in the process decision making as realistic and achievable as possible. The interdisciplinary approach includes the basic scientific field: Traffic Technology and Transport and a set of several other scientific fields: psychology, natural sciences, construction, information and communication technology, etc., which aim to provide relevant facts and information with the best possible description of the real situation. The interdisciplinary structure of the activity-based approach is evident throughout the paper [13] where behavioural segment is increasingly used as a fundamental feature of describing the population structure in the observed area and their desires and needs to define the process of selecting activities, travel times, travel modes and destinations. In addition to the classic way of collecting traffic system data through surveys and field research, mobile technologies are being increasingly used to determine travel characteristics and source-destination matrices. Defining source-destination matrices using data from mobile technologies makes it possible to streamline the collection process, reduce the resources required, and speed up the process itself. In this way the data collected can serve not only as an input parameter for traffic modelling, but also as data for calibration or evaluation of the created model. Data can also be collected using Smart Cards [14]. The required amount of data should be determined by a relevant sample for the observed area. After collecting the relevant sample and defining the catchment areas of the transport network and system, focus moves towards establishing population synthesis. Population synthesis is determined by a set of established statistical models, of which the "Annealing algorithm" shows the highest accuracy of the entire population and its characteristics [13]. Population synthesis approximately determines the population size, their spatial distribution by TAZ or households, and their characteristics by individual simulated populations. Recent research has developed several types of activity-based concepts in traffic modelling:

- FEATHERS;
- SCHEDULER;
- AMOS;
- ALBATROSS;
- TASHSA;
- ADAPTS;
- SIMTRAVEL.

Figure 12 demonstrates an example of an all-day decision-making process that follows long-term and medium-term selections. After selecting a daily activity, comes the selection of tours and travel times, followed by the choice of destination and mode of travel to the desired location. The final selection steps are the need for added trips within the defined tour and the possibility or need to stop.

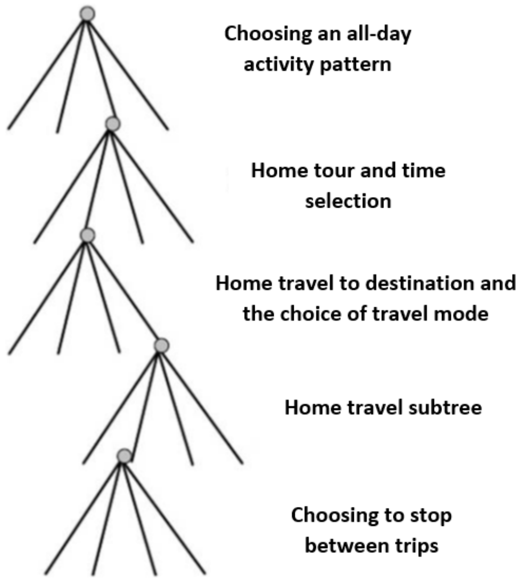

Figure 12. An example of the structure of the decision-making process of an all-day activity of an individual resident [12]

Validation is an essential part of the model development process for the practical application. The papers [15] show how and at what level it is necessary to carry out validation of the traffic demand model based on activities.

4. POSSIBILITIES OF FURTHER RESEARCH IN THE AREA OF ACTIVITY-BASED MODELING

Application in the real sector is made possible through increased availability of relevant data and the development of computer technology, allowing computer circuits to process large amounts of data and simulate large sets of variants based on certain variables. The disaggregation of population data is largely dependent on two components:

- Sample size and accuracy;
- Statistical method of sample dispersion and creation of simulated (artificial) population.

The disadvantages in researches are manifested through the insufficient description of selected sample sizes and outdated data [2]. The statistical data dispersion methods used are largely dependent on the model maker himself and the researcher who choose the statistical method independently. The variable methodology of the activity-based modeling concept in the segment of describing travel by synthesizing the population also depends on the individual researcher or team of researchers and the area in which the research was conducted. A study showed the possibility of implementing another set of data into a concept based on population activity, but this is not sufficient to be fully accepted as a basic knowledge for processing this data. Failure to capture transit and external travel data to or from the coverage area can potentially lead to a significant error in the simulated traffic flows, thus multiplying the error when assessing the impact of different solutions or measures.

5. CONCUSION

The concept based on population activity in the process of transport modeling, as a part of overall transport planning, is a new concept based on the disaggregation of a data sample by describing the characteristics of each individual household and / or resident in an area and more accurately describing their travel habits, mobility characteristics, population flows and the flows of goods. This paper gives a brief overview of the theoretical background, the analysis of the scientific literature in the field so far, and the possibilities of further research. The possibilities for further research are evident through:

- Defining sample size and accuracy;
- The selection of statistical methods;
- The mode of population synthesis;
- Selecting a subtype of activity-based concept methodology for the defined scope;
- Method of evaluating output parameters after data simulation;
- Completely unexplored allocation of travel on the transport network after the approach is used;
- Optimal approach to the implementation of transit trips and trips whose source and destination are outside the scope of the research.

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7th INTERNATIONAL CONFERENCE
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APPLICATION OF SMART CONCEPT IN SMALL CITIES (EXAMPLE: CROATIA)

Key Words

Smart city; Urban area; Urbanization; Internet of Things

Abstract

The term “smart cities” usually is connected with the functioning of the big cities. It is connected with the fact that today, as much as 54% of the world's population lives in urban areas (according to the 2014 UN Review, New York 2015). This trend is expected to continue, and it is projected that by 2050 the percentage of the population in urban areas will reach 66% of the world population. The urbanization process has affected most European and world cities, big as well as small. The increase in the urban population increases the need for mobility and the increasing consumption of food and energy. This leads to an increase in living costs, loss of time (e.g. in traffic), and to the development of poor living habits. That is why there is a need to find innovative solutions that will improve the quality of life of citizens and ensure sustainable economic growth in small cities, to preserve the regions from over-urbanization. The solution to these problems lies in the concept of small smart cities and modern technologies. It is a smart city that should solve the 21st century challenge posed by ubiquitous urbanization.

1. INTRODUCTION

Smart cities are human-sized cities. They represent developed urban areas that enable efficient use of natural resources and existing urban infrastructure, sustainable economic growth, support capacity building for research, development, and innovation and ensure a high quality of life and accessibility of digital services to all its citizens through the use of modern technology. According to the definitions of the European Commission, smart cities are striving for the development of holistic and sustainable solutions in which the quality of human life, as well as the environment, will be at a much higher level.

There is a perception that smart cities are just a vision of the future of what highly developed cities should one day look like. But the truth is different. Many smart cities still exist today, and some of them are approaching 100% energy independence through renewable energy.

This paper aims to present the characteristics of small smart cities and to analyze their determinants, citing examples from Croatia.

2. SMART CITIES

There is no universal definition of a smart city, but all definitions include the fact that smart cities are human-developed urban areas that enable efficient use of natural resources and existing urban infrastructure, sustainable economic growth, support capacity building for research, development, and innovation and ensure high quality of life and accessibility of digital services to all its citizens. Most importantly, smart cities are created not only by technology but also by the vision of those who lead it.

At its simplest, we can define a smart city as a system that uses digital and communication technologies to meet the needs of its citizens and improve the quality of city services. A smart city integrates all public service functions, such as lighting, transport, energy production, thereby increasing their efficiency, reducing energy costs, speeding up and economizing traffic, and reducing greenhouse gas emissions.

Smart city:

a) Maximizes in all activities citizens who are end-users of services,

b) innovative information and communication technologies (ICTs) should be used,

c) to have a vision of development that connects and integrates all segments to make it easier to use and accessible to citizens.

On the other hand, citizens with their knowledge and skills represent the main advantages of modern smart cities. The synergy of citizens and technological solutions achieves economic growth and a better quality of life in urban areas.

3. SMALL SMART CITIES IN EUROPE

The notion of a smart city is more likely to evoke the image of a bustling metropolis than a small town. However, cities of all sizes can become smart because the foundation of every smart city is the ability to collect and use data collected using different sensors. In the past, fewer residents meant fewer resources, but that dynamic is changing. While there are internet access and especially high-speed mobile broadband, anyone can connect to anything at any time. In the future, people will aspire to smaller cities, which support their desire for flexibility and freedom. Small and medium-sized cities face challenges in implementing smart solutions.

Interesting and useful innovations can also be found in smaller cities that have unexpected solutions, just to cope with the lack of money, experts, or the necessary infrastructure. Moreover, initiatives do not necessarily have to be “big” to have a big impact on smaller communities. Some of the advantages that come with smaller cities are easier to overcome regulatory hurdles, as fewer people slow down the process. Also, in a smaller place, it's easier to connect with people living in the city and design better solutions for citizens.

Each city is unique in that it has its unique past, position, and personality. An individual city can be positioned as a cultural center or business center. As the concept of "smart city" embodies multiple concepts, every city doesn’t need to implement "smart" solutions in all areas. This is especially true for smaller cities.

4. SMALL SMART CITIES IN CROATIA

When it comes to smart cities in Croatia, it should be borne in mind that there are 4 major cities in Croatia: Zagreb, Split, Rijeka, and Osijek, while all other cities, compared to intelligent European and world cities, can be classified as smaller cities.

Croatia has a total of 128 cities, and 40 of them are developing and implementing some of the smart solutions that make it easier to manage the city and improve the lives of its citizens. On December 15, 2017, a round table entitled “Smart City” was held at the round table organized by the Institute for Urban Transport at the Faculty of Transport Sciences in Zagreb. This term is increasingly used, and research has shown that Croatian cities are increasingly looking to become "smart" [10].

4.1. Smart urbanization concept in Croatia

When it comes to smart urbanization in Croatia, it should be said that, according to some studies, Croatia is a relatively conservative society when it comes to adopting new technological ideas. However, it can still be said that Croatia is making progress in introducing modern technologies into the daily lives of its citizens.

During 2017, the Department of Urban Transport of the Faculty of Transport Sciences, with the support of the University of Zagreb, conducted a scientific research project entitled “Mobility Indicators in the Smart City Concept”. The research aimed to establish a database at the national level, which will serve to analyze urban mobility indicators.

The results of the research showed that the concept of smart city was accepted in Croatia because of the surveyed Croatian cities, 32% of them have participated in the implementation of the Smart City concept, and 64% plan to apply it. One of the key roles in the Smart City concept is the "intelligent mobility" of citizens, which is a necessary precondition for the prosperity of the urban environment, and its important segments are the intelligent use of information and communication technology (86.2%), intelligent public urban transport (65, 6%) and intelligent parking (58.6%). So far, air quality control (33%), traffic control and monitoring (22%) and intelligent parking (11%) are in place.

In the future, cities plan to implement intelligent use of information and communication technology (60.7%), intelligent parking (50%), traffic control and monitoring (39.3%) and intelligent public transport (32.1%) [11].

Out of 128 Croatian cities, 40 of them are developing and implementing some of the intelligent solutions that make managing the city easier and providing a better life for citizens.

4.2. Existing smart features

Below will be a brief overview of existing smart features in some Croatian cities and certain categories. It is important to emphasize that no solution can be mapped on the example of another city, but they can certainly be a signpost for further development and the search for new, better intelligent components.

4.2.1. Intelligent mobility - the city of Koprivnica

Koprivnica became the leader of the electromobility in Croatia. This was achieved through the *Civitas Dynamo* project. A common problem with smaller cities is the lack of public transport. It is with this project that the problem has been addressed. Electric buses whose market and service base are still underdeveloped in Croatia represent a particular innovation. Energy efficiency is particularly pronounced in the extent of electromobility where the city has established car-sharing of electric vehicles for city employees and businesses and has developed a fast-charging infrastructure for electric vehicles in the city, built in partnership with the *HEP-ELEN* program and accessible to all citizens and visitors city.

4.2.2. Intelligent Management - the cities of Karlovac, Jastrebarsko, Rovinj

Many Croatian cities seek to encourage citizens to participate actively in solving problems of local importance. Many cities develop intelligent governance.

The city of **Karlovac** has developed the *DigitalKA* project, which has upgraded the capacities of the city administration as a service to citizens so that their operations are efficient, transparent, and optimal to budgetary resources. The project was launched in 2011, and positive experiences have encouraged Karlovac to introduce information and communication technologies into all other work and administrative processes. To speed up the process of marking, assigning, processing, sending and storing documents, Karlovac has established an e-office using information, and communication technologies (ICT). This provided the conditions for efficient office operations, organization and productivity in day-to-day operations.

Better solving of citizens' problems in the work of local government and establishment of a more efficient system of management and maintenance of unclassified roads was the main goal of the **Jastrebarsko** *E-road* project launched in the first half of 2014.

The system is designed in such a way that every authorized person, who has access to the system, has the opportunity to report problems on the ground in the field of transport infrastructure, ie road maintenance by photographing or making a video of the problem with his intelligent device, which is then automatically recorded in the system by obtaining a tag 'intervention'. With the introduction of this system, the city was able to consolidate several individual separate organizational systems into one central system, which accelerated the implementation of the process by at least 50% compared to the previous way of functioning.

An innovative Smart Rovinj system was developed and implemented in the city of **Rovinj**. Smart Rovinj - Rovigno is an intelligent IT system that enables the citizens of Rovinj to send suggestions and / or report various problems they see in their environment and thus contribute to their solution. The implementation of Smart Rovinj - Rovigno began in December 2015. The system is currently used by 4000 citizens.

The reason for the introduction and implementation of this project is to promptly address specific community problems, contribute to improving the quality of life of citizens, and improve the work of city institutions and organizations.

The city of **Dubrovnik** is the best example of a city that has focused on intelligent solutions on the waste collection and separation system. *Bigbelly* is not only a bin that compacts and announces when full but also an IoT platform that can host other intelligent solutions such as Wi-Fi hotspot and various urban sensors (measuring climate, noise, air quality). It is important to emphasize that it is fully solar-powered [13].

5. CONCLUSION

In the 21st century, everyone is connected to the internet 24/7, but most cities are not organized accordingly. By 2050, more than 70% of humanity will live in urban areas, whose infrastructure is already on the brink of congestion. Electricity consumption, garbage collection, transportation are all infrastructure problems of today, which will grow even more in the future. This latter is the trigger and roadmap for the adoption of intelligent solutions and the development of - Smart Cities.

These are innovations that quickly become widespread and make life easier for citizens. Examples of this are smart benches, parking by SMS, solar collectors, and the like. But in cities that want to become smart, it is not enough to satisfy just one segment, but the emphasis is on implementing as many intelligent solutions as possible. The major metropolises of the world, by nature, are implementing more intelligent solutions than smaller cities, mostly because of more money, infrastructure, and availability of professionals. However, smaller cities are also starting to follow the examples of big cities and are seeking to develop innovative solutions in organizing citizens' lives, primarily focused on transport mobility, energy management, and the development of intelligent governance. The advantage of smaller cities is that the impact of a solution in a smaller environment is far greater than the impact of more of them in a larger city. In smaller cities, the city government can better assess the needs of its citizens and accordingly develop an intelligent solution that will have the greatest impact on the lives of citizens.

Croatian cities have also recognized the importance of development in this direction. In addition to the four major Croatian cities, smaller cities also seek to implement some of the intelligent solutions to be labeled as smart cities. In this direction, they develop strategies and work to achieve them. The downside is the lack of money to finance innovative projects, but European funds remain available that could and should be better used to develop cities into smart centers of living.

Our research in the field of small smart cities, planned for the period 2019-2022 will be continued with additional papers on that matter.

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EFFECTS OF AUTONOMOUS VEHICLES TECHNOLOGY USAGE

Key Words

Autonomous vehicles; New vehicle technology; Positive effects; Negative effects

Abstract

Autonomous vehicles technology is a new technological concept of driverless vehicle in the field of automotive industry. This new vehicle technology could improve urban areas mobility and urban life quality. Many companies worldwide are intensively working on developing autonomous systems and testing self-driving vehicles. Driverless vehicle technology is expected to be available on the market and to the customers in the near future. Over the past few years, the potential benefits that can be achieved by switching to new driverless vehicle technology, such as improvements in traffic safety, local and global emissions, traffic flows, reduced travel time, increased mobility of disabled people and many others, were analysed. Accordingly, this paper gives an overview of the potential effects of introducing the driverless vehicle technology.

1. INTRODUCTION

Autonomous vehicles (AVs) also known in literature as self-driving vehicles, robot vehicles and driverless vehicles represent a new technology of vehicles whose usage is expected in the near future of transportation. New autonomous vehicles technology works on the principle of artificial intelligence where the vehicles move independently, without driver’s activity, using information from the real environment with the help of sensors (infrared, laser, radar, optical, etc.) automated controls (braking, steering, signals, etc.), navigation – Global Positioning Systems, special high quality maps, etc.

Traffic congestions, as a result of people mobility, currently represent the biggest problem globally. An increase in traffic accidents, wasted time due to traffic congestions, emissions, insufficient parking lots, etc., is also evident. According to expert forecasts, numerous traffic problems the large cities across the world are facing could be resolved by switching to new autonomous vehicles technology. Switching to fully autonomous vehicles would create significant socio-economic advantages including improvements to road safety, energy efficiency, traffic flow, mobility increase, travel time reduction, travel behaviour, congestion reduction and parking benefits [1].

Over the last few years, a large number of companies such as Google, Continental Automotive Systems, Nissan, Volvo, Audi, Toyota, Mercedes-Benz, Volkswagen, Delphi Automotive, Tesla Motors, General Motors and Bosch, have been working intensively on developing the autonomous vehicle systems. Fully automated vehicles are expected to be commercially available between 2025 and 2045, and to penetrate the market rapidly after their introduction, while the respective time-window for conditional automation is shorter, between 2018 and 2028 [2]. Besides developing autonomous vehicle systems, some states in the United States of America have determined and adopted automated vehicle legislation and regulation. Nevada was the first state to adopt automated vehicle legislation in 2011, Florida was the second, followed by California, Michigan, North Dakota, Louisiana, Tennessee and Utah. The most common purposes of state legislative efforts have been to: Introduce Definitions, Regulate On-road Testing, Regulate Deployment, and Address Liability [3].

This paper provides an overview of the potential effects that could be achieved if the fully automated vehicles replaced the vehicles with drivers.

2. AUTONOMOUS VEHICLES – LEVELS OF DRIVING AUTOMATION

There are different Levels of driving automation which are defined by The National Highway Safety Administration (NHTSA), Society of Automation Engineers (SAE) and the Federal Highway Research Institute (BASt), starting from the level where the driver manually controls the vehicle, to a complete automation system which executes control, acceleration and deceleration of the vehicle [4, 5, 6].

Both NHTSA and BASt taxonomies define five levels of automation. NHTSA relies upon a numeric system ranging from Level 0 (No Automation) to Level 4 (Full Self-Driving) while the BASt Expert Group uses labels ranging from Driver Only to Full Automation. SAE, in contrast, identifies six levels of automation ranging from zero (No Automation) to five (Full Automation). A classification system based on six different levels (Figure 1), ranging from no automation to fully automated systems, was published in 2014 by SAE International, an automotive standardization body, as J3016, Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems [5].

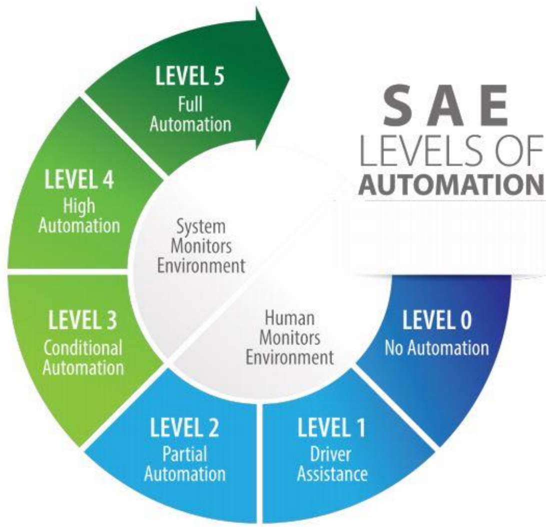

Figure 1. Levels of driving automation according to SAE International [7]

Level 0 – no automation refers to vehicles without any level of automation. Such vehicles require full attention of the driver who manually controls the vehicle, from steering, deceleration, acceleration to monitoring the environment and traffic conditions.

Level 1 – driver assistance refers to an automated driving system that assists driver when steering, braking and accelerating. This level features the facilitation of driving while expecting the driver to monitor the traffic conditions and perform other dynamic aspects of driving.

Level 2 – partial automation refers to one or more driving assistance systems, with vehicle controlling the steering, acceleration and deceleration while expecting the driver to take full control of the driving.

Level 3 – conditional automation means that, in a series of situations, the driver can let go of the controls in certain circumstances under specific conditions, and even direct attention at something else for a long period of time, but has to be alert and ready to take control at any time, if required. Compared to Level 2, the driver does not need to focus on operating the vehicle while the autonomous driving is active.

Level 4 – high automation refers to driving regime without the intervention of the driver. However, these vehicles are used in limited driving conditions, for example, a transport on limited road sections with lanes reserved for autonomous vehicles. The vehicle has the ability to stop if the driver does not take control of the vehicle.

Level 5 – full automation is the final goal of the driverless vehicle technology. At this level, the vehicles will perform all driving tasks without the driver, which is expected in the coming decades.

3. EFFECTS OF USING THE AUTONOMOUS VEHICLES

The potential traffic safety benefits - Because of the increased reliability of autonomous systems and reduced reaction time with respect to drivers, the automation has the potential to impact traffic safety significantly. Driver errors are believed to be the main reason of traffic accidents (errors of the perception process and reception of information). By switching to fully automated vehicles, it is expected for autonomous vehicles to lead to further reduction of road accidents [8]. With full automation there would be no more human error, and practically, the complete elimination of accidents would be possible if fully autonomous vehicles successfully reached the market. The technical failure category could become proportionally larger in the future, with the new technical risks of fully automated driving. However, the current prediction about the degree of efficiency of fully automated vehicles can not be precisely determined as numerous technical factors are still unknown.

Parking benefits – In addition to the positive impact of fully automated vehicles on traffic safety, the vehicle parking can also benefit from this technology. Autonomous vehicles have a positive effect on reduction of parking space demand close to destination because they have the ability to take the passengers to their destination, find a parking space without a human interaction, park further away, and then return later to pick up the passengers when needed. This allows passengers to enter/exit directly at the origin/destination of their trips. The driver saves the time in finding a parking spot as well as walking to/from a remote parking spot. In addition, access to the vehicle is eased spatially and temporally. After the passengers exit the vehicle, the autonomous vehicles can search for a cheaper/free parking space on their own, or eventually drive back home or even remain in the traffic for a short period. This yields a significant reduction in the generalized costs of parking in terms of both parking fees and search time [9]. Research results show that, by introducing shared autonomous vehicles technology, many trips will convert quickly to mobility-on-demand which will lead to a reduction of trips of personal vehicles requiring a parking spot. According to research results in Boston, shared AVs will lead to a reduction of number of parking spaces needed by 48%, including those on the streets and in the parking structures (Figure 2). Research results also show that the number of personal vehicles on the road will decrease by 15% because, more convenient, shared vehicle services will allow households to reduce vehicle ownership and use, whereas the total number of miles travelled will increase by 16% because the increased convenience and productivity contribute to increase in travel. However, travel time will improve by just 4% on average [10].

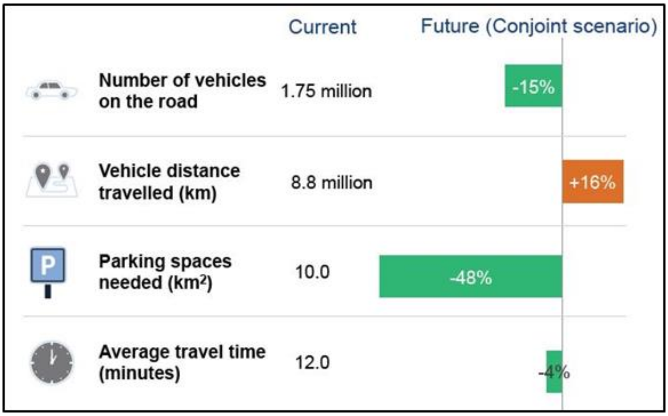

Figure 2. The impact of autonomous vehicles on the number of personal vehicles, distance travelled, parking spaces needed and overall travel time [10]

Increased mobility of user groups – Automation presents enormous potential for improvement of mobility and travel demand of the user groups whose mobility is limited and difficult such as elderly persons, disabled people, children, adolescents, people under the influence of alcohol and people who are otherwise deprived or do not want to drive. These user groups can use different transport models for mobility-on-demand, such as autonomous taxi, autonomous shared taxi or autonomous minibus. That directly benefits these user groups, improves their access to education and employment opportunities, increases their economic productivity, reduces responsibilities and burdens on their friends and family members [11, 12]. Participation of these user groups in economic and social life might yield benefits associated with increase in vehicle kilometres travelled. Total vehicle kilometres travelled is expected to increase between 0% and 3% in 2030 and between 0% and 27% in 2050 [2]. Another travel demand research has shown that the total vehicle kilometres travelled could increase between 4% and 26% after introduction of automated vehicles [13].

Reduced congestions and fuel consumption and increased road capacity – Autonomous vehicles can also have a positive impact on both, the increase of road capacity and the decrease in traffic congestions, on fuel consumption and consequently emissions because of the so called safety gaps between the vehicles and better management of traffic flow [14]. Such technology allows fine speed adjustments of following vehicles and shorter travel times, leading to slower brake wear and fuel savings. These improvements are related to the implementation of adaptive cruise control (ACC) and cooperative adaptive cruise control (CACC) which is already being integrated into automobiles. Some of the benefits will be realized before autonomous vehicles are fully operational [15, 16]. Some predicted benefits of the reduced congestion and pollution emissions etc. require that autonomous vehicles have dedicated lanes to allow numerous vehicles driving close together at relatively high speeds (platooning). Capacity benefits are expected to be higher on motorways than on urban streets. According to the research results, the capacity on motorways is expected to increase between 0% and 5% in 2030 and vary between -3% and 25% in 2050 [2].

In addition to these positive effects that are expected in the future, there are also predicted negative effects and additional risks of using fully automated vehicles [11]:

- Hardware and software failures - Compound electronic systems frequently fail, and even small vehicle operating system malfunctions such as false sensor, distorted signal, or software error can have disastrous consequences,

- AVs will certainly lead to additional crashes caused by system failures, platooning, higher traffic speeds, further risk-taking, and enhanced total vehicle travel,

- Assigned highway lanes for autonomous vehicle platooning may reduce capacity for human-operated traffic, which can present new risks, such as human drivers joining platoons and increased crashes austerity,

- Many potential advantages, such as decreased congestion and emission rates, reduced traffic signals and lane widths, require that most or all vehicles on a road function autonomously,

- In the long-term, the autonomous vehicles will probably be unable to operate in heavy rain and snow, on unpaved roads, or where GPS service or special maps are unavailable, and they may be rather slow and inaccurate in mixed urban traffic,

- Private autonomous vehicles are going to be more expensive than human-operated vehicles, because of additional vehicle equipment,

- Autonomous vehicles entail further investments for transport networks (physical and digital infrastructures), increased infrastructure costs can require higher roadway design and maintenance standards,

- Increased traffic problems. Enhanced vehicle travel may increase congestion, pollution and sprawl-related costs,

- Increased risk-taking. When travellers feel safer they commonly take further risks. If autonomous vehicles are regarded as very safe, passengers may cut down on a seatbelt use, and other road users may be less careful,

- May increase risks to other road users. Autonomous vehicles may have difficulty spotting, conveying and conforming to pedestrians, bicyclists and motorcycles, and also can decrease affordable mobility options such as walking, bicycling and transit services,

- Optimistic forecasts of autonomous vehicle advantages may reduce mobility options for non-drivers, because some communities may cause to reduce support for public transit services (transport improvements and management strategies),

- Autonomous vehicles are estimated to cost less than human-driven taxis and ride-hailing services, but more than human-driven private vehicles and public transit services,

- Self-driving taxi (shared autonomous vehicles) services will be more economical than human-operated taxis, but offer limited service quality. There will be no drivers to help passengers with the luggage and the vehicles may be unclean,

- Self-driving vans (micro-transit) take passengers to/or near destinations, but offer least convenience, comfort and speed, particularly in sprawled areas.

4. CONCLUSION

A review of the available literature and the research results about the potential effects that could be achieved by switching to driverless vehicle technology shows that there are a number of potential positive and negative effects associated with the introduction of this new technology.

Many vehicles currently have Level 1 and 2 technologies. Automation levels 0 to 3 require a licensed driver and driver alertness at all times because of their limited functionality, but levels 4 and 5 allow driverless operation. For many predicted benefits associated with autonomous vehicles, such as independent mobility, reduced traffic congestion, crash risk, parking benefits, etc. levels 4 and 5 are essential, whereas automation levels 2-3 can reduce driver stress.

With their arrival on the market, the autonomous vehicles could mitigate the effects of traffic and make the mobility of people safer and easier. However, the possibilities offered by this technology also carry some risks that may adversely affect the benefits of autonomous vehicles. Therefore, before autonomous vehicles fully reach the market, a high testing, defining the regulatory standards and approvals, will be required in order to avoid potential drawbacks and justify the use of this vehicle technology.

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REORGANIZATION OF THE POSTAL SECTOR AT URBAN AREAS

Key Words

Postal sector;
Last mile;
Urban areas;
Development

Abstract

Urban areas are increasingly confronted with a chronic problem of traffic jams. The overload of road infrastructure is obvious. This is reflected in the quality of life in urban areas. The consequence of congestion is also the decline in the quality of postal services. The liberalization of the postal services market contribute to a range of good solutions but has brought one negative externality - the overlapping of network capacity. Such an overlapping reduces the performance of the entire postal sector, i.e. induces under-utilization of the existing capacities, and disrupts sustainable development. The paper will consider scenarios that will propose solutions in this area, trying to coordinate the public interest with the interests of private postal operators.

1. INTRODUCTION

Postal traffic has undergone thorough changes during the past three decades. The main ones are the process of liberalization and the process of deregulation, which have opened the doors of competition. A burden, but a responsibility as well of the national postal operators lies in the fact that they were entrusted with the tasks regarding the universal postal service. The universal postal service may be a key instrument to a steady economic growth of a country. Such a view has not yet been adopted by the competition i.e. private postal operators, namely they focus on the most appealing parts of the postal service market which are primarily express services (the added value services) and they mostly focus on urban areas. In that regard one may notice the overlapping of the postal service operators' network capacities which on one hand decreases the quality of the postal service and on the other worsens the overall features of the traffic in the urban areas (lack of parking spaces, traffic congestions, pollution of the environment etc.)

The role of the postal sector is changing from the root. Demand for delivery of letters, newspapers, flyers and other documentation is decreasing as electronic communication develops further. At the same time there is a rise in demand for package delivery due to the growth of e-commerce and just-in-time management method in production process. A decrease in demand for mailing letters is a result of the development of digitization and electronic substitutes for said services. User communication which was in the past being conducted via mailing letters is today widely replaced by websites and other electronic means. When a decrease in demand for mailing letters occurs due to its electronic substitute it is usually a lasting change.

2. E-COMMERCE

E-commerce is a result of the popularization of internet transactions i.e. the possibility of conclusion of buy and sell agreements in virtual environment. Significant advantages of e-commerce are [1]:

1. availability 24/7
2. delivery to home address (no need for a trip to the store)
3. easier comparison of offers
4. affordable prices
5. easier finding of rare products
6. significant amount of product information
7. bigger selection than the one found in traditional shops
8. the right to a refund for every distance sale

E-commerce is not exempt from influencing the environment. The basic feature of e-commerce is its delivery service. As the amount of transactions via e-commerce increases so does the number of deliveries and delivery vehicles. Generally speaking, there is a noticeable increase in the number of package deliveries (with a decrease in their mass at the same time) which consequently leads to the increased frequency of deliveries.

Digitalization has influenced retail to redefine its online business management aside from its physical sales network. Key factors that initiated such change, developed due to the influence of internet. This change enabled small and medium businesses to offer their services to customers all around the world. In such an environment where products available in retail stores are delivered to home address as well, the role of a postal operator as a link between a seller and a customer is becoming all the more important.

The basic factor of growth of e-commerce i.e. package delivery segment represents a growing challenge regarding urban logistics. Hence the last mile segment is the main point of concern for postal operators who have (especially national postal operators) long experience in dealing with the problem of city logistics. This area includes activities that increase traffic congestions as well as the pollution of the environment via the emission of exhaust gases. Undelivered packages may require additional attempts of delivery which may represent a significant problematic field for postal operators.

3. URBAN AREAS

The amount of traffic congestions is constantly growing which influences the efficiency of postal services. The key factor in calculating costs of traffic congestions is the assessment of operating expenses of vehicles per hour. In the case of vehicles being stuck in traffic their operating expenses increase due to higher fuel consumption per km, the time of the driver that is wasted, the transportation vehicle being idle etc.

Traffic congestions impact deliveries in several ways:

1. reducing the time available for pickups and increasing the number of empty trips as a consequence,
2. decreasing average speed on congested roads
3. as reliability of delivery time decreases, companies may increase their number of vehicles as a response and try to ensure that they have a large enough transport capacity to satisfy their clients' needs

Mentioned effects have insufficiently utilized transport capacity as a consequence.

The amount of traffic and congestions in urban areas is growing more and more, resulting in postal operators having to deal with new challenges to keep shipment transportation systems reliable. Impacts on supply chains are becoming more significant not just for national operators, but for the private sector operators as well.

The two main decisions for shipment delivery are the market size and the number of delivery vehicles. Increase in the number of traffic congestions may cause these decisions to change with various cost-related factors. With the rise in congestions, the time needed for delivery vehicle to get to the next delivery point in urban areas is increasing. This becomes more noticeable during rush hour. In other words, potential delivery area for a single vehicle is becoming smaller as a direct consequence of congestions which causes the need for more vehicles on road network. Aside from directly related added costs regarding driving staff and vehicles, these changes give rise to additional expenses in regard to constant adjustment of schedule for carriers and deliveries.

With progressive development of e-commerce postal services strive to satisfy customer expectations for faster and more flexible deliveries. Current developing models have a difficult task of surviving if they do not adjust to the cost-efficient solution. Existing models currently have shortcomings in regard to flexibility and the assurance of cost efficiency. With the expected increase in the number of package deliveries from 74 billion in 2017. to 100 billion in 2020. [2], postal operators will be directed toward better cooperation for the consolidation of the amount of packages along their infrastructure.

Trends in customer behaviour have a significant influence on postal operators. Users in urban areas have at their disposal a wide assortment of options (so not only do they demand products in a certain manner, but at a certain time as well). In the case of online shopping instead of adjusting their daily schedule to the reception of a delivery, users tend to ask for the delivery to be adjusted to their personal schedule and so options of delivery scheduling and its tracking are becoming basic services offered to the customers. Initiators of user habits are: best price, time-saver, the option of ordering anywhere and anytime and exempt from postage.

4. LAST MILE ISSUE

Cities consist of human clusters which encourage development of transport infrastructure and communication networks. On the other hand, placing a large part of populace in a limited space causes air pollution, noise, as well as other negative effects on the environment and by encouraging it e-commerce makes the issue worse. Package delivery to home address as well leads to higher pollution of the environment (higher emission by postal operators).

The expression ‘last mile’ originates from telecommunications where it is used to describe technologies and processes applied for connecting end user to communication network. Last mile problem includes three basic entities: user, seller and delivery provider, where each entity has its own set of specific skills and challenges [3].

Users’ set of expectations regarding speed, flexibility, safety and price of delivery is becoming larger and more complex. They are gradually evolving and moving toward this expectation set’s growth.

Regarding urban areas, postal operators’ tasks are becoming more and more demanding which is primarily a consequence of the growing segment of e-commerce. The biggest problem is failed attempts of delivery which results in higher costs in this segment of business activities (failed delivery rate in France in 2015. was 16.2% [4]).

With the population increase in the cities and the increase in the amount of business activities, urban areas may become overloaded which may have an adverse effect on product transportation. Delivery in urban areas leads to traffic jams and increases noise and air pollution, which effects the quality of living. In that regard one should strive toward balance between service quality and the impact on the user's quality of living. Namely, users of e-commerce expect their package deliveries to be quick and cheap, but at the same time wish to enjoy clean air, without traffic jams etc. That is why it is important to come up with an optimal solution for often conflicting demands.

Intensive development of e-commerce has caused a significant expansion of the express services market. Last mile in e-commerce is regarded as the most expensive, least efficient and most polluting section in the whole logistic chain [5]. One of the main problems concerning last mile is multiple attempts of delivery in a short time interval. This leads to inefficient activities and high transportation costs which in turn narrows development options of e-commerce.

Online salespeople most often adopt the two-echelon approach (warehouse-delivery units-users) for rendering user services in urban areas with high population density [6]. In this approach warehouses conduct the packaging of products and their delivery to the appropriate delivery unit whose function is the reception and consolidation of shipments from various warehouses and their delivery to the end user in their delivery areas.

With the growth of e-commerce, user expectations are moving towards the center of attention of once business-oriented package market. Big players of the e-commerce have identified last mile as a key attribute regarding competition. Different options of delivery as well as their perceived quality are basic criteria for user decision making and so have a direct influence on the success rate of said individuals in the field of e-commerce.

Digitalization has rapidly changed the way in which users satisfy the two basic needs via postal networks: communication and purchasing. The exceptional growth of e-commerce is supported by new user segments, new products, new channels of communication etc.

Liberalization of the market aside from its user benefits may have certain negative effects as well. Such approach may lead to network doubling, which is a consequence of mutual competing among rivals. Network nature of the postal sector differs not from other network systems. Overlapping of mutual characteristics is evident in transport and communication systems when it comes to creating and organizing networks where there is a need for coverage of a certain territory. For effective and secure operations in urban areas, it is necessary to ensure coordination while taking the limitations of urban infrastructure into consideration. On the other hand, aspects such as stopping points which influence the safety of the transport process, significant time loss, increase in costs etc. need to be taken into account.

In order to avoid doubling of available capacities, operators need to cooperate. In regard to package shipments it is necessary to consider all available models of delivery as to be ready for the challenges traffic brings. The key challenge for regulators is defining present user needs as well as their evolution, consequently it is necessary for the postal operator market to develop quickly.

5. LAST MILE APPROACHES

In order to adjust to the last mile market demands, it is crucial to realize the significance of the roles of automatization, real-time data prediction and management, as well as flexible delivery networks. One may say that there is no simple solution considering that infrastructure, regulation and economic environment vary from market to market.

Flexible transportation networks may include more efficient ways of using available market transportation capacities (getting higher factor of utilization of transport space, decreasing costs, achieving quicker end-user connection, decreasing harmful influence on the environment). They also contribute to the possibility of easier shipment routing between various types of transport as to further interconnection.

Aside from higher level of automatization processes in processing centers, automatization may also include the relocation of autonomous vehicles and robots to reduce labour costs, increase productivity and improve service quality.

Data management enables salespeople and postal operators better predictions and asset position in order to reduce waste in their supply chains and to make supplies more accessible. It also makes better view of transport routes possible, enabling postal operators more efficient route and exception management, as well as providing tracking to enhance customer service.

The last-mile technical innovations are:

1. drones – drone flight is controlled autonomously from a remote. The main factors which incentivize the use of drones are expenses and the importance of fast delivery
2. autonomous vehicles - autonomous vehicles that are capable of partial or full self-movement will become a reality in the near future. It is expected that they will improve safety, reduce fuel consumption and enhance worker productivity
3. self-service lockers -by being more flexible and efficient, this kind of delivery is also cheaper for the user compared to home address delivery and it reduces delivery time as well so the user isn’t constrained by the time frame provided for home delivery
4. delivery to car –provides access to the user’s car in order to realize delivery. The user downloads the appropriate application and then connects his bank account with the car service receipt. On delivery day users park their car in the specified address area and a delivery person realizes delivery in the designated time frame. Customers receive a confirmation when the car is unlocked and upon delivery, they lock it.
5. delivery inside home when customer is away- On delivery day the operator sends a confirmation of the four-hour delivery period during which it is estimated that delivery person will arrive at the customer’s address. Before they arrive, the user receives a confirmation and may, if they choose, observe delivery process as it is happening. A delivery person sends a

request to unlock the user’s door via a manual scanner. The operator verifies that the packages belong to the specified address and that the delivery person is in front of the door and in the process of unlocking them. When the delivery is complete and the doors are locked, the user receives a final confirmation and may use a video recording of delivery.

6. crowdsourced delivery – when the order is complete, the company application for crowdsourced delivery, assigns the delivery to occasionally hired couriers. Couriers may offer to accept a local delivery or they can automatically be assigned a request based on their proximity to the pick-up location. After the package pick-up, the courier in charge delivers the consignment to the customer using his own vehicle. Pick-up and delivery may be realized immediately or inside a requested time frame.

6. CONCLUSION

The postal sector is going through a turbulent period. Postal operators recognize the importance of implementing new technologies to keep up with the changes that are happening. E-commerce is an area of great challenge for postal operators, where the dominant is primarily parcel shipping. The increase in the amount of shipments resulting from this also leads to increased competition, which has certain negative consequences in a limited urban infrastructure.

On the other hand, customers are becoming increasingly demanding about the services they are provided. In that regard, it is necessary to find a balance between the user requirements and the impact of the postal sector on the environment in which it operates. In order to achieve this, closer cooperation of postal operators is needed in order to make the most out of the use of available capacities (better utilization of cargo space, reduction of congestion and environmental pollution, reduced number of unsuccessful deliveries, etc.).

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ELECTROMOBILITY MODELS AND SUSTAINABLE URBAN DEVELOPMENT - SARAJEVO CASE STUDY

Key words
Sustainable urban development; Electro mobility; Air pollution; Efficiency of management

Abstract
The paper describes models of four electromobility segments, model of E bus, model of E bike, model of E taxi and model of E charge stations. Besides to the descriptions of individual models, the paper presents an analysis of the current state of electromobility in Sarajevo and several cities in the Europe. The method of financing and coverage of each of the electromobility models with elements of promotion and education of all interested segments of society are described. The paper analyzes the benefits and costs of new technologies when implemented in urban areas, especially taking into account their environmental aspects. For each model developed, implementation steps, proposed activities, and steps that need to be implemented in a specific area are given in order for these relatively new technologies to be accepted by the wider community. The goal of developing electromobility in urban areas is to provide users with attractive, convenient, fast and affordable public transport, with lower investment as possible, lower operating costs, and harmless and clean public transport.

1. INTRODUCTION

The most developed cities in Europe have action plans and established strategies for the development of sustainable transport and work intensively to inform and educate residents about the need to move from the current mode of transport to sustainable transport. The experiences of cities that have passed the initial stages of project implementation show that educating the population is the first step in realizing such a project. Some of the benefits of sustainable transport are: a healthier life for citizens, less noise, less pollution, a nicer city. The concepts and determinants of sustainable development and urban mobility should be presented to the urban population in acceptable ways and that the citizens should be presenters of such development for the purpose of humane and safe living. More investment is needed in educating residents about the problems of globalization, climate change and alternative ways of solving them, is education should accompany infrastructural development to make the new mode of transport in a reality.

In addition to the redesign of public transport in cities and city of Sarajevo, it is necessary to analyze new technologies that are more present in Europe concerning the use of electric vehicles (passenger cars _E vehicles, buses _E Bus, electric bicycles E_bikes, E _ romobiles and scooters).

2. ELECTRIC VEHICLES

The following four main types of electric vehicles are used in EU cities: Hybrid Electric Vehicles; Plug-in hybrid electric vehicles; Electric vehicles with extended range; Electric vehicles with battery. The Commission's 2050 transport strategy aims to break the EU's dependency on gasoline transport and offers a target to reduce greenhouse gas emissions by 60% by 2050. In addition, vehicles using conventional fuels in urban transport should be halved by 2030 and gradually phased out by 2050. In some major cities, there is an obligation to build virtually carbon-free public transport by 2030. One of the basic motives for initiating the model of electro mobility in Sarajevo Canton stems from the strategic commitment to improving environmental conditions contained in numerous strategic documents at the state, entity and especially cantonal levels. The measures and objectives contained in the KEAP that relate to the electromobility models are:

- Implementation of measures from the Transport Strategy with the new concept of public transport system in Canton of Sarajevo for alternative modes of transport and walking.
- Renewal of rolling stock for public regular passenger transportation in Canton of Sarajevo - procurement of electric buses and trolleybuses,
- Establishment of a network of electric vehicle charging stations in Canton of Sarajevo [1].

3. MODELS OF ELECTRIC DRIVE TRAFFIC

The development of electro mobility in Canton of Sarajevo will take place through the development of four models for the introduction of electrically operated traffic in the Sarajevo Canton, namely:

a) model for development of electrically operated bus in public transportation
b) model for development of electric and/or hybrid taxi in public transportation

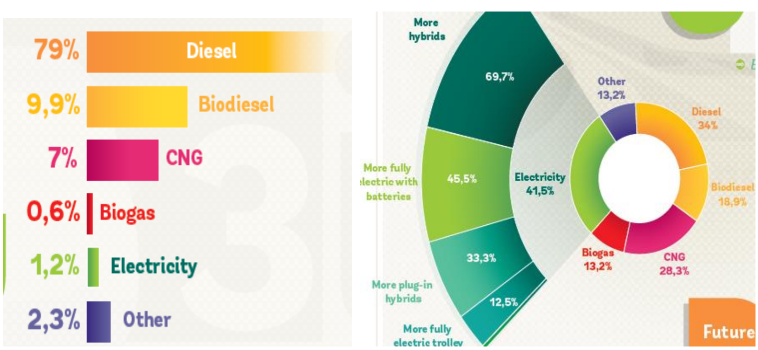
c) model of development of bike traffic with application of electric drive
d) model for the development of electric vehicle charging stations with the possibility of using renewable energy sources.

Making the models for the development of electric traffic in Sarajevo Canton will include:

- Analysis of the current state of investment justification for the development of electrically operated traffic with set goals;
- Coverage of the model of electric traffic development;
- Method of financing the electro mobility traffic models;
- Plan and program of education for participants in the implementation of the electro mobility traffic models;
- Communication framework for promotion of the electro mobility traffic models;
- Roles and responsibilities of participants / relevant bodies / institutions / organizations / enterprises [2].

3.1. Model of E-bus

The rapid development of electricity storage technology and charging systems have made the concept of electric bus more and more prevalent in many European cities and around the world in recent years. According to the EU ZeEUS (Zero emission Urban System) project report from October 2017, 85 cities in Europe use purely electric buses [3]. The representation of buses by type of EU drive in 2013 and the expected representation of buses by type of EU drive in 2030 are shown in the Figure 1. An overview of individual solutions and layout of E-bus is shown in the Figure 2.



Source: Bus system in Europe-current fleets and future trends, 3IBS project EU,2012-2015

Figure 1. E-bus in 2013 and predicted share of E-bus in 2030

E-Bus in Luksemburg

E-bus in Belgrade

E-bus in Graz

E-bus in Frankfurt

E-bus in Bremen

E-bus in Berlin

Figure 2. Photos of E-bus in several EU cities

In the case of introducing an e-bus into public transport, a simulation of the use of electric buses was carried out on some of the already existing bus lines in Sarajevo Canton. For this purpose, a comparison of electricity and motor fuel consumption (diesel or CNG) was made. Also other exploitation and environmental parameters for the introduction of electric buses (vehicles) were defined. The simulation analysis was performed on the current public transport bus route Sutjeska - Vogosca - Sutjeska, which is today covered by diesel-powered and CNG buses and connects the central part of Sarajevo with the settlement of Vogosca. By its character, the line is a suburban city with pronounced ups and downs on individual sections. This line is part of a line that was once covered by a trolleybus before the war in Bosnia and Herzegovina where a contact network was destroyed. Today, there are plans to re-cover the line using a trolleybus, but there are additional costs involved in training part or all of the contact network. The analysis conducted on the line Sutjeska - Vogosca - Sutjeska has proved that the Electric bus with super capacitor design has the least cost in the observed life span of 14 years, amounting to 11.39 million Euros. Higher overall costs are attributed to the exploitation of CNG buses (13.14 million), while the highest total costs are associated with the introduction of a trolleybus into the transportation system. The budget shows that a trolleybus with autonomy has a lower total cost (14.9 million Euros) compared to a trolleybus without autonomy of 16.31 million Euros, since in this case it is necessary to build 6.3 km of contact network instead of 9.2 km to be built in the event of the introduction of a trolley without autonomy. If we compare the operation of E-bus and CNG buses in the observed period, at the end of 10-year the total costs equals, while in the period 11-14 years the cost is higher for CNG buses.

The analysis showed that a more cost-effective solution was to implemented an E-bus electrically operated bus that uses a 40 kWh super capacitor and fast chargers installed at terminals compared to the introduction of a trolleybus and CNG bus.

The supercapacitor e-bus has a lower unit cost, lower infrastructure costs, higher energy efficiency, lower maintenance costs compared to trolley buses [4].

3.2. Model of E-bike

The main advantages and benefits of using a E-bike model would be:

- reducing the need to use cars and taxis especially in the city center and in the inner city area,
- simply and easy access to venues for various cultural and sports events of mass character (downtown, gyms, stadiums), important tourist destinations, theaters, restaurants and city and cantonal institutions
- environmentally friendly, non-polluting substances are used, contributing to the improvement of air quality
- electric bike can be used multiple times a day by multiple users (approx. 10 to 50 users)
- no need to search for parking space.

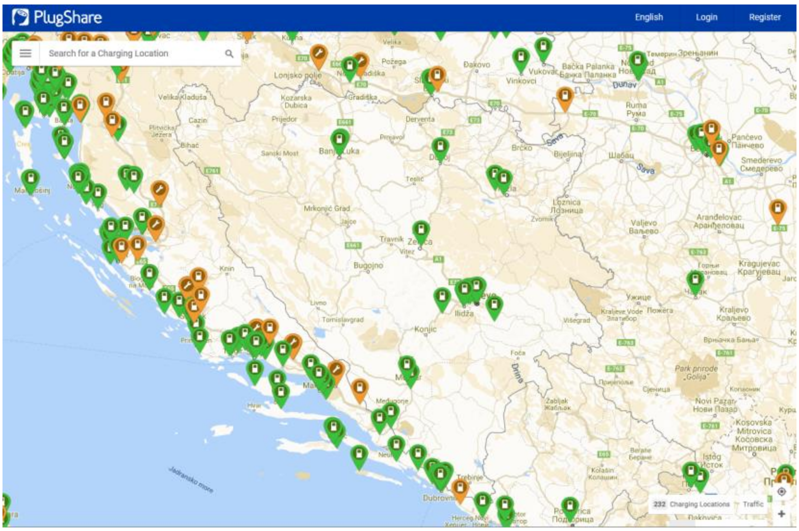
Implementation of the model of E-bike traffic and transportation according to the presented concept would result in the introduction of a new and very attractive mode of transport by E-bike and scooter, which would significantly reduce the need for use of cars and taxis especially in the city center and the inner city area. It would also provide quick and easy access to all places of interest to citizens and tourists with environmentally friendly means of transport without pollutant emissions [5].

3.3. Model of E-taxi

The introduction of electric vehicles in the taxi service fleet will provide service users with quality, fast and safe driving. Through the popularization of electric vehicles, popularizing the use of electric vehicles not only through taxi transportation but also for personal use, people directly affect the quality of life in the city. The model for introducing electric vehicles into public transit will be based on the following: procurement of hybrid or electric taxi vehicles (about 10-20 percent of the current taxi fleet) in the first phase, E-taxi vehicles would be procured through state subvention (cantonal government, city administration, etc., subvention of vehicle distributors, credit lines of commercial banks, taxi stands would be installed and electric chargers for faster replenishment of hybrids/plug in). The additional system would be provided for use of taxis and electric vehicles through the application the same platform would be put at the disposal of citizens for the use (calls) of hybrid (eco) taxis, but also for the use of electric cars (their reservations, retrieval and driving). The whole process would also be harmonized with air pollution data, potentially from one place, to the application section of E-taxi it could have partners in Google, Master card, Telecom and international regional development partners [6].

3.4. Model of charging stations

According to data from 2018 [2], a total of 501 passenger vehicles have been registered in Bosnia and Herzegovina, which can use electricity as fuel. Of these, 15 were registered as pure electric vehicles and 486 as hybrid (gasoline / electric or diesel / electric vehicles). Currently, there are over 20 electric vehicle charging stations in Bosnia and Herzegovina (2019), of which 10 are in the Sarajevo Canton (Figure 3) [7].



Source: https://www.plugshare.com.

Figure 3. Map of charging station in Bosnia and Herzegovina according to the PlugShare map (June, 2019)

Charging infrastructure is a prerequisite for the development of the electro mobility market. The impact of (non)existence of charging infrastructure on the sale of electric vehicles in Bosnia and Herzegovina can be seen in the context of three different charging stations technologies: home charging stations, public AC charging stations and fast DC charging stations). Charges on public parking lots and sidewalks adjacent to buildings - for drivers who do not have access to a private garage with a home and home charge. Semi-private or public AC charging stations with business facilities - for public fleet owners or corporate users, taxis and car rental companies, etc. Public AC filling stations in cities and larger settlements in frequency locations (e.g. city centers), shopping malls, sports halls, hotels, picnics, etc.) - to recharge the batteries of local drivers. Fast DC charging stations - for transit passengers from the EU to Bosnia and Herzegovina and vice versa (diaspora, tourists, other users), as well as for transport between cities within Bosnia and Herzegovina. Also, it is limited number of DC filling stations in the city for fast charging for local drivers (e.g. taxi vehicles) [8].

4. CONCLUSION

Electro mobility in cities in the coming period will be increasingly present in all forms of its observation. Electric vehicles and electric means of transportation will be a form of public transport in most cities. Electric charging stations will be more and more present in all parts of cities and areas and will most likely experience their standardization. With new technologies of charging and autonomy, E-buses will be the technology that, in addition to the environment, has its economic side as a technology that will be increasingly affordable and comparable to all other technologies. Sarajevo has started the development of four models of electro mobility (E-bus, E-taxi, E-bike and E-charging stations). This approach will provide clear procedures and conditions for the introduction and construction of all models and lower prices for all segments of e-vehicle technology.

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ELECTRIC MICRO MOBILITY VEHICLES - TECHNOLOGIES, OPPORTUNITIES, ASSESSMENT AND FORECAST

Key Words

Electric Micro Mobility; Vehicles; Modes of transport; MaaS

Abstract

Today thanks to rapid development of electric vehicles we are witnessing of booming new mobility service called Micro Mobility. Micro Mobility is a category of transport modes that includes variety of extremely light vehicles with limited range, such as electric: scooters, skateboards, bicycles etc. Electric micro mobility vehicles, compared to cars, are extremely cheaper to own, occupied less space and they are significantly more energy and fuel efficient. They require little or no additional infrastructure. This emerging mobility service is not detailed studied, so this will give chance to researchers as well as professionals to deal with this issue. Electric Micro Mobility can expand access to public transportation, increase mobility, reduce environmental footprint, and save money. On the other hand, we must address concerns over safety and how to best incorporate two-wheel Electric Micro Mobility traffic on streets and pedestrian sidewalks. Large cities are facing increased congestion and pollution problems. With emergence of Electric Micro Mobility cities now can tackle with congestion issues. This paper will present the review of Electric Micro Mobility Technologies, analyse opportunities of Micro Mobility, assess and forecast the Electric Micro Mobility as a service.

1. INTRODUCTION

The term "micromobility" has become a catch-all term for several modes of transportation, namely docked and dockless bikeshare systems, electric bikes and electric scooters. Many of these modes share some distinct features (DuPuis at al., 2019).

Micromobility is the trip in short distances. This trip is usually between walking and driving distances or trip related to the first or last kilometer of traveling with another transportation mode, usually public transport. Micromobility is increasing in cities, especially booming increase is in electric micromobility.

Micromobility is revolutionary due to a several advantages related to electric micromobility vehicles such as: weight, space, efficiency, running costs, healthy and environment friendly, etc.

Urban population is growing, car ownership is growing, along with increase of urban mobility resulting congestion on street network. Micromobility will play a crucial role of additional mobility service in cities, thus helping tackle with increasing congestion. With micromobility, cities will achieve a reduction in congestion, as well as changes in parking and road space allocation.

Due to its advantages, electric micromobility will replace car for the significant number of short trips and especially short trips in cities. This will help cities to exclude cars from city centres.

2. HISTORY AND DEVELOPMENT

Since ancient times, roads and street were for pedestrians, horses and carriages. From the beginning of motorization cars occupied streets and roads. At the same time small vehicles emerge, but they did not increase their influence until the beginning of 21st century (Figure 1.). Increasing usage of small electric vehicles for micromobility purposes is due to decrease of weight of micromobility vehicles, increased life of battery and increased distance that small micro mobility vehicles can cover.

The history of electric micromobility vehicles is marked by many attempts (Figure 2.). Electric scooters gain popularity and win due to their costs, simplicity, weight, and other advantages over other types of small vehicles.

Woman riding an electric scooter, 1916

Woman riding an electric scooter, 2019

Figure 1. Development of micromobility vehicles

Figure 2. Types of electric micromobility vehicles

3. ANALYSIS OF MICROMOBILITY STRENGTHS, WEAKNESSES, OPPORTUNITIES AND THREATS

The number of vehicles in the world is increasing, which has numerous negative effects on society, such as traffic congestion, air pollution, noise and other negative effects (Glavic et al., 2017, Glavic et al., 2019). This problem is emphasized in big cities and is caused by a large number of car related transport demands. To manage this problem many measures of Transport Demand Management-TDM can be applied to reduce the use of cars. Among these measures, the one that is the most effective is shifting from car to other more environment friendly modes of transportation, where micromobilty can play crucial role together with public transit (Figure 3).

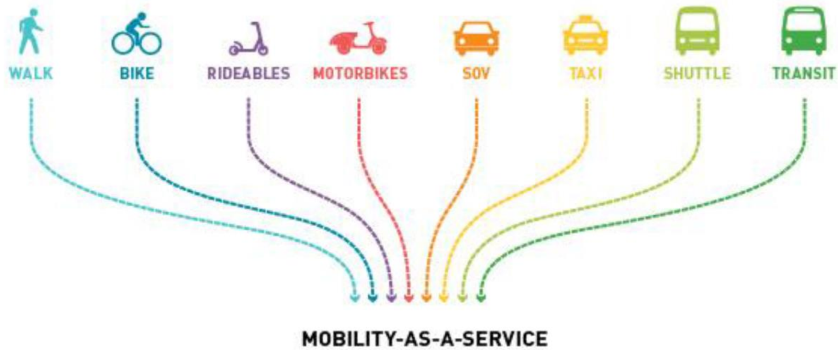

Figure 3. Micromobility as a MaaS

At the moment, an increasing number of researchers and decision makers are recognizing micromobilty as a promising mode of transportation.

This concept restricts the total use of cars in the way that the users use electric micro-vehicles for short trips or for last and first mile instead of cars. Distribution of trip distances is presented on Figure 4. One can see that majority of trips are short trips up to 8km or 5 miles.

Micro mobility is a booming mobility service that can cover this short trips, especially in last few years (Figure 5).

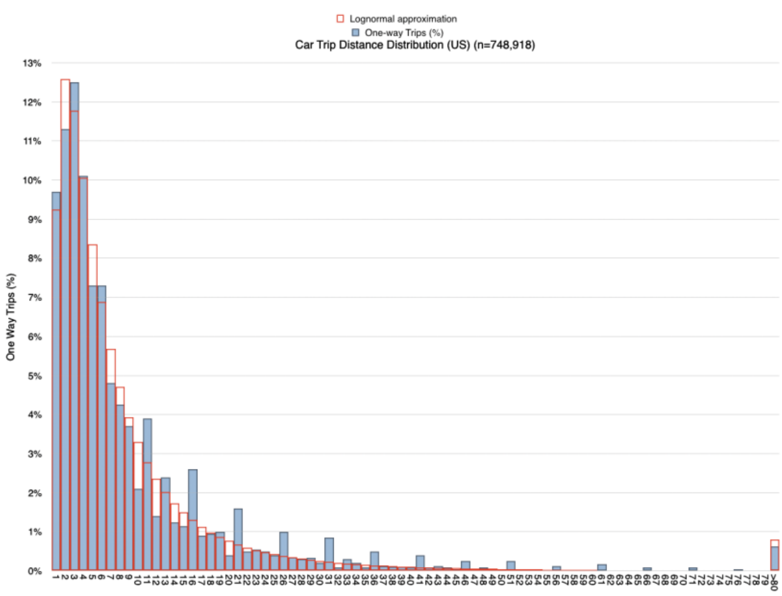

Figure 4. Distribution of trip distances (Dediu, 2019)

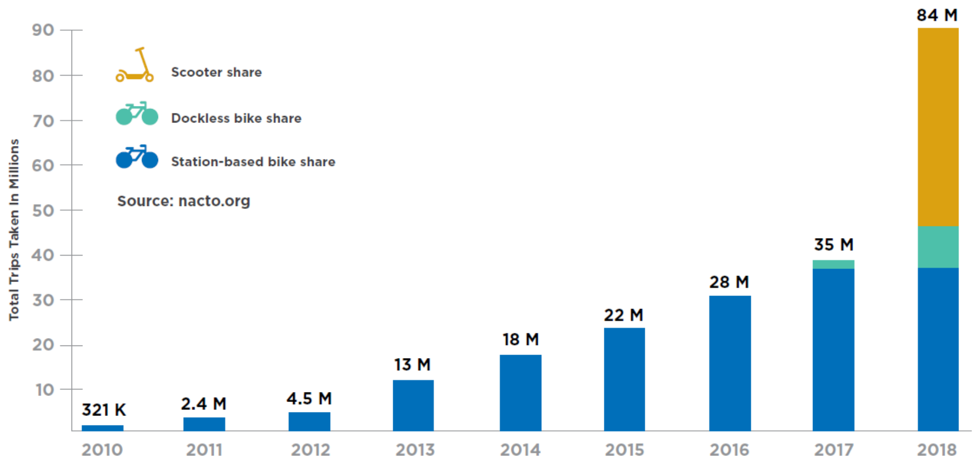

Figure 5. Trips on shared micromobility 2010-2018 (DuPuis et al., 2019)

The analysis of electric micro mobility is conducted with a SWOT analysis. SWOT analysis is a structured planning method that helps to evaluate the strengths, weaknesses, opportunities and threats.

The SWOT analysis also helps the decision-makers to better understand micromobility and effect of micromobility on users and cities. Results of conducted SWOT analysis are represented in Table 1.

Table 1. SWOT analysis of micromobility

	Micromobility
Strengths	Reduction of car traffic Reduction of parking congestion Generation of revenues with shared micromobility (which can be allocated to Public transport subsidies and infrastructure investment) Air quality improvement Reduction of Noise Reduction of Climate change Urban space improvement Better Land-use
Weaknesses	Traffic safety Lack of regulation rules and laws

	Micromobility
Opportunities	Social equity Eco mobility Shared mobility Can reduce number of parking lots Can reduce number of traffic lanes for cars
Threats	Legislative framework Enforcement measures Weather conditions Terrain conditions

According to SWOT analysis one can see that micromobility have many advantages and opportunities. While weaknesses and threats are caused mainly due to a rapid and booming usage of micromobility that did not followed with rapid changes in space allocation and regulation.

4. CONCLUSION

Micromobility vehicles as an emerging technology and micromobility as a MaaS can reduce our environmental footprint, save money, increase efficiency, increase population health and improve use of land.

Still some questions stay unanswered such as safety, law regulations and how to incorporate two-wheel micromobilty electric vehicles traffic on streets and sidewalks.

Solution is in new allocation of street space. Land and lanes should be taken away from cars and dedicated to pedestrians, micromobilty vehicles, and public transit.

Safety issue is also important. Accidents involving pedestrians and riders or riders and cars are common due to a lack of regulation and old street design. To solve this issue redesign of infrastructure is needed. Some measures can include new lanes on spaces previously dedicated to cars, or even create road barriers between micromobilty vehicles lanes and car lanes.

Another measure that can improve safety is regulation. As micromobility vehicles are emerging concept of mobility, regulation mainly do not exist for it. Currently due to a rapid development of micromobility local authorities usually do not have proper regulations.

Weather and terrain conditions is issue that can restrict usage of micromobility in cities with cold climates, such as snow conditions or cities on hilly terrain. Terrain issue can be solved with increased capacity of batteries and with more powerful engines, but weather restriction will remain.

Despite all of issues that need to be solved, future look bright for micromobilty thanks to advancing technology in batteries and implementation of AI and BIG data usage for shared micromobility.

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USER′S ABILITY TO USE INTERNET TECNOLOGIES IN TRANSPORT

Key Words

User;
Willingness;
Quality of service;
Transportation

Abstract

The paper shows the willingness of service users to apply innovative models based on advanced Internet technologies in transportation. Research on the development of an innovative e-business model based on advanced Internet technologies will be presented in the form of problem analysis, methodology used and solutions, followed by different presentation of comparative results and conclusions. A survey questionnaire will be used to determine the attitude of service users as a research instrument. The main purpose of the research is to improve the quality of service in comparison with existing traditional models, customer satisfaction with the use of mobile advanced Internet technologies. The application of new models and technologies has led to a reduction in operating costs. The application of mobile technologies has made it possible for business anywhere and anytime.

1. INTRODUCTION

Every business transaction that is realized through mobile devices and mobile telecommunication network is a mobile commerce. The following technologies are used to conduct business transactions in mobile commerce:

- SMS (Short message system) means sending short messages via mobile communication systems;
- Unstructured Extra Services Data System (USSD) is a protocol used to communicate with services hosted on mobile carriers' servers;
- Mobile Internet, which refers to the ability of a service user to access mobile search;

- NFC (Near Field Communication) technology is a communication and set of standards for mobile devices where radio communication and two-way communication between them are established.

Many specific business needs in an enterprise context cannot be effectively met by using current business process technology. Furthermore, end users are allowed to interact with the process they created on their smartphones. Finally, the usability of the approach was evaluated on a small set of users in the actual business scenario. The results show that end users can effectively build their personalized business processes [1].

Researchers pay particular attention to the relationship between customer satisfaction and loyalty, which has attracted the attention of the international community, as transport agencies aim to identify ways to increase the number of outsiders. In the paper, the authors [2] examine how users 'perceptions of transportation services and customer satisfaction affect loyalty. Using the satisfaction questionnaire information collected by two Canadian transit providers, an attempt was made to better understand the complexity of several factors affecting passenger satisfaction and behavioral intentions. The findings from this study are used to define areas where transit agencies can develop specific strategies to determine customer satisfaction with the goal of increasing quality. Insights into passenger perception provides useful information that can help transportation organizations understand what inspires customers' perceptions of satisfaction and loyalty in general.

An example of behavioral analysis and stakeholder engagement in urban transport planning creates an integrated modeling framework that allows for the assessment of policy acceptability, taking into account their heterogeneous preferences and their interactive behavior. The proposed stakeholder behavior analysis, together with technical and economic analyzes, contributes to the assessment required to support decision makers [3].

2. MATERIALS AND METHODS

Critical business activity is the purchase of tickets at the cash registers of the service provider and the possible modalities of monetary transactions (payments) are by cash or bank payment card [4]. The interaction interplay of messaging and transaction roles can be analyzed across six semantic context dimensions (who? What? Where? When? How? Why?) Paired with six situational factors of communication dynamics (space, relationships, time, interactions, roles, contexts). POVIUK) [5] [6]. A tabular overview of the semantic dimensions of context and communication dynamics factors for users and service providers is given in Table 1.

Table 1. Semantic dimensions of the context coupled with the situational factor of the dynamics of business communication

Semantic dimension of context/Factors of communication dynamics	Service user	Service provider
Who? (ROLES)	Urban transport service users integrated from the rail and road transport modules	transport service providers from the rail and road transport modules
What? (RELATIONS/ FUNCTIONS)	Customers' personal needs for the transport service realized through the activities of ticketing and transportation	Provision of reliable urban transport service to customers with satisfaction of quality standards in all activities
Where? (SPACE-LOCATION)	Space-real physical locations to meet the needs of transport service users	Operational area of the transport service provider
When? (TIME-MOMENT OR PERIOD)	Checkout time - fixed daily ticket purchase time	During the seven days of the week and according to the operational plan from the winter / summer timetable
How? (INTERACTION/ TECHNOLOGY)	Performing User Roles in Process Technology Transportation Activities and Business Transactions with Multimodal Interactions	Implementation of the programmed process structure of the transport service with operational certainty, functional suitability and reliability of the transport system and technical infrastructure
Why? (QUALITY/ PLEASURE)	Satisfaction of personal wishes, needs, demands and expectations of users	Maintaining the parameters of a reliable transport service

The primary objective of the research is to develop a new model of ICT transactional business in a transport organization based on internet technologies. Internet technologies are not only used to search for information and conduct transactions in e-commerce, but also as a platform for providing customer service. For the integration of a web service in a transport organization, the interaction process related to the service, its flow and interdependent calls is defined. Business process implemented with Internet technologies is an e-process.

Comparative view of transaction models was generated based on the situation parameters that include: *space, time, roles, relations, interactions and environment* (Table 2).

Table 2. Comparative view of the factors of the communication dynamics of the Conventional, and ICT transaction model of transport service (Adapted according to [7]*)*

Model Situation parameter	Conventional transaction model	ICT Transaction Model
Space	Passenger cashier at TO offices authorized to sell tickets	A virtual cash register for choosing, paying and getting a service
Time	Limited daily travel cashier hours	24 hours over seven days
Roles	Service user with need, request and expected card service / service provider direct distribution implementer	Ordering, selling and delivering the requested service through the service
Relations	Service user in f-f communication with cashier	communication between users of the service and the service in the transaction activities of ordering, paying and obtaining a ticket
Interactions	Customer Service Employee	Service user with server u to select, order, pay and obtain the requested service
Environment	Physical access of the user to the cashier / work space for the employee	Development of a virtual platform for transactional business between service and service users

For the purposes of the research, a comparative overview of the factors of communication dynamics between traditional and innovative transactional ICT models is presented based on the following indicators: space, time, roles, relationships, interactions and environment. At the heart of the innovative ICT transactional model is the service user as the most important resource for initiating the entire process. The service user needs to meet their travel needs in the easiest and most affordable way.

Technological innovations in the process structures of urban transpot service imply not only the extension but overall the replacement of traditional contacts in the real physical space of the service provider into contactless transactional models of provider and user communication. The goal in designing and implementing the model is not only to increase the operational readiness, functional suitability and reliability of the transport organization's resources, including technical infrastructure, business efficiency, but above all to increase the level of quality that is an indicator of a "customer satisfaction measure" [8]**.** Based on the presented parameters, the model has the option of reviewing all cash transactions for the purchase of tickets as well as the service user and the opportunity to cancel the trip [9] [10].

3. RESULTS AND DISCUSSION

The analysis of available literature in the field of Internet technologies, electronic business, models currently represented in traffic, showed the possibility for business improvement and overall satisfaction of users of services, found space for the development of a new business model. The new model should encompass the service user as a customer and the integrated transport organization as a service provider.

As part of the empirical research, a survey will be conducted for users of services and a survey for employees. The survey covers user issues, where new possibilities for integrating transport organizations' Internet services are covered, with the special reference that the service user can start a journey in one place, end in another, use an alternative mode of transport and arrive at a specific planned location. Shopping related activities are carried out through a mobile application and the service user can make online cash transactions using a payment card. After the cashless payment, the user receives a digital bar code card as a confirmation. The bar code contains all the necessary information related to the date of travel, route, vehicle and destination. The service user is obliged to validate the e-ticket, store and show the bar code on the smartphone to the authorized person for control before commencing the journey in the transport vehicle.

The sample of the service provider operator consists of employees who are in direct business communication with customers. and they answered 15 questions with five offered answers in the survey questionnaire. The input data in some of the questions that represent the research variables include: years of service, education level, IT education level, IT certifications, participation in IT projects, analysis of IT competences, readiness for new ways of doing business, ... Assessment was used Likert scale where each answer is represented by a number (1- no, 2-I'm not sure, 3-maybe, 4-very likely and 5-yes). Based on the data collected through the survey and processed by statistical analysis using IBM SPSS software, information was obtained on the profile of the surveyed operators through the distribution of frequency of response values. Based on the obtained profile data in the study, the attitude of the employees towards the development and implementation of the new model of IT transactional business is partly positive. Special attention should also be paid to the attitude of employees exploring the possibilities of developing and improving the business of the transport organization in relation to the traditional business to date (purchase of a ticket at the counter of a passenger ticket) [11].

A sample of service users is made up of surveyed students and citizen travelers who travel daily, use mobile phones and the Internet. The main research variables are: satisfaction with the current service, quality of service, objections to the service provided, objections to the work of employees in TO, willingness to apply new ways of doing business, confidence in TO ...

Empirical research has shown a positive attitude of service users (employees and students) who travel and use transport vehicles on a daily basis, as well as employees of the transport organization who are in direct communication with the service user. The primary objective of the research is to look at the indicators for the development of an innovative model based on the models and services currently in use based on the attitude of the service users, their wishes, and the needs and requirements. In addition to service users and employees, they also contribute to the development and implementation of a technologically innovative contactless transaction business model.

4. CONCLUSION

The innovative ICT transactional model of transport service is conceptualized as a unique whole of technological, behavioral, process and contextual components of functioning and business in transport organizations for transport of passengers and complexity of interactions with service users. The initial hypothetical research set-up is oriented to the observation of parameters with the aim of improving the performance of functional and transactional business processes and raising customer satisfaction to a competitive level of service quality. The results of a field survey of the profile views of users of representative sample services confirm the hypothetical assumption of a willingness to accept the ICT transactional model of transport service in the electronic business of transport organizations. The user readiness indicator for adopting advanced Internet technologies is higher than the readiness of railway transport employees for the carriage of passengers who express a certain indecision and distrust of new business models.

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URBAN SUSTAINABILITY AND SMART STREET LIGHTS CASE STUDY SARAJEVO

Key Words

Sustainability;
Streetlights;
Air pollution;
Entrepreneurship

Abstract

Smart Cities concept is a complex system that uses the ICT solutions and the IoT hardware devices to collect data and optimize the city management process focusing on improvement of the Quality of Life for citizens. ICT-driven solutions involve “smartness” in current services based on data analytics, finding a new knowledge using machine learning, and artificial intelligence for optimization of resource allocation. This paper describes the methodology, management, and benefits of the smart public lighting system proposed for the City of Sarajevo in the Call for Proposals on Smart Sarajevo in the City Mind Lab initiative by the UNDP Bosnia and Herzegovina and the City Council. Aims of the smart public lighting system are to decrease the power consumption as a primary goal, but also to enable reaching secondary goals as an air and light pollution decreasing and many others. The collected open data is the crucial catalyst for launching the entrepreneurship ecosystem and the economic growth in the City. This vision is a part of the EU vision in the concept of Open Innovation 2.0, known as the Quadruple Helix model, which engages all community sectors as a government, industry, academy, and civil society. The paper describes the case study for the City of Sarajevo and the general survey of opportunities and benefits of the smart public lighting system implementation.

1. INTRODUCTION

Public Lighting System aims to decrease power consumption, air pollution, and light pollution to improve public service delivery. In Sarajevo, a lot of city's energy expenditure goes to street lighting. When times are lean, energy efficiency is becoming increasingly important. The aim is also to keep maintenance costs under control. Investing in energy-saving measures with intelligent street lighting, therefore, seems a logical step. Even the transition to LED lighting is still not a visible development, but it could be a first step forward.

Our project proposal revolved around Smart Public Lighting System aims to decrease the power consumption, air, and light pollution to improve public service delivery, i.e., street lightning and help address the priority city challenges. Besides primary benefits, there are many secondary and tertiary benefits of the Smart Public Lighting System implementation. The collected data could be defined as Open Data licensed what means that the data or at least some part of them could be published and made available to analyze from the third-party subjects. Many upcoming start-ups related to new and smart ICT-based solution in hardware and software topics find this very useful, what directly affects the entrepreneurship ecosystem and affects the economic growth in the City.

2. SMART CITY: CASE STUDY – CITY OF SARAJEVO

Technology-driven Smart City concept is a response to challenges that many cities face, such as lower ICT use level, unemployment, weak infrastructure, socio-economics inclusion, increasing competition, and many others.

A city becomes "smart" when investments in human and social capital and traditional transport and ICT-driven communications infrastructure fuel sustainable economic growth and high quality of life, with a wise management of natural resources, through participatory governance. Smart City system strikes a balance between economic, social, and environmental demands, focused on Smart Sustainable Green Growth, recognizing economic growth and sustainability as welfare prerequisites.

The City of Sarajevo, urban and suburban area, is characterized by good development potential of the Green Growth sector. Focused interventions on highly innovative Smart City themes can enhance innovation level in the area lagging behind the EU average, implementing UN Sustainable Development 2030 Agenda and EU Digital Agenda 2020 strategies.

In the City of Sarajevo, a lot of city’s energy expenditure goes to street lighting. When times are lean, energy efficiency is becoming increasingly important. The aim is also to keep maintenance costs under control. Investing in energy-saving measures with intelligent street lighting, therefore, seems a logical step, but it does not assume the current situation in this respect. Even the transition to LED lighting is still not a visible development, but it means a first step forward.

Since the City of Sarajevo is in the early stage of Smart City launching and one of the most important priorities is the public lighting system. The Public Lighting System (“System”) in the City of Sarajevo is a conventional old-fashion system with a very low or not-at-all modern ICT-driven solution present. It means that there is no bidirectional transfer of information on the current state of the system to any of the potential stakeholders in the process of the City public services management. Some and minimal overview of the state of the system exists in the Power company, which monitors its system from the aspect of power flow and state estimation perspective.

Additional savings and improvements are defined as follows. This approach understands that the Public Lightning System is not fixed anymore on 100% power all the time, and the System should be connected with some other parameters. The System is working in time cycles setting the power level on more than one e.g., 100-70-40-20% of maximum power or any other regime. Transitions could be defined by timer e.g., every 3 minutes until pedestrian or car appears what triggers the System to go back to the maximum level 100% power. Power levels and length of time cycle is the subject of the optimization process during the implementation and operation phases [1].

The System is currently designed to work with the predefined schedule in manual or semi-automatic mode with limited installations of photocells in some location, which can regulate the timing of the System turning on and off. In some plans for future implementations and minimal current implementations, there is an option for remote control of the System. Both solutions are very limited to the conventional framework of the Public Lighting System without any autonomous self-regulation, collecting data, and sending feedback to the operating centers [1].

The new System enhanced by intelligent self-regulating mechanism and with the quick response to citizens' habits and profiles of their needs should deliver the optimal quality of service, increasing the total efficiency of the System based on a data-driven decision from the data center. The System is connected in bidirectional communications mode with the data center(s) where the collected data is stored for the analysis and calculating optimal decision, using Artificial Intelligence and Machine Learning algorithms and advanced mathematical techniques as a response on real needs in the real-time. That means that the data-driven decision making can deliver the maximal quality of service and the Quality of Life for the citizens against the power consumption and environmental degradation. This trade-off is possible by collecting the relevant group of parameters for deterministic mathematical-based calculations.

The essential data to be collected are the daylight period depending mostly on the period of a year. Current weather state, intensity of presence of pedestrians and traffic in the location, profiling citizens habits by hours (e.g., intensity is lower during the night hours), days (e.g., citizens are more active during weekends), months (e.g., citizens are more active during the summer period) become the set of data critical for further analysis and decision making. The collected data may prove some additional presumptions.

The total effect prediction for the ICT-driven Smart Public Lighting is expected no worse than decreasing the power consumption by up to 38%, decreasing air pollution up to 150%, decreasing the light pollution up to 300%. It depends on the very local current state and the level of implementation of all intelligent functions.

Besides primary benefits, there are many secondary and tertiary benefits of the Smart Public Lighting System implementation. The collected data could be defined as Open Data licensed what means that the data or at least some part of them could be published and made available to analyze from the third-party subject. That includes many upcoming start-ups related to new and smart ICT-based solution in hardware and software topics what directly affects the entrepreneurship ecosystem and affects the economic growth in the City.

3. SMART PUBLIC LIGHTS FOR TRAFFIC SAFETY

Nature and buildings shape the environment of urban traffic participants during the day. In the night, artificial light is an additional factor that determines the perception of the environment and object, their shapes, size/volume, position, and space. The illumination of roads and their immediate surroundings allows visibility, orientation, and safety of the mobility of both motor and pedestrian and bicycle traffic. The use of vertical and horizontal light of different luminosities and colors of light, and light and shadows determine the ambiance through which traffic participants move in night conditions.

Illuminations of roads and their more extensive areas are an element of the environment that assists in the overall flow of safe traffic, and if properly positioned, will result in better detection and detection of obstacles and dangers on and off the road.

Traffic participants rely on their observation, defined as the ability to detect and respond to visual information during movement, which provides them with their safety of movement. The reliability of observations depends mostly on the ability to spot details and changes in the field of view.

The primary function of traffic lights and the environment is to ensure a minimum prescribed value of illumination, uniform illumination, and reduce the effect of the headlamps. Traffic lighting and the surrounding area should allow for such conditions of vision that guarantee the following at night:

- safer rides for drivers
- observing potential hazards, better orientation, and getting the impression of safety when walking for pedestrians and cyclists
- observation of the whole and essential details in the visual environment of traffic participants.

When driving at night, the visibility length depends on the illumination: light sources on the vehicle front or the constant lighting of the roads or their combination. By decreasing general illumination, most of the essential visual functions, e.g., visual acuity, contrast sensitivity, depth of vision, speed of observation, color differentiation, are gradually diminished and lost.

The illumination of the road must be such that the driver recognizes in time any obstacle, has sufficient visibility, and is sure of the traffic on the road. It is necessary to ensure the uniformity of street lighting and highlight critical points, e.g., pedestrian and bicycle crossings, crossings, bridges, turns.

Figure 1. Conventional vs. LED Illuminations on the road

The lighting of the road from the aspect of driving must satisfy the following conditions:

- the road must be visible in full detail when driving,
- the route of the road must be visible and marked visually, equipped with various aids, such as signposts, curb lines,
- all hazardous locations should be highlighted so that the driver can notice them on time,
- visibility comfort must be ensured to prevent the driver from straining while driving,
- uniform lighting of the entire road should be provided,
- all horizontal and vertical signage and other devices must be visible and must not blind the driver.

Currently, there are a significant number of cities in the world that have implemented the intelligent traffic light system. The City of San Diego (CA, USA), with the help of a wireless remote control and monitoring system for 3000 streetlights, saves more than $ 250.000,00 per year in electricity and maintenance costs over the conventional system of public lights. The City of Oslo (Norway), has reduced energy consumption by 70% and CO2 emissions by 1440 tones per year by introducing innovative and energy-efficient street lighting with 10.000 installed sodium lights, which adjusts the light as needed using an intelligent lighting system [3].

Each public lighting system shall comply with EN-13201 European Standard for Road Lighting Systems. This standard defines the classes (types, categories) of illuminated roads and visibility requirements, as well as methods for measuring and evaluating the characteristics of road lighting systems. The group of standards EN-13201 is adopted in the regulations in Bosnia and Herzegovina as BAS-13201, as it follows:

- BAS/EN-13201-1:2017: Road lighting Part 1: Guidelines on selection of lighting classes,
- BAS/EN-13201-2:2017: Road lighting Part 2: Performance requirements,
- BAS/EN-13201-3:2017: Road lighting Part 3: Calculation of performance,
- BAS/EN-13201-4:2017: Road lighting Part 4: Methods of measuring lighting performance,
- BAS/EN-13201-5:2017: Road lighting Part 5: Energy performance indicators [1].

From the perspective of Smart Public Lighting in the City of Sarajevo, the limitations and additional parameters noticed in the group of standards BAS/EN-13201 are added and shall be taken into account for optimal decision calculations on the working regime for the Smart Public Lighting System in the City of Sarajevo.

All details on parameters, their classes, values are presented in the group of standards. Values are correlated with the speed of movement for pedestrians and vehicles, and the level of illumination shall be aligned with these levels or better, for the moment when pedestrians or vehicles cross the street. The sensors must detect the movement of a proper object in advance to be able to analyze collected data and to send a command to increase illuminations from saving level to full power level before pedestrians or vehicles reach the street. The geographical distribution of the System, routes of roads, traffic intensity parameters, and many other factors are related to each specific environment for the deployment of the smart public lighting, and it is difficult to consider the general model.

For future analysis, it considers a few examples of critical parameters for calculations of the smart public lighting system correlated with the driver's vision abilities and speed of moving.

Figure 2. Public Lights in the City of Rijeka (Croatia), Pedestrian crossing signing [2]

Approximately 95% of all decisions made by the driver while driving relate to visual information. For adequate reception of visible information, the following are essential:

- width of the field of vision,
- depth of vision as well
- the ability to adapt to changes in light.

The sharpest field of vision is within 3° (degrees) of the fixation point. From 3 to 6 degrees there is an entire field of view from 6 to 10 degrees there is a right field of view (called Reading Field), from 10 to 20 ° (degrees) is a satisfactory field of view from 20 ° (degrees) and more peripheral field of view.

As the speed of movement of the vehicle increases, it changes the width of the field of view of the human driver. The field of vision narrows functionally (e.g., at a speed of 25 km/h, the width of the field of vision is about 100° (degrees) and at a speed of 100 km/h) the width of the field of vision is about 40°.

Visibility also depends on the condition of the pavement, namely on a wet and wet road, the shape of the illuminated object and space is lost, especially when the pavement surface is smooth. It is better to improve the reflective properties of the road, but to enhance the light source, thus achieving a better contrast of objects and the road while reducing blinding. The rough surface of the road is better than the smooth surface. When laying the surface of the road, the light spectrum should be as similar as possible to light in all conditions concerning the reflection of light. Causes that lead to traffic accidents in night driving conditions should assume the aspect of visibility and observation due to the elements of a vision of the individual - the driver. The ability of the eye as the most critical traffic information authority is not in all situations of equal quality. It changes according to the intensity of the light, and the lower the light, the less the eyes can see. When it comes to vision, it should know elements of driving in the evening, dawn, and night, as well as when streetlights or headlights illuminate the roadway. The sight of a driver on a well-lighted pavement is almost half worse at night than in the daytime. If the pavement is still wet in the dark, it reduces visual acuity to 1/10 of healthy vision in daylight. Reduced visual acuity results in an automatic reduction in the distance to the observed object. Reduced vision in the night is physiologically conditioned, so all this imposes the need to adjust driving visibility.

The biggest mistake is that many drivers who, regardless of age, still have a relatively good day view, find that they also see well at dusk. With the help of the “mesoptometer," it is possible to accurately measure the degree of visual efficiency in the conditions of night traffic. With changes in the organ of vision, which inevitably occurs with age and aging, it is not only a decrease in visual acuity but also a decrease in the sensitivity of the eye to contrasts, which again manifests itself in the dark. Unlike the eyes of younger people, the eyes of older drivers can only perceive striking, heavily outlined contrasts. Night contrasts play a vital role. Failure to notice the contrast often leads to a dangerous overlook of the pavement, which inevitably leads to road accidents.

Analytical or simulation model, which includes all parameters considered in this survey, is not presented in this paper, but it could be the subject for future work.

4. CONCLUSION

The design of a high-quality decision-maker software tool is a challenging task. The data center should consider tens of parameters and calculate their interactions and correlation, including different requests from the goal function. Calculation of optimal or suboptimal points of the working regime for any applications is not deterministic, and it may assume an iterative approach verified in practical application in real systems and environment.

The Smart Public Lighting System in the City of Sarajevo is the data-driven system run by the simplified model based on the goal function. It has to be optimized with the criteria of the minimal energy consumption against the length of the lifecycle of streetlight bulbs, decreasing the number of power transition and dimming as possible. At the same time, the quality of service, which includes subjective observation of citizens (pedestrians and drivers, both), has to maintain the same or similar level as it exists in the conventional public lighting system.

Additional criteria, which include the recommended level of observation from the perspective of drivers and the relation between the system management and the speed of driving, can be considered in the future upgrades of the system.

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OPTIMIZATION OF VEHICLE TESTING CENTER LOCATIONS IN ZAGREB COUNTY

Key Words

Technical inspection of vehicle;
Vehicle testing center;
Demand and supply for service;
Service optimization

Abstract

In this paper the emphasis is placed on the vehicle factor from the aspect of roadworthiness. In order to determine whether it is a technically correct or defective vehicle, vehicles are subjected to vehicle technical inspections at vehicle testing centers. There are 161 vehicles testing centers in the Republic of Croatia, and 9 more that deal exclusively with preventive vehicle inspections. The aim of the paper is to optimize the locations of vehicle testing centers in relation to the demand for its service. The methodology of the work is as follows, based on the obtained and available statistics from the Center for Vehicles of Croatia (CVH), an analysis was made according to the requirements for the needs of the vehicles testing center. The paper consists of the following chapters: introduction, review of previous research, methodology, analysis of service requirements at vehicle testing centers, discussion and conclusion with the proposal of measures for optimization of services at vehicle inspection stations.

1. INTRODUCTION

This paper present influence of technical soundness of vehicles as a factor in the road safety. There are 170 vehicle inspection stations in the territory of the Republic of Croatia. The aim of this paper is to show the relationship between supply and demand at vehicle inspection stations in Zagreb County and possibility of optimization. The methodology of the paper is next: based on the statistics of the Croatian Vehicle Center, an analysis of demand for services was made for the vehicle's technical inspection stations, which will provide a clearer insight into the relationship between supply and demand in the observed stations over a period of 3 years (2015, 2016 and 2017).

2. LITERATURE OVERVIEW

According to Repin, Maksimov, Golovkov, and Kuzmichev, the paper entitled: Method of Optimizing Placement of Mobile Car Service Stations in Sparsely Populated Areas (2016), considers the development of an optimization method for the deployment of vehicle maintenance stations in less populated areas. The method involves analysing the territorial location of settlements, the number of vehicles in the observed settlements, calculating the travel time between settlements, and determining the optimal location and location of vehicle maintenance stations according to a series of criteria. The necessity to develop a method of optimizing the location of mobile vehicle maintenance stations is caused by insufficient coverage of vehicles in sparsely populated areas, where technical services are provided for inspection and repair of vehicles, and therefore the number of traffic accidents increases due to technically defective vehicles. Fifteen settlements were taken into consideration with data such as: population, number of vehicles, travel time and others. By studying the presented settlements data, it is concluded that there are two variants of station placement. The first variant is in the settlement, while the second is in a special place outside the settlement. There are two basic ways of computing that are carried out in a settlement (with included population and without included population in settlements) [1].

According to Guangdong, Mengchu, Peigen, Chaoyong and Hongfei in a paper entitled: Multiobjective Optimization Models for Locating Vehicle Inspection Stations Subject to Stochastic Demand, Varying Velocity and Regional Constraints, this paper presents a new statistical multi objective optimization solution to address the issue of selecting a vehicle inspection station location as a typical example in the automotive industry. This paper is based on two practical stochastic multi objective programs dependent on stochastic demand, variable speed and constraints. To solve the proposed programs, a hybrid intelligent algorithm is proposed that integrates a stochastic simulation and a multiobjective learning-based optimization algorithm. This approach is already being applied in China to solve the problem of selecting a vehicle inspection station location, and the results have proved satisfactory [2].

According to Hong - Feia, Qiang and Guandong, the paper entitled: A Multi - Objective Optimization Model for Locating a Vehicle Inspection Station with Fuzzy Demands determining the location of vehicle inspection stations is a very important issue in the field of logistics research. To solve all the uncertainties, some researchers have looked at finding the location of stations for vehicle inspections, according to time and cost factors according to Fuzzy. The travel time factor in selecting the location of a vehicle inspection station is also vague due to the influence of some other unpredictable factors. In order to solve this problem, a Fuzzy multiple objective approach is proposed to implement optimization. To solve the problem, a multicriteria programming model has been developed, which determines the most favourable locations according to the set requirements. To solve the problem, a hybrid algorithm model is proposed that integrates fuzzy simulations, neural networks, and genetic algorithms [3].

According to Guandong, Liu, Guang, Dai, Ren in a paper entitled: Analysis of network layout optimization problem for vehicle detection station in random environment, suggests that given the impact of uncertain factors, the problem of randomly positioning a network of vehicle inspection stations was introduced to describe the real circumstances. Furthermore, stochastic programming models for accessible and inaccessible location for vehicle inspection stations have been established, and at the same time a genetic algorithm based on stochastic simulation is used to solve the problem, using the model [4].

Described papers dealing with the optimization of vehicle inspection stations in different areas, using available data such as: number of vehicles in specific areas, analysis of territories of specific areas, average travel time in areas, based on spatial and other constraints using different methods like: stochastic, different algorithms, using Fuzzy logic and various simulations. By studying the above papers, it is possible to optimize the locations of the stations for the technical inspection of vehicles.

3. EXAMPLES OF SYSTEMS FOR TECHNICAL INSPECTIONS OF VEHICLES IN THE EUROPEAN UNION

The vehicle inspection system in the Republic of Croatia is very similar to system of The Federal Republic of Germany. The regular technical inspection of vehicles in Germany is also carried out by an expert organization as in the Republic of Croatia, which is a private legal entity, and which is authorized by the provincial administration in accordance with provincial legislation. In relation to the Croatian system, in which public authority is granted to the Croatian Vehicle Center (which performs technical inspections directly) and the Croatian Auto Club (which performs professional supervision), there are several expert organizations in Germany performing technical inspections (Dekra, TUV, GTU etc.). The reason is that Germany is a federal republic, which has a different administrative structure than Croatia. There are over 61 million vehicles registered in Germany, so it is simply impossible for all these vehicles to be tested by a single expert organization. Vehicle inspection stations in Germany also cannot be opened according to market criteria. The regulations do not contain detailed criteria for determining the network of stations for technical inspection, but the system is organized in such a way that each provincial administration independently determines the area where a new station can be opened. Obviously, there were different characteristics of the areas of individual provinces (population, number of vehicles, etc.), which should be considered when opening stations [5].

Regular technical inspections of passenger cars in the Republic of Ireland are also carried out by Applus + Car Testing Service Ltd., a private law body. The mentioned legal person performs the technical inspections in its 46 test sites and is the only one authorized for these tasks. The authority is granted by the public authority in charge for transport road safety, with the consent of the minister of transport and the minister of finance. Authorized legal examination centres must be within an acceptable distance (within 30 miles of 90% of vehicle owners as well as in major cities connecting or adjacent to state roads). Also, they must satisfy construction, safety and aesthetic criteria's [5].

4. ANALYSIS OF SERVICE QUALITY IN VEHICLE INSPECTION STATIONS

The analysis carried out in this paper refers to the demand for service at vehicle inspection stations in the Zagreb County area, which has ten vehicle inspection stations. The first reason for this selection is the appropriate available data, which can be analysed and se is it possible to implement the optimization of vehicle technical inspection stations in relation to the demand for the service. Another reason for choosing precisely Zagreb county is because of the highest number of registered vehicles compared to other counties [6], [7].

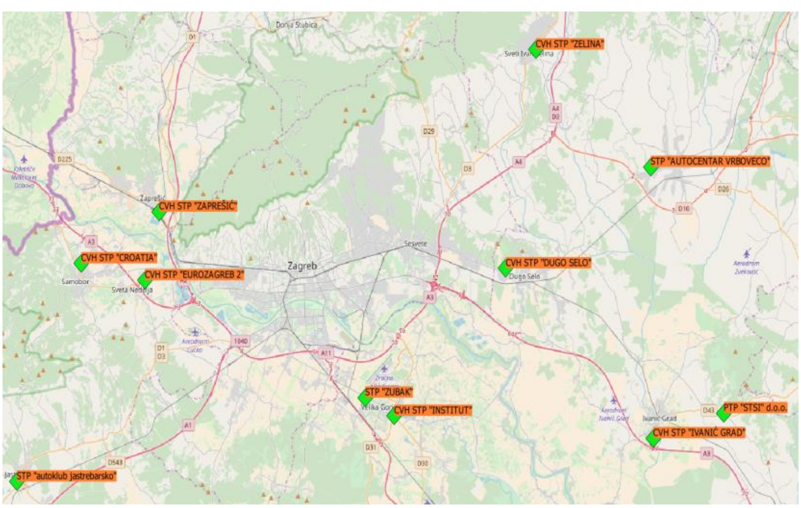


Figure 1. Locations of technical inspection stations in the Zagreb county

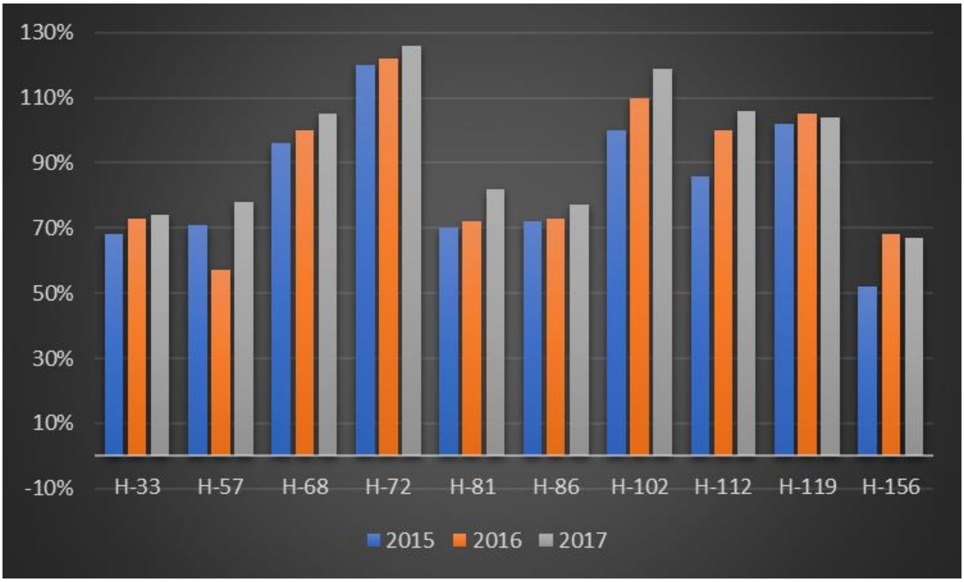
The time period covered through the analysis is 3 years (2015, 2016 and 2017). The services provided at vehicle inspection stations are: regular technical inspections, exceptional technical inspections, preventive vehicle inspections, Periodic vehicle technical inspections (PTPK), vehicle testing (approvals) and approval of vehicles [9], [10]. Table 1 shows the data from the observed stations for the technical inspection of vehicles in Zagreb county, which will be analysed. Table also show information such as the name of the station, its location, the county municipality and the type of vehicle inspection station.

Table 1. Data of vehicle technical inspection station in Zagreb county

Name of station	City of settlements	Station type	Station mark (H)
cvh stp "dugo selo"	Dugo Selo	STP	112
ptp "stsi" d.o.o.	Graberje Ivaničko	PTP+PTPK	9
cvh stp "ivanić grad"	Ivanić Grad	STP	86
stp "autoklub jastrebarsko"	Jastrebarsko	STP	81
cvh stp "croatia"	Samobor	STP	156
cvh stp "zelina"	Sveti Ivan Zelina	STP	57
cvh stp "eurozagreb 2"	Sveta Nedelja	STP	119
cvh stp "institut"	Velika Gorica	STP	33
stp "autozubak"	Velika Gorica	STP	72
stp "autocentar vrbovec"	Vrbovec	STP	68
cvh stp "zaprešić"	Zaprešić	STP	102

5. DISCUSSION

Graph 4 show data as a result of capacity utilization of the observed stations in Zagreb county over a period of three years. Of the ten vehicle inspection stations, five stations with their scope of inspection exceed 100%, which means that such stations are over their capacity. In sequence, these are stations (STP): H-68, H-72, H-102, H-112 and H-119. Of the five stations mentioned over the period of 3 years, 3 of them exceeded the capacity limit every year (H-72, H-102 and H-119). Furthermore, the largest increase in the observed period was recorded in the station H-57, in 2016 the figure was 57%, while in 2017 it was 78%, which is an increase of 21%. There are also stations that have seen a negative trend when it comes to vehicle inspection, and is H-119 station, where a slight decrease of 1% between 2016 and 2017 is noticeable, and station H -156. where a decrease of 1% was also observed.



Graph 1. Capacity utilization of vehicle technical inspection stations in Zagreb County for the period 2015 to 2017

6. CONCLUSION

Increased demand for service at vehicle inspection stations is a great challenge to find the right optimization solution. In this paper, used available and obtained data shows that the implementation of the optimization process is possible, and in some cases necessary. Further collection of relevant data is needed in order to conduct better and more accurate research. Analysis show, that five from ten observed vehicles technical inspection stations in Zagreb County were over capacity used, while the remaining five operate within the prescribed limits. The implementation of optimization is necessary above because of the laws and regulation, and to the satisfaction of all service users, and also to respond properly to the demand for the requested service.

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MICROMOBILITY REVOLUTION – CHALLENGES AND POTENTIALS

Key Words

Micromobility;
E-scooters;
Street redesign;
Legislation;
Safety

Abstract

Modern cities and their transportation systems are challenged by new mobility options – micromobility. Electric scooters as the advanced successors of the Segway have flooded the streets of modern cities precisely because of their positive features. They are easy to use, environmentally friendly, faster than traditional public transportation and more compact than a bicycle, allowing users to travel quickly and cheaply and retain complete autonomy of their movement. Regardless of whether they are private vehicles or part of an organized transport service offer, e-scooters are increasingly more important in the daily modal share in urban areas. On the one hand, this seems like a dream come true for the future of mobility, but the reality points to the potential problems that these changes are bringing and which must be addressed appropriately. The street profile has its spatial limitations and usually separates non-motorized and motorized users, and this could be disrupted by new micromobility options. Even in the cases of shared spaces, these vehicles could change the usual mobility pattern. Also, the legislation does not recognize e-scooters and we cannot legally define and protect them, nor we can assign them a place in the street profile. Special attention

must be paid to the safety issue for all traffic participants, especially for pedestrians and vulnerable categories. This paper will give a brief overview of the present situation of micromobility in urban areas worldwide and in Serbian cities. Furthermore, it will consider the possibilities and preconditions for its wider use.

1. INTRODUCTION

Rapid technological advancement and innovations lead to continuous social changes, which consequently has an impact on the development of the complete traffic system. Standard vehicles powered by fossil fuels are being replaced by electric and hybrid vehicles – more environmentally friendly and cleaner ones. Drivers do not have to operate vehicles since this is done by a computer. Due to the development of artificial intelligence, computers have made the implementation of autonomous vehicles possible. Artificial intelligence has enabled the development and testing of the V2X system for informing, warning and communication, which encompasses V2V, V2I, V2P, V2N[1] technologies. The collection and usage of data in real time, development of new transportation modes, such as drones, electric bicycles and electric scooters, represent further technological advancement, developed with the aim of sustaining urban mobility and creating intelligent and ecologically clean cities.

Bicycles, skateboards, electric bicycles and the most recent transportation mode which is the subject of this paper – electric scooters – are representatives of a relatively new concept – micromobility. Although this idea has been present since the 1960s, micromobility has been actively considered since the development of modern electric scooters – the ones that can be seen on the streets nowadays. An electric scooter represents a motorized version of the classic scooter, which is separately produced for children and adults. An adult electric scooter usually weighs up to 15 kilograms, has a 250-watt motor and a 250-watt-hour lithium-ion battery. The maximum speed of these e-scooters is up to 30 km/h, although there are some which can travel at the speed of up to 50 km/h [1].

Today, electric scooters are present in the traffic as private means of transportation and as part of the flexible public transport service offer. The largest number of these vehicles is part of the offer of different public services. However, due to their characteristics and reasonable price, they are often bought by users. This transportation mode, particularly as part of the public transport service offer, had its major expansion in 2017. This continued during 2018, when the Lime Company was founded. This company enabled renting of e-scooters in more than 100 countries worldwide [2].

Popularity of this transportation mode rose rapidly, primarily due to favourable features of e-scooters. Their efficiency is seen in the fact that they are easy to use,

[1] V2X – „vehicle to everything“, V2V - „vehicle to vehicle“, V2I – „vehicle to infrastructure“, V2P – „vehicle to pedestrian“, V2N – „vehicle to network“

environmentally friendly, faster than the traditional public transport and more compact than bicycles, thus allowing the users to travel quickly, cheaply and in a flexible manner while retaining the complete autonomy of movement. An additional advantage of this transportation mode is its availability. Namely, after using an electric scooter, users can leave it at any location around the city.

By the end of 2018, electric scooters mostly replaced bicycles and electric bicycles so there were 85 000 e-scooters in 100 cities in the USA. In the same period in the USA, 38.5 million of trips were realized by e-scooters, out of which 40% of the trips were in Los Angeles, San Diego and Austin [3]. Similarly, in all larger European cities, the offer of public renting of e-scooters has been enabled. Thus, it is estimated that Paris has approximately 20 000 e-scooters, Copenhagen about 7000, while in Cologne this number is estimated to reach 40 000 by the end of the year [4]. In Belgrade, approximately 35 000 e-scooters were sold during the period of several months in 2019 [5].

Figure 1 represents the share of individual mobility services from the moment they were enabled until 2018. This figure proves the above-mentioned fact that electric scooters had experienced the expansion in a short period of time.

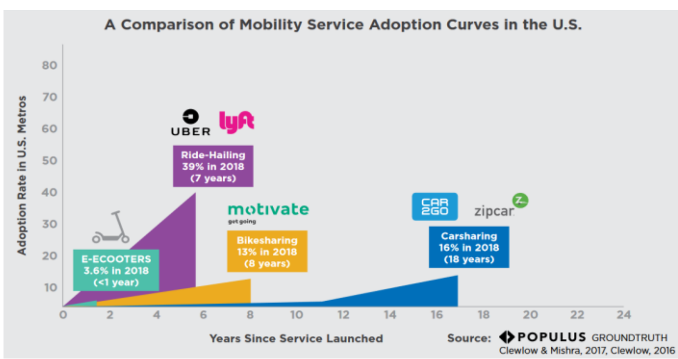

Figure 1. A comparison of mobility rates according to services

2. INFRASTRUCTURE FOR E-SCOOTERS

One of the basic preconditions for the efficient functioning of e-scooters is adequate infrastructure. Currently, this is one of the most important issues micromobility is facing. Physical limitations of the street network and road profile, different structures and characteristics of the base course and the existing separation represent the obstacle for the safe usage of e-scooters.

Traffic experts worldwide agree that streets with the surface course made of cobblestone or sheets, as well as the streets with tramway tracks, are not safe for e-scooter riding. The characteristics of these vehicles, primarily their small wheel circumference and radius, limit their use on the above-mentioned streets.

Although a large number of countries have started introducing amendments to the law in order to properly handle this transportation mode, insufficient attention is still paid to the development and modification of the existing infrastructure. In the countries and cities where the arrangement and adaptation of the space has already begun, e-scooter users are mostly redirected to the cycling infrastructure. Such examples can be found in Tel Aviv where the existing bicycle lanes are used for e-scooter riding. A similar situation can be seen in Paris, France, where bicycle lanes and paths are used by e-scooter riders. Most American cities represent good examples of the integration of e-scooters into the existing cycling infrastructure network.

In London, Great Britain, the government intends to legalize the use of e-scooters primarily in business zones, parks and campuses. The representatives of the company Voi in Sweden plan to introduce “Zones 20” where e-scooters would be allowed to move. The government in Copenhagen intends to introduce and test 200 electric scooters in the historical city centre, as well as of 3000 e-scooters in satellite zones [6].

For instance, in Texas it is allowed to ride e-scooters on sidewalks, while in Colorado sidewalks are the only places where they can be used. In California, it is strictly forbidden to ride e-scooters on sidewalks, but riding is allowed on the carriageway along the right brink of the sidewalk. In reality, the situation is considerably different, and e-scooters are frequently ridden on sidewalks in spite of the prohibition and warnings that this compromises traffic safety. A similar situation can be found in Serbia, where the use and movement of e-scooters is not regulated, so users frequently ride them on carriageways, sidewalks, bicycle paths, etc. This can be seen in Figures 2a, 2b.

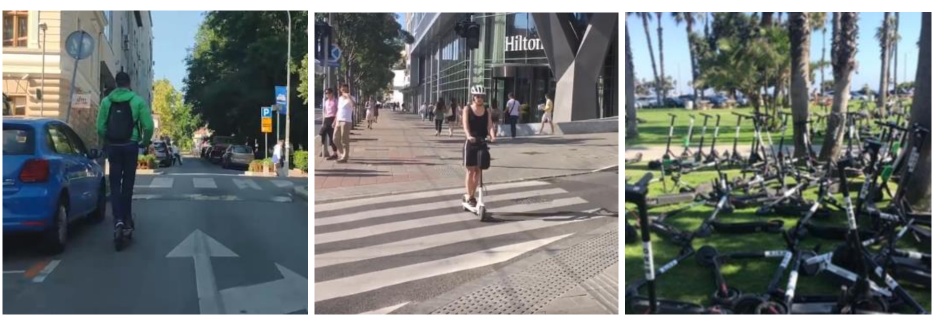

Figure 2. An example of using (a,b) and parking of e-scooters (c)

At the moment there is the issue of parking management as well as the implementation of the equipment necessary for e-scooter charging. Although most companies choose the system of parking on sidewalks, the above-mentioned possibility of leaving e-scooters at any location in the city after using them has had an effect completely opposite to the desired one. Such an example is presented in Figure 2c.

Generally speaking, there are two concepts regarding the redefinition of the space for electric scooters. The first one, based on the example of Germany and several American cities, relies on the complete separation of all user categories. The second concept is based on the idea of “naked streets” where all traffic users operate in the shared space without separation [7]. However, the current situation in cities, which face both the exponential growth of the e-scooter number in the street network and the lack of space, indicates that the solution could lie somewhere between these two mentioned concepts, and could be a result of their combination and coordination.

3. LEGISLATION

The amendments to the law of the countries where e-scooter services can be used have been induced by a large number of traffic accidents and inadequate behaviour of e-scooter users in traffic.

The existing laws could not follow the increasing popularization and development of this transportation mode. Consequently, the use of e-scooters is currently prohibited in some countries. For example, in Britain it is illegal to ride electric scooters on public roads, sidewalks and bicycle lanes and paths. In addition, an e-scooter rider has to be at least 14 years old [8]. E-scooter riders are fined with £300 and 6 penalty points on their driving licence. In theory, e-scooter riding is allowed only with a valid driving licence for mopeds, a registration plate, insurance, a homologated helmet, paid vehicle tax, etc. In practice, no driver or vehicle fulfils these predefined conditions, so the use of e-scooters is considered to be illegal except on private properties. Similarly, the use of e-scooters is technically prohibited in Denmark.

Some countries such as Germany and France have already defined or are currently classifying a new vehicle group (PLEVs – “personal light electric vehicles“ [9]. In Singapore, electric scooters are treated as PMD (“personal mobility devices“), while in Poland there is an initiative for amendments to the law in order to introduce a new vehicle category (PTD – “personal transport device“), which would allow the use of e-scooters of slower speed on sidewalks and cycling infrastructure [10].

In California, obligations, possibilities and conditions required for using e-scooters are thoroughly defined by the law. First, a driver has to possess a driving licence, i.e. a licence for operating an electric scooter. The use of cycling infrastructure (paths of class II and IV) is allowed at the maximum speed of 25 km/h. It is allowed to ride an e-scooter on the street with the 40km/h speed limit, but only if the e-scooter moves at the speed of up to 25 km/h. Also, it is allowed to use the roads with the speed limit of up to 56km/h, with the previous permission of the authorities. In this case, the speed of the e-scooter must not exceed the 25 km/h speed limit [11].

In Serbia, there are no regulations regarding the use of e-scooters. However, certain amendments to the existing Law on Road Traffic Safety have been announced. The Road Traffic Safety Agency has proclaimed the amendments to the law to start in 2020. Until then, the users are only offered experts' recommendations, which are mainly related to the use of protective helmets and careful operation of e-scooters.

4. MICROMOBILITY SAFETY

Despite their numerous advantages and possibilities, electric scooters have aroused strong public opposition. The main opponents of this transportation mode are cyclists. Namely, they are placed under a lot of pressure due to the need for sharing the infrastructure and the fact that their safety is jeopardized. Pedestrians, as the second largest group which opposes this new trend, state the same reasons. They are generally the most vulnerable category since in most countries riding e-scooters on sidewalks has not been regulated by law yet. As a consequence, traffic accidents including pedestrians are very frequent.

The data for the year of 2018 from 110 hospitals in 47 American cities show that there were approximately 1500 recorded injuries caused by the use of e-scooters. Out of the total number of casualties, eight people were killed [12].

A study conducted in Austin, Texas, for the period of three months (from September to November) found out that 271 people had been injured as a consequence of using e-scooters. A more thorough analysis showed that during the observed three-month period at each 100 000 trips by e-scooters 20 people were injured. In the total sample, 58% of the injured were the users younger than 30. Head injuries (48% of the respondents) and fractures (35%) were the most frequent. It is important to mention that in the total number of the injured, 62% were novice users, while only 4% of the users wore a helmet while riding [13].

In spite of the frequent occurrence of injuries, but due to the lack of regulations, certain companies, organizations and associations offer only recommendations related to using e-scooters. These recommendations are treated as the system of pre-legislative activities until the amendments to the law or new laws are adopted.

5. CONCLUSION

The established trends and expansion of new transportation modes within the concept of micromobility ask for the change of the previous attitudes and perceptions of the traffic system as a component of the city. The most recent representative of this concept – e-scooter – has shown that certain countries and cities are not prepared for the abrupt changes that this transportation mode brings. This is confirmed by numerous negative consequences whose number is continuously rising.

Although certain countries have started to change and improve their traffic and legal systems, this process is long-lasting and requires considerable effort in order for the first significant results to be noticed. So far, Serbia has not taken any measures in dealing with these new changes. Therefore, it will have to actively and seriously address this issue. The first and most important step in dealing with this issue is the improvement of legislation in order to form a basis for taking further actions. A good example is set by Germany, France, Singapore, Poland, etc. In their legislation, these countries have defined or classified a new vehicle category. This can be a good starting point for defining domestic laws and by-laws. The amendments to the law enable the incorporation of this new transportation mode into the existing traffic system; they offer the possibilities of arranging and constructing the required infrastructure, and sanctioning of improper behaviour of traffic users. During the process of e-scooter implementation, all users that could be affected by this transportation mode should be considered, particularly pedestrians and cyclists. The examples seen around the world offer the solution of using shared spaces or part of the infrastructure, which requires all users to make certain concessions. Therefore, the improvement of the legislation and traffic system makes the solid basis which will provide equal conditions to all participants in traffic.

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METHODOLOGY FOR THE NATIONAL HOUSEHOLD TRAVEL SURVEY IN THE REPUBLIC OF SERBIA

Key Words

NTS;
Travel characteristics;
Methodology

Abstract

The National Household Travel Survey (NHTS or NTS) provides monitoring of changes in travel characteristics, differences between categories of road users, as well as between different territories of one country. In addition, it represents a base for forecasting future traffic indicators, like traffic safety indicators and the environmental impact of traffic etc. The paper presents the methodology for NTHS in Serbia which relies on the experiences of similar surveys in developed countries, and with strong restrains introduced in local conditions. At the end, some improvements in the proposed methodology are presented, based on a pilot survey conducted in 27 (out of 174) local self-governments in Serbia.

1. INTRODUCTION

National Household Travel Survey or National Travel Survey represents a survey dealing with trip characteristics of people on public road network of a whole country. It is a whole country scale survey relying on a data collected on household level, or on the level of each individual member of the household.

The information is collected through an interview that usually contains a daily, multi-day or weekly travel log. The National Household Survey is the main source of data on the population travel characteristics. The survey contains detailed questions about the household, car ownership, as well as the trips of all household members or only members older than a certain age (usually older than 6 years).

Considering its spatial scope, this type of survey always contains questions about “long journeys” in relation to the total spatial scale of the particular country.

2. METHODOLOGY OF NTS IN SERBIA

The methodology is developed in accordance with the recommendations on NTS harmonization, i.e. harmonization of traffic indicators in Europe as a result of a project "OPTIMISM WP2: Harmonization of national travel statistics in Europe, Analysis of national travel statistics in Europe" [1] and guidelines on data collection on trip characteristics of “EU Transport Statistics, Eurostat guidelines on Passenger Mobility Statistics” [2]. Local experiences in conducting similar travel survey were also taken into account.

The methodology for planning and conducting the NTS in Serbia covered the following elements: (1) spatial coverage, (2) time span and calendar of the survey, (3) survey frequency, (4) sample size, (5) survey method, (6) questionnaires and survey forms, (7) research testing – pilot survey, (8) required number of interviewers, (9) selection, training and control of interviewers, (10) data collection using the selected method, (11) control and encryption of collected data, (12) data processing and (13) data analysis. The focus of this paper will be on the spatial and temporal domain, sample size, survey method, pilot survey and main conclusions after conducted pilot survey.

2.1. Spatial, temporal and survey frequency domain

The survey will be conducted in local self-governments in Serbia, taking into account the number of residents in urban and suburban areas (urban and rural). Methodologically, depending on the size of the sample, a research minimum will be established for each local self-government, since indicators derived for the whole of Serbia should also include differences at the local level.

The survey will be conducted in April, May, September and October, which are relevant periods for conducting traffic research. In the first survey (test or pilot survey), the periods of summer and winter holidays and vacations will be avoided. Respondents will be asked about their trips on an average working day (Tuesday/Wednesday/Thursday). As the data will serve to express indicators on an annual basis, the data on trips for the previous weekend (only one day - Sunday) and data on long trips and vacation periods will also be collected.

These information allow determining travel patterns during the week. The proposed approach avoids a seven-day survey, which would fall harder on the respondents, resulting in a greater likelihood of achieving the required sample. Research activities in other periods are planned in the future in order to define differences and irregularities over the period when standard travel patterns are recorded. These surveys would be done on specific households, which will be predefined and their consent secured for further research.

Survey frequency varies in the countries of the European Union. Only four EU countries collect travel data annually, while in some countries surveys are conducted every ten, six or five years, while in some countries it is not regular.

2.2. Sample size

In the countries of the EU, households are the most common observation unit in NTS and stratified random sample is the most commonly used sampling method [2]. Key feature for the classification of households in this methodology will be a geographical distribution (by local self-governments) and household size (number of members). In each household layer (stratum), households will be randomly selected. The number of households included in the survey follows the distribution of the households in the latest available statistical Census data. The economic activity of the population will be used to expand the collected data to the entire population in local self-government.

The recommendations for stratification of the Eurostat [2], mainly relate to geographical distribution, gender and age groups. In this case, the number of household members and economic activity were chosen, since the number of members is related to the number of trips at the household level and the economic activity of the inhabitants is related to travel characteristics and also the number of trips. It is certain that these data will be available in the coming years through the official reports of the Republic Bureau of Statistics. Spatial stratification will ensure that the sample is distributed into all parts or districts of the country. Consequently, the major cities of the district, as well as smaller urban and rural areas will be included in the sample, thus avoiding concentration of the sample in the largest cities.

Since this is the first National Household Travel Survey, the required sample size would be determined according to foreign experience. Countries with a smaller population (up to 10 million) conducted survey on a larger sample. The average sample size was 0.16% of the population size.

The target sample size in the first National Household Survey in Serbia was set at 0.1% of the population/households. The methodology implies that at least 10 households should be interviewed, even in the cases of small self-governments. In addition, the methodology implies that at least one household belonging to each household stratum should be interviewed, which increases the target sample to 0.12% of households in Serbia.

Recommendations given by the Eurostat on the harmonization of data suggest providing indicators by age groups, covering respondents from 15 to 84 years. In some countries, only one or two household members are included in the survey, but in accordance with research practices in Serbia, all household members will be included and only ones older than 6 interviewed.

2.3. Survey method

Telephone interviewing is nowadays the most commonly used research method relying on Computer Assisted Telephone Interview (CATI). It is also common for households/respondents to be contacted by mail explaining the purpose of the survey. A computer-assisted telephone survey has many advantages over other research methods (like direct face-to-face interview, direct computer-assisted interview CAPI, CAWI online survey): research costs are lower, interviewers are trained to clarify the questions to respondents and quickly enter the answers received, the highest response rates for residents over 60 years of age are recorded in this type of survey, easier and cheaper data collection in remote areas of the country. The main disadvantages of this method are: the duration of the interview (not recommended longer than 15 minutes and the best is about 10 minutes) and the potential lack of the phone number data base [2,3].

Experience has shown that the response rate for the computer-assisted telephone interview method is less than or equal to 60%. Higher response rates (of about 80%) are recorded in a face-to-face interview, but this method is twice as expensive [3].

So, the chosen method is a telephone survey. Telephone survey is supposed to be combined with a direct interview or internet survey, in case of sample shortage.

Table1. Proposed survey phases

Phase 1	Households will be recruited by phone and instructed to memorize future trips (next day trips) for all household members. On this occasion, the interviewer records the general household data and data on individual members in order to keep track on the proposed sample size. Additionally, it is possible to reduce the duration of the next telephone call when travel diary data should be collected.
Phase 2	Second call after two days to record data on travel characteristics of household members and possible consent to participate in the future survey activities. Based on suggestions given in the Phase 1 (where household members record their trips during the day) one household member could be able to answer for all household members.
Phase 3	Repeated call to those who did not answer the first time.
Phase 4	Household members who have accepted to be contacted again are examined for differences in other survey periods (months of the year).
Phase 5	Additional interviews to be conducted if there is a need to achieve the designed stratified sample.

The households willing to be included in subsequent surveys (travel characteristics for other periods of the year in order to determine seasonal variability), could be awarded with modest reimbursement. Experience shows that repeated cross-sectional household surveys are most commonly used for repeated surveys, with the use of a permanent, longitudinal panel and a rotating panel [4].

A team of permanent interviewers could be created, preferably from the local area of survey. Hiring local researchers can have a positive impact on the quality of research [5]. Such selection should improve the reliability of the data obtained and ensure easier organization of research in the future.

2.4. Pilot survey and results

Pilot research was conducted in order to test defined survey forms, improve the interview process, as well as all other research elements. Pilot survey helps interviewers refine their communication skills with interviewees. It is far smaller in the extent than the comprehensive household survey, and serves to identify any shortcomings in the survey process. The recommendations indicate not less than 30 households as a sample in a pilot survey, while 100 to 200 households are considered sufficient [6]. Pilot research also serves to check the estimated degree of response to a survey in order to increase the reliability of sample completion [5].

Pilot survey enables improvement of the main survey on several levels [7]:

- revision of the questionnaire - formulation and order of questions,
- improvement of interviewer procedures,
- identifying possible unexpected reactions and behavior of the respondents,
- an estimate of the time required to conduct an individual survey and
- correcting preliminary estimates of the final sample size.

Pilot survey was conducted in 27 local self-governments in Serbia with a sample not less than 0.1% per local self-government. The entire territory of Serbia is divided into 27 police departments. One local government was selected as the representative of each police department. In this way, the geographical coverage of the whole country was also complied in the pilot survey. Travel characteristics were collected for one standard weekday, for Sunday and for long-distance trips (longer than 50 kilometers). Control and encryption process was performed, all elements of the questionnaire have been checked in the sense of missing data and the logics of the set of trip purposes, modes and travel times.

Based on the collected travel data, standard processing is performed to generate the travel characteristics on a standard workday (mileage and travel times related to modal distribution are in focus). The same processing is performed on the weekend (Sunday). Based on the previous data, the movement characteristics for the second day of the weekend (Saturday) are estimated. In this way, the travel characteristics for a one-week period are estimated. Data on long trips and vacation periods are also processed.

The data collected on the sample were expanded to the level of the local self-government based on the economic activity of the population and the number of registered motor vehicles. Estimates of average annual travel characteristics were generated by assessing seven-day travel behavior and long journeys. The basic parameter for the calibration of the estimated values was the reported value of annual mileage by passenger car.

3. DISCUSSION AND CONCLUSIONS

The NHTS is the only survey that provides monitoring of changes in travel characteristics, differences between categories of road users, as well as between different territories of one country. It represents a base for forecasting future traffic indicators, like traffic safety indicators and the environmental impact of traffic etc. At the same time it is very important data source for transport planning process.

Implementation of NTS in Serbia is of great importance, but it should be noted that survey activities at national level with the focus on local self-governments needs significant funds. Given the cost and scope of the survey it is proposed to be conducted every three years.

The questionnaire (mainly relying on a classic household interview) could be revised in a few details, mainly related to long trips, for easier reconstruction of annual behavior. The wording and layout of the household survey questions proved to be appropriate.

Improving interviewer workflows: the recommendation is to create a team of permanent interviewers, preferably residents of the research area. Such selection should improve the reliability of the obtained data and should ensure easier organization of the survey in the future.

The estimated time needed to complete the interview proved to be useful and justified. It was shown that informing the respondents about the purpose and scope of the survey significantly contributed to the quality of the data.

Households' interest in participating in future surveys is very low. Pilot research has shown that some reimbursement or rewards for participation should be introduced. It would be useful to conduct the survey in the shape of panel (repeated) survey so that changes in the travel behavior over time can be identified.

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PUBLIC FIGHT VS AIR POLLUTION: IS THE MONITORING SYSTEM A FIRST STEP FOR AIR QUALITY MANAGEMENT IN THE TOWN OF BITOLA

Key Words

Monitoring;
Air quality;
Bitola town

Abstract

Air quality remains one of the most pressing problems in urban areas. Providing information about air pollution and finding out its spatial distribution through monitoring network is a crucial starting point in the planning process of measures for air quality control and improvement. Hence, monitoring is an indispensable component of air quality management and its first activity. But, despite the significant deterioration of air quality in the town of Bitola, there is a lack of monitoring network and systematic measurements. Considering the importance of monitoring and its absence in the town of Bitola, this analysis gives an overview of the current air pollution problem and public initiative and determination for changes. Most importantly, elaborated recommendations for introduction of monitoring network in the town are presented.

1. INTRODUCTION

Air pollution is one of the most important environmental concerns, particularly in urban areas. To protect humans and the environment from damage by air pollution, it is of the utmost importance to measure the levels of air pollutants [1].

Air quality monitoring provides the basic information for air pollution levels, and appoints the polluters of bigger concern. The continuous monitoring is necessary for dealing with air quality problems, in wider extent and higher certainty [2].
For effective approach to air pollution management, it is of particular importance to diagnose the pollution problem of urban air, to assess the impacts from pollution sources and to identify available and sustainable solutions [2]. The first step always is determining the seriousness and nature of air pollution problem. This can be perform by air quality monitoring network, which unfortunately, for the town of Bitola is missing.
Having in mind the significance of air quality management for air pollution control and reduction, and the lack of monitoring as a starting point to handle air pollution problem in the town of Bitola, public revolt and displeasure is understandable and justifiable. As well as public insistence not to reconcile with the unacceptable air quality situation, this paper is trying through analysis of the current inconsistencies in air quality maintenance, to tackle the problem in its core and to indicate a way out. As already mention, monitoring data have potential to optimize air quality management. Hence, recommendations for creation and placement of monitoring network as a starting activity for building of system for air quality management are elaborated.

2. THE AIR POLLUTION PROBLEM IN BITOLA TOWN

2.1. Main air polluters

As in most of other urban areas, air pollution in Bitola town is caused by industry and urban transport as main air polluters.
Industrial polluters are represented by the biggest thermo-plant in Macedonia for production of electricity, located near the town (10 km distance). It produces almost 80% of the electricity needed for the country, using high quantities of coal as a single energy source. In comparison with pollution amounts from this plant, other much smaller and not very numerous industrial factories in Bitola, mainly using oil, have insignificant contribution to air pollution [4].
The economic situation in the town of Bitola and in the country in general defines the average age of the urban vehicle fleet. Therefore, the biggest part of the vehicles - around 47% (approximately 10.000 vehicles) are older, ranging from 14-20 years and above 20 years [5]. Being frequently used on everyday level, these vehicles realize significant part of passenger kilometers in the town with higher exhaust emissions at the same time.
Households could be counted as a significant pollution source in winter, considering that town doesn’t have central heating. Usually, their first choice for heating are cheaper energy sources, such as wood or coal. Unfortunately, aren’t any statistical data for this.
Nevertheless, all these facts clearly highlight the seriousness of the actual air pollution problem in the Bitola town.

2.2. Current monitoring situation

In practice, placement of the monitoring network in a wider urban area most often is very expensive and with high working and maintenance cost [2]. Not all cities have monitoring network that covers the whole area and/or mobile monitoring equipment.
Bitola is such a town without monitoring network. There are only two monitoring stations: Bitola 1 is located in the town's periphery, at 13 km distance from the previously mentioned plant; Bitola 2 is in the town's centre, in public organization's courtyard. Bitola 2 is very often out of order. Both stations measure: O_3, NO_2, SO_2, CO и PM_{10}. The stations aren't mutually connected. Results from Bitola 1 are used in the reports of Ministry of environment, health organizations, NGO and others.

Figure 1. Monitoring station Bitola 1 [6]

Figure 2. Monitoring station Bitola 2 [6]

The usual obstacles for systematic monitoring of the pollutants, especially of the particles (PM_{10} и $PM_{2,5}$), and for the network creation are working/maintenance cost and cost for repair of the instruments, as well as the shortage of qualified personnel.
Without monitoring network to cover the whole urban centre and surrounding residential and rural areas, it is obscure to have real-time information for the level of air pollution. Moreover, no modeling of industrial, transport and household pollution is undertaken to predict future pollutants concentrations or risks from air pollution.

2.3. Results of the monitoring measurements

According to the Annual report of environmental quality data (the latest one for 2018), measurement of particles (which are the biggest problems for air quality) at Bitola 1and Bitola 2 continuously exceed air quality standards for PM_{10} [4].
According to the report, the average annual concentration at both stations is around 50 mg/m^3, with annual limit value being 40 mg/m^3. The problem is additionally emphasized by the following: if permitted excedance is 50 days/year, two stations shows up to 92 days/year with excedances of daily limit value [4].

For PM_2 the situation is similarly serious: the annual average concentrations at Bitola 2 are above the maximal level of 26 mg/m^3, being around 33 mg/m^3 [4]. At this station it should be considered that for measured amounts of particles, apart of industry, the main contributors are urban transport and households.
Other pollutants measured are in the limited values and don't represent problem for air quality [4].
Hence, the revolt from the public is clear and justified – on the basis on data from two monitoring station it can be concluded that the pollution in the town has deteriorated air quality. Therefore, the public is determined in its quest for starting point as a way out of this non-qualitative life.

2.4. Public reactions

In those urban areas where monitoring network is established, the link between data from monitoring sensors and end-users should function as shown in Figure 3. But, in the town of Bitola, this link is missing. This has been an initial trigger for public revolt and protests.

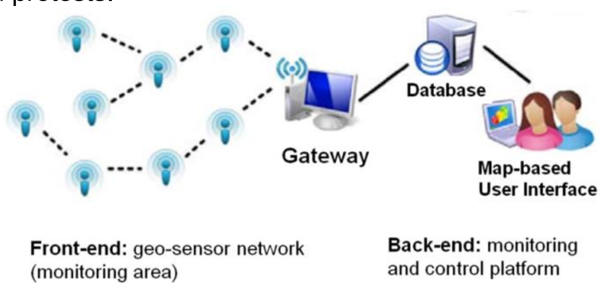

Figure 3. Monitoring network in function [7]

Air pollution problem, especially intensive during the winter (Bitola often has temperature inversions, which last for couple of weeks), often not publicly and explicitly reported, has initiated displeasure of public. Their rage towards inactivity of authorities to deal with air pollution problem was manifested through several protests (held on 04.11.2014 and 13.12.2014).
The paroles of the protests were deeply significant: "We want to breed", "Take off the gas-masks", "Air is a life, air is a right", "Bitola on gills" (Figure 4). Several demands had been delivered from NGO "It's all about us" to local authorities: urgent placement of monitoring system in central area of the town; air pollution reduction and system of penalties for biggest air polluters; maintenance of air quality according to permissible limits.
So far, public reaction achieved no progress in their quest and situation is unchanged. Therefore, public protests are not longer at the streets, but are transformed into campaigns for public awareness, without wide media cover and support. Unfortunately, still without any visible results from local authorities to start with any kind of activity.

Figure 4. The atmosphere of the public protests [social media]

3. THE RELEVANCE OF MONITORING IN THE SYSTEM FOR AIR QUALITY MANAGEMENT

Air Quality Management System (AQMS) is directed towards designing and implementing control strategies, assessing their results, determining the consequences for air quality and measuring progress [8]. AQMS includes a number of closely related tasks that can be grouped into monitoring, modeling and data presentation using GIS, together with related reporting and public information. Hence, it enables the user not only to present and evaluate the current situation, but also to undertake environmental planning for sustainable future (Figure 5).

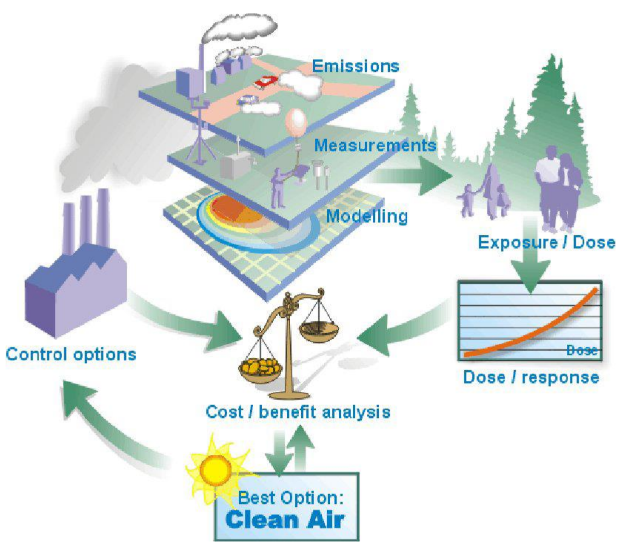

Figure 5. Elements of an optimal abatement strategy planning system [9]

In the frame of AQMS monitoring should be integrated with air quality modeling and GIS. All these features are designed to address difficult analytical problems with large volumes of data, and at the same time provide a convenient and easy to use user interface [3].

In AQMS, monitoring is the first operation. Continuous monitoring data have many uses throughout the process of air quality management, such as [8]:

- determining compliance with air quality standards;
- characterizing air quality and trends;
- estimating health risks and ecosystem impacts;
- developing and evaluating emission control strategies;
- evaluating source-receptor relationships;
- providing data for input to run and evaluate models; and
- measuring overall progress of air pollution control strategies.

The data also form the basis for air quality forecasting and other public air quality reports. Hence, monitoring is needed to keep authorities, major polluters and the public informed on the short- and long-term changes in air quality, thereby to help in raising awareness [8].

At present, AQMS are applied in many cities in the world, considering them as an opportunity for improvement of air quality planning.

4. RECOMMENDATIONS FOR BUILDING OF MONITORING NETWORK

Monitoring air for pollutants is a complex technical task, requiring not only direct measurement, but also measurement standards and quality assurance to ensure that the information provides a correct understanding.

The key recommendations for Bitola town are [8]:

- New urban monitoring network need to be built on the current monitoring stations, but also to incorporate new directions in monitoring and to begin filling measurement and technological gaps that have accumulated over the years.
- Monitoring network need to produce high quality data by:
  - including a higher number of multipollutant monitoring sites in urban, but also in surrounding rural areas; monitoring sites should comprise stationary and mobile stations, with an option to work either independently or in direct connection with a central station through wireless technology [1];
  - expanding use of advanced, continuously operating instruments and new information transfer technologies;
  - supporting advanced research level stations.
- The importance of rural background monitoring for evaluating long range transport, cross-border concerns and long-term trends needs to be recognized [8].
- A new urban monitoring network design should provide:
  - data presentation through contour maps for air quality [2];
  - trend determinations and seasonal variations;

- comparison with air quality standards;
- reporting to the public;
- assessment of the effectiveness of emission reduction strategies;
- assessment of source-receptor relationships;
- health assessments data;
- verification of the modeling results and assessment of the deviations.

- Periodic assessments of monitoring network must be performed to determine if the existing network structure is optimally meeting national and local objectives referring station representativeness and monitoring accuracy.
- The network modifications should be conducted within current resource allocations used to support monitoring (e.g., with respect to staffing). However, modest investments in new equipment are needed to upgrade monitoring systems in order to meet new priorities and accommodate advanced technologies.
- Public opinions and suggestions should be engaged in the network changes.
- Finally, for air quality monitoring is especially important to be regularly performed and institutionalized [2].

Reliability of monitoring is crucial. The real monitoring must be well documented. Today, low- as well as high-technological monitoring methods are available, with their own advantages and disadvantages. Regardless of the choice, the technology must be appropriate in a sense of resource availability and maintenance [2].

5. CONCLUSION

Air pollution becomes a problem when ambient concentrations of harmful pollutants are increased and exposure is high. Episodes with high concentration levels of harmful pollutants have negative impacts on the health and environment. In order to minimize the effects from these episodes, it is necessary to be followed.

Monitoring is a first step in building a system for air quality management. Developing focused monitoring network will contribute for prioritization and clarification of the air pollution problem and latter for assessment of the improvements considering chosen and implemented strategies.

Monitoring is essential to assessing the effectiveness of air pollution control strategies and to keep authorities, major polluters and the public informed on the short- and long-term changes in air quality, thereby helping to raise awareness.

Having these important roles for air quality management, monitoring should be established in the Bitola town, in order to start dealing with the current air pollution problem. It is clear that the air pollution problem is real and serious and cannot be neglected. Expressed public revolt through years for unacceptability of air pollution problems has been an initial trigger that has a potential to make a difference. Hence, this paper emphasizes the significance of monitoring network and gives recommendations for its introduction.

In brief, with a focus on minimal maintenance and low cost of ownership, air quality monitoring network should be reliable, easy to use in the field for both long-term and short-term deployments, and to features research-level accuracy. Experience of the towns, long-term commitments, long-term financing and training are key factors for establishing successful monitoring network [2].

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IMPROVEMENT OF PARKING CONDITION ON THE TAXI STANDS IN THE CITY OF NOVI SAD – CASE STUDY

Key Words

Taxi stand; Parking characteristics; Vehicle detection technology; Case study

Abstract

Characteristics of a quality taxi transport are efficiency, being economical and functional, which are provided by, among others, an adequate distribution and capacity of taxi stands in accordance with the needs of the passengers. The lack of parking space at a taxi stand affects the occurrence of additionally covered distance and unprofitable use of working hours which taxi drivers spend cruising, trying to find another vacant parking lot. Within this paper, the methodology of the taxi stand assessment from this point of view has been described, and the analysis of the cost effectiveness of the introduction of contemporary vehicle detection technology at the taxi stands as a measure for the reduction of the consequences of lack of parking capacity.

1. INTRODUCTION

Parking problems in urban environments are one of the main problems of contemporary society. The research studies show that drivers spend a lot of their time trying to find vacant parking lots. Previous research studies have shown that drivers waste between 3.5 and 14.0 min to find a parking lot in congested centres, therefore between 8 and 74% of vehicles in the flow cruise trying to find a vacant parking lot [1]. During last two decades different ITS systems have been implemented in the field of parking in the form of different devices, applications and software packages which would increase the level of service and reduce the cruising time spent in an attempt to find a vacant parking lot. ITS systems in the field of parking serve to give the drivers all necessary information on the available parking places. Traditional systems of traffic management towards parking lots connect detectors at the entrances and exits of the parking with the signs with changeable contents, while lately applications on mobile devices have been more and more used enabling an immediate insight into available parking places.

Apart from passenger cars, in many cities there is a lack of parking places for the vehicles of commercial or public transport. Taxi vehicles spend a significant part of their working hours in the state of inaction at parking places. In order to have an efficient, economical and functional taxi transportation, it is necessary to provide the distribution of taxi stands in accordance with the needs of passengers and enough parking lots at the taxi stands. In the situation when there is not enough parking space at the taxi stands, taxi drivers are forced to find another vacant parking, to stop the vehicle temporarily on the roadway, making a traffic offence or to park their vehicle on parking places intended for citizens or other surfaces, which is also not allowed.

Within this paper there is a short methodology of analysis of the taxi system in the city of Novi Sad from the aspect of possibility of finding a vacant place at taxi stands and defining the cost incurred in the system due to the impossibility to find a vacant parking place and from the aspect of the assessment. Subject analysis is a part of case study [2] whose aim was determining the possibility and the needs for the introduction of new technologies and benefits which would be achieved with the introduction of contemporary systems for vehicle detection at taxi stands, users informing and the control of system functioning.

2. GENERAL PARKING CHARACTERISTICS ON THE TAXI STANDS IN THE CITY OF NOVI SAD

In the city of Novi Sad there are totally 39 locations with 393 taxi stands [3]. Efficient and quality taxi transportation, apart from efficient inner organization and communication among the members of the association, demands a regular and equal distribution of parking places within the city. A good organization and spatial distribution of parking places enable the reduction of the taxi vehicle driving time to the beginning of the realization of transportation service, the increase of efficiency and reduction of costs of zero rides. The city of Novi Sad has a relatively well developed taxi transportation and spatial distribution of parking places on the level of the city. However, it is noticeable that at certain locations, in certain periods of the day, the demands for taxi vehicles parking exceed the capacities of the predicted parking places. Due to this, taxi vehicles are stopped or parked on the roadway, as well as on regular parking places, and very often drivers give up from parking and move to another location. On the other hand, some parking places for taxi vehicles are in certain periods insufficiently used, therefore, there is an excess capacity.

Characteristics of parking at taxi stands have been determined through 24-hour counting of vehicles at the taxi stand. After the conducted counting, a set of data on characteristics of vehicles arrivals and departures from the taxi stand was formed, which was the basis for further determined basic characteristics of parking (turn, delay time, accumulation, etc.). Apart from this, a classification of vehicles has been done for the vehicles which use the taxi stand into: taxi vehicles (TX), private automobiles (PA) and delivery vehicles (DST). During the period of 24 hours at the taxi stands on the territory of the city of Novi Sad, 11,364 arrivals/ departures of taxi vehicles have been recorded.

Simultaneously with the vehicles counting at taxi stands, the survey of taxi drivers was also conducted. During the period of the survey, 2,363 questionnaires were collected. The survey at each location determined whether it was the first stand for the driver after the last passenger they drove, and if it was not, to state at which stand he tried to stop but did not find the vacant place. On the basis of this data, the travel time was determined, as well as the distance covered as a consequence of the lack of parking place at certain taxi stands and the percentage of the unmet demands for parking. After that, drivers were asked to assess the possibility of finding a vacant parking lot at the arrival at a taxi stand in the part of the day when they were surveyed, and to state which taxi stands in the city are the most difficult for finding a vacant parking lot. On the basis of the last two questions there was a ranking of the stands by the possibility of finding a vacant place and the average probability of finding a vacant place for each analyzed stand.

2.1. Assessment of the current state

The assessment of the current state of parking is based on the results of parking characteristics, taxi drivers survey and specific characteristics of taxi stands on the territory of the city of Novi Sad. The assessment of the taxi stand capacity and position was conducted on the basis of the following parameters:

- Real capacity of the taxi stand achieved by dimension measuring on the field;
- Maximal values of average hour accumulation of taxi vehicles;
- Maximal values of average hour accumulation of all vehicles which use the analyzed stand;
- Percentage of taxi vehicles which stop outside the stand;

- Participation of all vehicles (private cars and delivery vehicles) in the structure of all vehicles which use the stand.

For the assessment of the stand capacity and position, a multicriteria assessment has been defined for evaluation according to which the current capacity and position of the stand are considered to be acceptable if the following conditions have been fulfilled:

Criterion 1a. Maximum values of average hour accumulation of taxi vehicles does not exceed 85.0 % of values of the stand capacity

Criterion 2a. Maximum values of average hour accumulation of all vehicles does not exceed 85.0 % of values of the stand capacity

Criterion 3a. Percentage of taxi vehicles which stop outside the stand is lower than 50.0 %.

Criterion 4a. Other vehicles in total number of arrivals participate with less than10.0%.

If the first criterion has not been fulfilled, it is considered that the capacity of the taxi stand is not appropriate and it is necessary to conduct certain technical and regulative measures which means the introduction of the system for determining free places at taxi stands, parking space reorganization of space for parking or the change of number of places for parking in accordance with specific characteristics of the location. Also, at certain number of taxi stands due to a high turnover of vehicles, there are sudden changes of accumulation which exceed the stand capacity although the maximum value of an hour capacity meets the first criterion, therefore these locations are considered as potential for the introduction of certain technical and regulative measures. If the second criterion has not been fulfilled, it is considered that the stand capacity is reduced due to the occurrence of the other vehicles at the taxi stand. If the third or the fourth criterion have not been fulfilled, it is considered that the taxi stand position is not acceptable, that is, taxi vehicles do not use the taxi stand enough. In case when only the fourth criterion has not been fulfilled, (and the third has been fulfilled) the was of using taxi stand is not acceptable and it is necessary to conduct control measures and prevention of parking by the vehicles which do not provide the service of taxi transportation. Based on this analysis, certain taxi stands have been determined as stands with a problem related to parking conditions.

2.2. Assessment of possibility of finding a vacant parking place at taxi stands

On the basis of the counting results and the survey with the taxi drivers, the assessment of possibility of finding a vacant parking lot at taxi stands on the territory of the city of Novi Sad was conducted. The basic goal of this part of analysis was to separate those stands which by their basic parking characteristics of possibility of finding a vacant parking lot represent a priority for the introduction of vacant parking lot detection system. The assessment of this state, that is, the need for the introduction a detection system and control at taxi stands was conducted by the following criteria:

Criterion 1b. The relation between maximal hour accumulation of taxi vehicles in the day and maximal available number of places at the taxi stand. Criterion 1 has been met if the value of the stand usage is higher than 85.0 %.

Criterion 2b. The percentage of the unmet demands for the parking at the stand incurred due to the lack of vacant parking lots.

Criterion 3b. The average value of hour probability of finding a vacant parking lot based on the subjective assessment of the interviewed taxi drivers in the survey. Criterion 3 is fulfilled by the taxi stands where the average probability of finding a vacant parking lot is lower than 0.80.

Criterion 4b. Frequency of reporting a stand as a problematic one from the aspect of finding a vacant place has been determined on the basis of subjective assessment of the interviewed taxi drivers in the survey.

Taking into consideration the results of the previous analysis, the priority stands are the ones which meet the conditions by at least two out of four possible criteria. By applying the above mentioned criteria, 11 taxi stands on the territory of the city of Novi Sad stand out as unfavourable regarding the possibility of finding a vacant parking lot at the taxi stand. Analysis determined that taxi vehicles which due to the lack of vacant parking lot at these stands during the day totally cover additional 1,060 kilometres trying to find a vacant parking lot at other stand. In order to find a parking place on other taxi stands, these vehicles during the day totally waste 56.4 working hours.

3. PROPOSAL OF VEHICLE DETECTION TECHNOLOGY AT TAXI STANDS AND EVALUATION OF THE EFFECTS OF THE SYSTEM APPLICATION

Analysis of different technical solutions of the vehicle detection technology at parking spaces and information transmission, analysis of the examples of experiences from the world and taking into consideration the purpose and needs of taxi service and characteristics of the taxi stand location, were taken into account when proposing a system which is to have the following operational and technical characteristics:

- Clear and precise detection of macrolocation - parking space and micro-location - vacant parking lot;
- Without ambient, electronic, time and other interference in the detection procedure;
- Cheap system maintenance and fast replacement of damaged detectors (vandalism, incidents, etc.), without any work interference with other subsystems;

- Forming a unique data base for each parking space and complete system;
- Software part for system functioning tracking – “panel“;
- Software part intended for system users – mobile application.

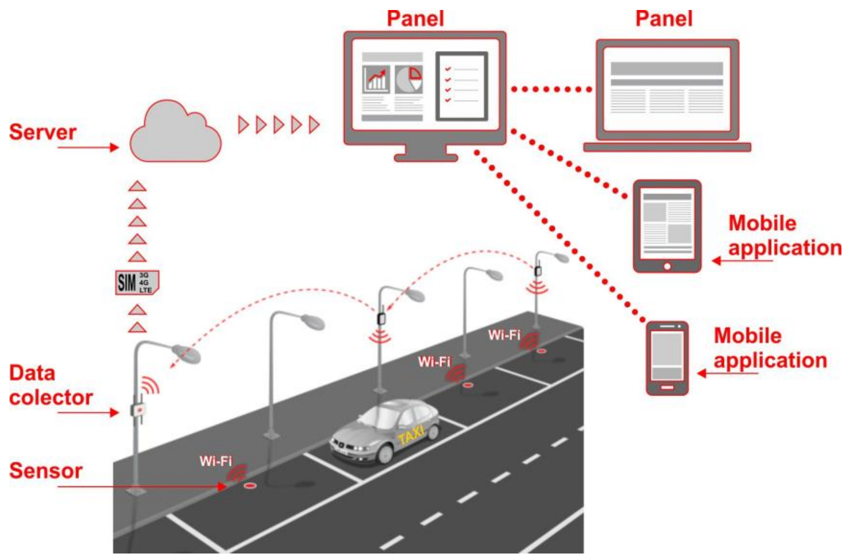

Figure 1. Schematic display of one complete system functioning for vacant places determining, based on experiences from the world [2]

3.1. Evaluation of the effects of the application of detection and parking control system introduction

Analysis of investment cost effectiveness has been conducted in accordance with the determined values of distance prolongation due to parking occupancy, that is, savings of fuel cost and travel time, alongside the benefits which would be achieved through the reduction of emission of gases which cause the effects of green glass, first of all CO_2. On the basis of the data which are the result of the conducted research,pessimistic, realistic and optimistic variants of system using were considered. Due to the fact that all taxi drivers for objective reasons will not be able or will not want to use the information achieved from the proposed system for the reduction of travel distance and time, a realistic variant means that in 70% of rides, drivers will use the obtained information and reduce the unnecessary ride length. A pessimistic variant means that only 60% of taxi drivers will use the information, and the optimistic variant is that 80% of drivers will completely use the possibility of the proposed system and reduce the ride length.

Taking into consideration the market state, the estimated investment costs in the first year would have the structure displayed in the following table.

Table 1. Investment costs in the first year

Investment	Amount
Investment (equipment delivery and installation)	90,000 EUR
System maintenance costs	6,500 EUR
Operational costs	1,200 EUR
Electricity costs	800 EUR

Taking into consideration investment costs, maintenance and business costs, and the savings which can be achieved through the application of the detection and control technology at taxi stands, discount values of costs, income and internal profitability rate for the period of 5 years according to these analyzed variants have been shown in the following table.

Table 2. Business operations for the analyzed variants

Discounted costs/revenues	Pessimistic variant	Realistic variant	Optimistic variant
Management and maintenance costs	38,548 EUR	38,548 EUR	38,548 EUR
Total savings in fuel, travel time and reduced emission of harmful gases	208,181 EUR	242,878 EUR	277,574 EUR
Internal profitability rate	22.1 %	32.9 %	43.1 %

4. CONCLUSION

This paper concisely shows the analysis methodology of the state of taxi transportation in Novi Sad from the viewpoint of parking. The research covers 39 locations of regular parking spaces for taxi vehicles on the territory of the city. For the needs of determining critical taxi stands, the criteria were defined for separating 11 key taxi stands on the territory of the city of Novi Sad. In the research it was determined that due to impossibility of finding a vacant place at certain taxi stands, taxi vehicles cover additional 1,060 kilometres trying to find a vacant parking lot at another stand, that is, they totally all spend additional 56.4 working hours during a work day.

After the performed analyses, system characteristics have been defined, whose aim was to reduce the lack of vacant parking lots at taxi stands and improve the efficiency of parking at the researched locations. Taking into consideration real economic parametres and savings which would incur due to the reduction of fuel consumption, travel time and emission of harmful gases, as well as investment into the system, system operational and maintenance costs and electricity, an evaluation has been performed, that is, a cost and benefits analysis. In analysis, virtually the most unfavourable scenarios were considered. Three parallel analyses were conducted - for realistic, pessimistic and optimistic variant. The analyses showed that the internal profitability rate for the pessimistic variant is 22.1 %, optimistic 32.9 %, and for realistic 43.1 %. Based on this data, it can be concluded that it would be justifiable to introduce this system at the defined 11 taxi stands.

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7th INTERNATIONAL CONFERENCE
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OPPORTUNITIES OF INTELLIGENT TRANSPORTATION SYSTEMS FOR PUBLIC TRANSPORTATION

Key Words

Public transportation;
ITS;
Big data

Abstract

Cities that have yet to implement intelligent transportation system give us great opportunity to analyze current state of public transportation and measure how well public transportation companies in those cities are fulfilling demands. Many companies involved in public transportation around the world are relying on outdated forms of data collection from their users. Lack of proper data causes those companies to operate in sub-optimal way organizationally, financially and operationally. Team behind Bus Routes software platform took Novi Sad as example of a city without implemented ITS for analysis. It turns out that 82.4% of survey participants experience some kind of incident with public transportation daily. Those incidents range from being late to important event, not knowing when bus is going to arrive or experience missing scheduled bus journeys. This paper provides suggestions on how most valuable data from users of public transportation can be acquired which presents great opportunities for all companies involved in public transportation worldwide to serve people in a better way by analyzing it and providing better service while lowering expenses.

1. INTRODUCTION

The way that public transportation companies are creating their timetables, driving schedules and projections of customer behavior is mostly based on trends in tickets sales and surveys. Most of the time surveys are conducted over few weeks in different parts of the city.

Usually questions are structured in such a way so that participants in public transportation give answer about when they require transportation during the day. Examples of questions in these kinds of surveys are: “When do you usually leave for work”, “When do you usually make a return trip” and “How do you travel to initial station where you wait for public transport” [1].

There are variety of models of surveys that use different forms, questions and sampling techniques [2].

The idea behind survey is to provide random sample of real users of public transportation and based data gathered help traffic planner predict and anticipate the volume and demand for public transportation.

While these surveys themselves are good and give some insight into needs of end-users this kind of approach in data gathering can be misleading and could cause unnecessary additional expenses for companies involved in public transportation.

Projections based on partial data can cause companies to create suboptimal timetables as well as cause them to use their resources sub-optimally. The reason why is because when surveys are filled in they aren’t taking into consideration weather, city-wide events or time of the year and in some cases time of the day. The results are adjusted statistically based on those parameters or they are ignored completely. All mentioned factors greatly alter behavior of those who need and use public transportation.

The missing data of those times when surveys aren’t conducted and data from people who haven’t participated in surveys can be acquired by using intelligent transport systems (ITS) and big data analysis. The role of ITS and analysis of data is that it should give complete overview of end-user behavior and demand for transport year round.

2. CURRENT TRENDS IN PUBLIC TRANSPORTATION

There are huge efforts being made all over the world to lower the number of vehicles especially private single occupancy vehicles. The reason why this is the case is that private vehicles create additional strain and burden on existing traffic infrastructure which causes traffic jams, more traffic accidents and difficulty of keeping transportation effective in urban areas.

Many cities are adopting policies that are having demotivating effect on citizens that are using private vehicles in those cities. Some of the policies involve increased pricing for public parking spots or increasing number of cycling lanes so that bikes can be used as alternative to daily migration.

The matter is sometimes worse due to increased number of people that are using ride sharing services like Uber and Lyft which have set a new standard of customer experience [3-4].

EU is stimulating public transportation campaigns and promoting it as much as possible [5].

They are advising usage of C-ITS - coordinated intelligent transport systems which is a strategy that recommends actions to create synergy between different initiatives and improve interoperability as well as recommending adopting customer-centric mindset and prioritizing sustainability [6].

At the moment companies that are involved in public transportation have great challenges ahead of them. Their goals aren't just to provide transportation services to citizens but to be accountable and reliable. Transportation in urban areas needs to be as, if not more, reliable than all other means of transportation in order to be attractive to end-users. Public transportation companies need to offer same customer experience that ride sharing applications are offering in order to be considered by some end-users.

3. INTELLIGENT TRANSPORTATION SYSTEMS

Intelligent transport systems are systems that encompass traffic management, helping drivers and overseeing the movement of vehicles. ITS is used in traffic lights, roads, and bridges, to establish an interconnected transport system with direct communication between vehicles and devices. ITS can control traffic so it runs smoothly and public transport runs according to schedule. ITS sees that citizens can retrieve real-time information about traffic and public transportation and it can provide valuable data to companies involved in public transportation based on which they can serve everyone on higher standards than ever before.

Implementing ITS minimizes pollution because it promotes usage of public transportation in general masses. By providing real-time data about transport schedule, delays, cancellations they provide great alternative to private vehicles. The more people use public transportation less private vehicles are involved in traffic thus lowering traffic congestion and lowering pollution levels. Having ITS in place would allow cities, public transportation companies and anyone involved in traffic to benefit from it. Timetables, route information and payment systems would be electronic. Ease of use encourages travelers and tourists to use public transportation instead of ride sharing applications. Part of ITS are mobile applications that are used to provide users of public transportation with real-time data but they also collect data about users behavior which and it can provide year round complete overview with visible changes for the demand for public transportation over the holidays, summer, vacation season, daily migration, etc.

4. PUBLIC TRANSPORTATION WITHOUT ITS - CASE STUDY OF THE CITY OF NOVI SAD

Novi Sad is the second largest city in Serbia with urban population of 277,522 and the only form of public transportation is road transportation and it is specifically by bus. Which is the case for many cities in Europe where buses are also the only way public transportation operates. Even though there are suggestions from EU to diversify the ways transportation operates in urban areas buses still make up 83% of all public transportation journeys worldwide [7].

The Public City Transport Enterprise of Novi Sad has not yet implemented any Intelligent Transportation Systems at the moment and as such is is great example for analysis how public transportation operates without having any ITS implemented.

In 2018 informal survey was completed in order to find out how satisfied end-users with public transportation services in Novi Sad are [8].

Survey results concluded that:

- 12% of participants aren't satisfied with transportation services
- 36% are partially satisfied
- 79% had incidents where they missed important event because bus was late
- 65% rely on taxi services when time is of the essence

The team behind Bus Routes conducted another survey in summer of 2019 specifically targeting Novi Sad. This time there was 846 participants and most of them were students between the age 19 and 26. Students were chosen as a focus group because they are using public transportation for their daily migration most consistently in Novi Sad. Goal of the survey was to find out how often is focus group late to important collage or work related events and what is the frequency of those incidents. Results were following:

- 82.4% of participates experience such incidents daily
- 15.4% of participants experience them from time to time

One important thing to note is that huge majority more than 80% expressed desire to know where the bus is and when it's coming without having to predict that themselves based on timetables.

Novi Sad could benefit greatly from implementing ITS.

5. DATA ITS CAN PROVIDE

Mostly companies involved into public transport analyze the data they have which is usually one time survey. The idea behind survey is to provide random sample of real users of public transportation and based on that help traffic planner predict and anticipate the volume and demand for public transportation.

That doesn't have always to be the case. Depending on day if there was for instance big city event survey will have different profile of people filling it in. Ticket sales also are partial indicator of true need for public transportation. Tickets sold at specific time just isn't good enough metric for determining the demand for transportation. That is only a metric of those who actually participated in that journey but the missing subtle data point are all people who wanted to use transportation but were unable because they waited for transport for too long or they used inaccurate timetable and they were forced to use any other means of transportation. More convenient, reliable and on-demand service will always win the customer.

Public transportation companies that rely on surveys and tickets sales as data which they use to model their driving schedules, timetables and frequency of transport journeys are missing key data points. The demand for public transportation is dynamic and changes on daily basis.

By having the public transportation demand data from users companies can provide better service to the people while minimizing expenses.

In this day and age there are a lot of applications that offer information about public transportation in certain cities. Google transit, Transit app, Moovit app are just a few examples of this new trend [9-11].

These applications boost ticket sales because of the data they provide to users of public transportation. Even though they don't contain support for canceled trips.

Most of those applications don't give the most valuable data back to the transportation companies which traffic and data analysts can use it in their analysis of demand for transportation in urban areas.

Most valuable data points for transportation analysis are:

- sheer volume of people by time of the day and time of the year
- which lines are needed and when
- which bus stops are points of interest and when
- vehicle capacity utilization

All the parts of cities including suburbs have different kinds of demands for transportation depending on time of the year and even time of the day.

Public transportation companies need to have control over the data that users are generating in order to properly anticipate and predict demand and come up with proper response to fulfill that demand.

Public transportation companies that are having the data would allow them to optimize operating procedures and cut costs. Knowing how many passengers are using which bus line at what time is one of the most important data points for any company that deals with public transportation. The more knowledge companies have about how their routes are being used the more cost efficient they can be in deploying their resources.

They can predict targeted increases in ticket sales. Having big data at your disposal can create system-based sales forecast based on historical data. Of course big data applications can do more than that. They can employ techniques of machine learning to accurately predict customer behavior based on weather, city-wide events, holidays, previous predictions… All this allows companies to improve timetables, better predict customer behavior and act in a more customer-centric way.

Some experts advise cities to fully delegate their public transportation or partially delegate some aspects of public transportation to ride sharing companies. Many of them are citing Uber and Lyft as great candidates that are popular but due to regular financial loses that those companies are suffering every quarter it is very risky. Risk comes from the fact that if those companies were to shut down or be dissolved due to their financial problems cities that use them to assist public transportation could come to a grinding halt [12].

6. CONCLUSION

With trends of increased number of people in urban areas that are migrating great strides are being made from government bodies and also local authorities to keep private vehicles of the roads and provide great public transportation.

Opportunities for ITS and data analysis are vast and should be used in order to provide best possible value to most people. Companies involved in public transportation that are neglecting customer experience could be easily solved with proper application of software, ITS and data analysis of customer’s needs. Using big data application systems would lead company to being more in line with current trends in EU that are striving to minimize greenhouse emissions while reducing operational costs and improving customer experience.

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GROUP OF ARTICLES 3
Public transport organization

7th INTERNATIONAL CONFERENCE
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REORGANIZATION AND DEVELOPMENT OF THE TROLLEYBUS SUBSYSTEM IN BELGRADE

Key Words

Reorganization; Development; Trolleybus subsystem; Sustainable mobility

Abstract

The IME (Identity - Mobility - Ecology) Project, initiated by the City of Belgrade, aims to bring together a number of different projects focused on strengthening the city identity, promoting and implementing the concept of sustainable mobility and enhancing environmental awareness. The implementation of this project significantly influences the appearance, concept and organization of the trolleybus subsystem in the central city area. The extension of the pedestrian zone in the city center must continue to ensure the functioning of public transport in order to meet the needs of the city's residents to reach the desired destination in an easy, simple and safe way. The main goal of the analysis Reorganization and Development of the Trolleybus subsystem in Belgrade, is to find the optimal solution for reorganization of the existing trolleybus line network as well as further development directions of the trolleybus subsystem as a significant sustainable city mobility factor.

1. INTRODUCTION

Within the IME Project, several sub-projects have been defined, among which is one of the most significant, and also the most demanding, the Extension of the

Pedestrian Zone of Knez Mihajlova Street. The realization of this project significantly influences the appearance, concept and organization of the public transport of passengers in the central city area.

For many years, the concentration of significant activities in the central city area, as a consequence of the monocentric organization of urban space, had a direct impact on the formation of intensive passenger flows and their directing towards the central city area. Accordingly, the public transport line network was formed with direct penetration into the city center, as the goal destination for most passengers.

2. INPUT PARAMETERS

The input parameters for the analysis are defined through the infrastructure projects:

- The project for construction of a new trolleybus-bus terminal "Dunavska" in Dunavska Street;
- The project of construction of trolleybus corridor Cvijićeva - Jaše Prodanovića - Vanizelosova - Gundulićev venac - Dunavska Street with a line branch through Dobračina Street to the trolleybus depot "Dorćol";
- Procurement of trolleybuses with IMC (In Motion Charging) system for up to 20 kilometers;
- The project of construction of a new underground garage “Studentski trg“;
- Abolition of the existing trolleybus terminus "Studentski trg";
- Project design of the route Čingrijina Street from Bulevar Kralja Aleksandra to Batutova Street with associated infrastructure - planned construction of a new trolleybus-bus terminus "Zvezdara 2" at the corner of Aradska and Milana Rakića Streets;
- SMT Project section Borska - Petlja "Lasta" - planned construction of a trolleybus network on the corridor from Paunova Street to the terminus "Medaković 3";

Taking into account all the above projects and plans and considering the current state of the public transport line network, the possible directions for the development and reorganization of trolleybus lines were analyzed.

3. TROLLEYBUS TODAY

The last fleet renewal was carried out in 2009 and included the procurement of modern low-floor vehicles with energy recuperation and other technical solutions implemented in the latest generations of trolleybuses.

Characteristics of the trolleybus subsystem:

- trolleybus contact network length of 28,3 km
- contact network voltage of 600 V

- number of rectification stations - 21 (2 exclusively for trolleybuses, 10 mixed for tram - trolleybus and 9 for trams built in the period 1950-1960)
- depot " Dorćol " was built in 2000 (rebuilt after the fire)
- number of lines 7
- the line network length of 55,8 km
- mean line length of 8,0 km
- 123 trolleybuses in inventory, of which 97 solo and 21 articulated and 5 e-buses
- average fleet age of 10,41 years
- 94 trolleybuses in operation at peak hours
- maximum frequency on the section (Vasina Street) of about 60 vehicles/hour
- average daily (working day) number of 158.832 passengers transported by the trolleybus subsystem
- participation of the trolleybus subsystem in the total number of transported passengers of about 9 %.

The following figure shows the existing trolleybus subsystem line network.

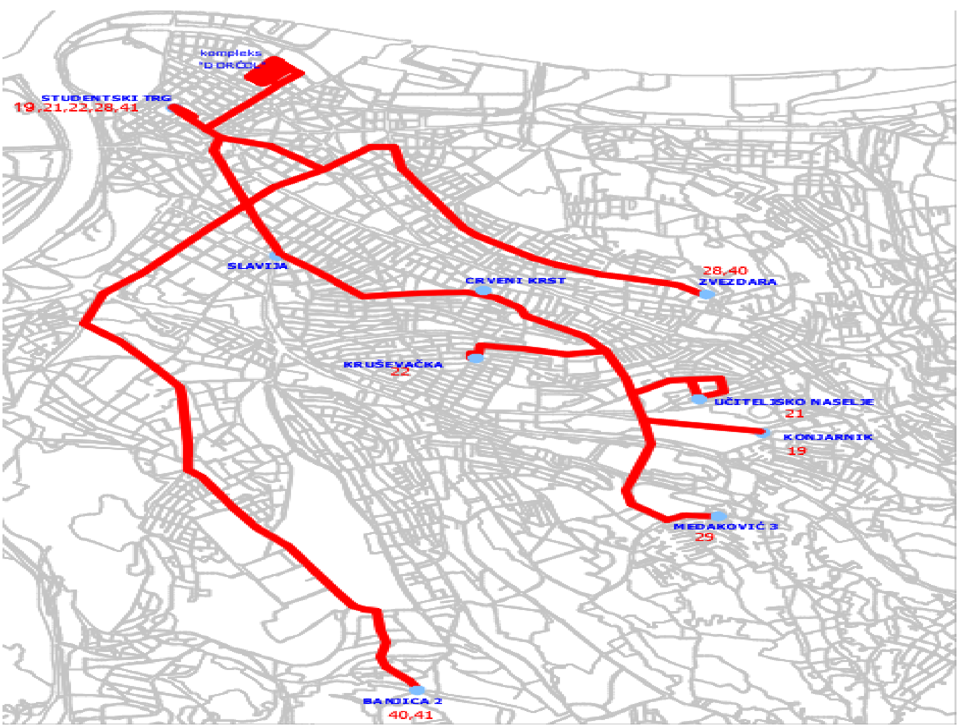

Figure 1. The existing trolleybus subsystem line network

Elements of operation of the existing trolleybus line network based on the winter timetable (22.01.2019) are given in the following table:

Line	Name of the line	vehicle- type solo	vehicle- type articulated	N (voz)	L (km)	To (min)	Vo (km/h)	i (min)	f (voz/h)	Q
19	Studentski trg - Konjarnik	5		5	7,0	80	10,6	16	3,8	379
21	Studentski trg - Učiteljsko naselje	9		9	6,7	74	10,8	8	7,3	737
22	Studentski trg - Kruševačka	8		8	6,3	77	9,8	10	6,2	630
29	Studentski trg - Medaković 3	18	6	24	8,0	90	10,7	4	16,0	1.852
28	Studentski trg - Zvezdara	7		7	5,4	65	10,0	9	6,5	653
40	Zvezdara - Banjica 2	18	2	20	12,5	110	13,6	6	10,9	1.166
41	Studentski trg - Banjica 2	14	7	21	9,9	103	11,5	5	12,2	1.476
TOTAL		**79**	**15**	**94**	**55,9**					**6.892**

4. DEVELOPMENT OF THE TROLLEYBUS SYSTEM IN BELGRADE

Development of the trolleybus network

Development of the trolleybus system in Belgrade is defined by the city development planning documents as well as the GSP "Beograd" development projects.

According to the GUP, by 2021, the development of trolleybus transport has not been specifically treated, as it corresponds to the bus system in capacity. The possibility of the network extention is left open, where it's technologically and economically justified for the replacement of buses, taking into account the integrity of the trolleybus network.

In accordance with the above input parameters, and considering the reconstruction of Trg republike and the extension of the pedestrian zone in the central city area, it is necessary to reorganize the trolleybus line network. The procurement of new IMC trolleybuses opens the possibility of the network upgrading and adapting to new conditions. IMC trolleybuses, with their own properties and technical characteristics will contribute to the development of the entire project for the organization of the central city area in accordance with modern trends and high standards. Reduction of pollutant emissions, more efficient energy consumption, noise reduction, non-use of the network in the central city area are the benefits of acquiring new IMC trolleybuses and reorganizing the trolleybus subsystem line network.

In accordance with the set requirements, one of the possible new line network variants is shown on Figure 2.

The proposal for a new network implies the operation of new IMC vehicles on lines passing through the city center. The existing vehicles operate on the lines which terminate on the perimeter of the central city area or pass along the perimeter of the central city area. One of the conditions, which also has to be met by the new line network, is to maintain the existing capacity on trolleybus routes as well as the rotation speed.

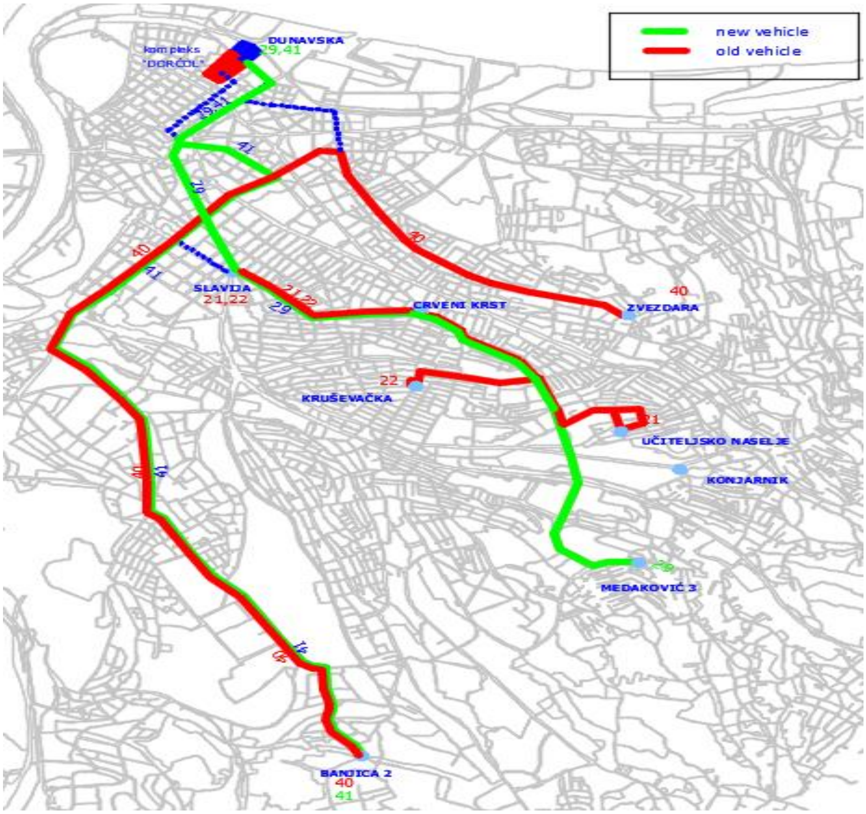

Figure 2. Proposal for a new trolleybus line network

In addition to modern trolleybuses, the operation of e-buses is also planned for the central city area, which would reduce the emission of harmful gases and the noise level.

In line with the concept of sustainable development and development of environmental awareness, a new line (service) "Vrabac (Sparrow)" has been introduced, which is a real attraction for both tourists and residents of Belgrade. The service is free, it operates within the pedestrian zone, with 6-passenger electric vehicles.

Construction of a new trolleybus-bus terminal in Dunavska Street at Dorćol

In order to realize the described concept of trolleybus network, the construction of a new terminal is planned, which represents the realization of the plan defined urban development program for Belgrade based on dislocation of the central city termini "Studentski trg" and "Trg Republike" to the perimeter of the central zone.

The trolleybus - bus terminal will be built on the site of approximately 20.400 m2 in Dunavska Street, with necessary supporting facilities.

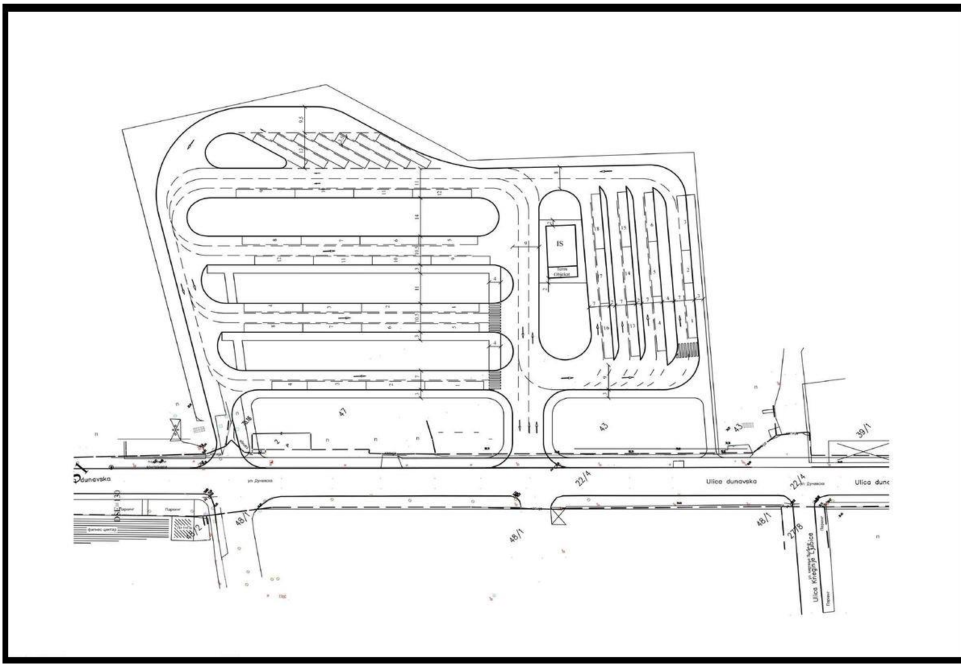

Figure 3. Conceptual design of the new trolleybus - bus terminal

The new trolleybus depot "Kosmaj 2"

According to Detailed Regulation Plan, “Kosmaj 2“ settlement in Voždovac municipality presents a purpose-defined area for the construction of a new trolleybus depot for accommodation and maintenance of 150 trolleybuses.

The construction of a new trolleybus depot is necessary, since the existing depot at Dorcol is spatially insufficient for the existing number of trolleybuses, therefore further development of the trolleybus network and the procurement of new vehicles requires timely provision and construction of a new depot.

5. CONCLUSION

Formation of the entire proposed line network, construction of a bus-trolleybus terminal at Dorćol and a new trolleybus depot will result in an extended and more efficient trolleybus line network. Further expansion of the trolleybus network will allow the replacement of a number of bus lines by trolleybus lines, which will lead to:

- reduction of pollutant emissions;
- more efficient energy consumption;
- noise reduction;
- reduction of the system costs per pkm.

The quality level of transport service will increase, and therefore the attractiveness of public transport.

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INDICATORS OF SERVICE QUALITY IN PASSENGER PUBLIC TRANSPORT ON THE TERRITORY OF STARA PAZOVA

Key Words

Rated quality;
Desired quality;
Service quality;
Indicators;
Public transport

Abstract

An assessment of the quality of the public passenger transport service can be obtained by an evaluation by the service user. This paper presents indicators of the quality of transport service received by users of the public transport system in the territory of Stara Pazova municipality. The above indicators were obtained as the rated and desired quality of the transport service in the real public transport system of passengers in the 2017. The analyzed data on the quality of transport service were obtained by direct survey of users, according to the already defined survey form.

1. INTRODUCTION

There is a mutual interdependence between the quality of the public transport system and the quality of the transport service, which is required by combining the interests of the users, the carriers and the development strategy of the cities or the entire transport system.

Depending on the author and the aspects of observation, the literature provides a number of different approaches to the quality of the transport service, and therefore there is a difference in defining the quality characteristics as well as in defining the quality of the transport service itself.

The quality of the public passenger transport service is valued by many parameters. For example, frequent occurrences of incorrect and uneven vehicle movement on routes lead to a loss of public confidence in passengers, leading to a reduction in the number of users. The inaccurate and uneven movement of vehicles also burdens the operating costs of transport companies due to the irrational use of capacity. Therefore, public transport companies should be particularly interested in achieving a high level of transport service quality.

2. DEFINITION OF PARAMETERS OF TRANSPORTATION SERVICE QUALITY

In the literature, depending on the author and the aspects of observation, several different approaches to the quality of transport service are given, and therefore there is a difference in defining the quality of the transport service.

As the transport service is characterized by many specifics, the most acceptable structuring of quality properties can be considered: Organizational support for service (Service support performance), Service operability performance, Service availability (Serviceability performance), Service integrity, Capacities of production of the system (Capability) and Exploitation reliability of technical exploitation (Dependability).

In the standards (1/191-19-01) the quality of service is defined as the general effect of a service property that determines what degree of satisfaction of the needs of the service user, emphasizing that the quality of service determines the complex of quality properties.

In the literature, the quality of the transport service is given special attention, so that as a result of the long-term desire to clearly define the quality of the transport service, a number of defined quality concepts have emerged. This is how we distinguish:

- desired (expected) quality,
- projected quality,
- realized quality and
- perceived (rated) quality.

3. PUBLIC TRANSPORT QUALITY INDICATORS IN THE STARA PAZOVA

As mentioned above, the quality of service can be seen as rated and expected. Users of public transport systems in an area expect the quality of service to be at a certain level and, as a rule, an assessment of the existing quality of service is also performed during the research.

In the area of Stara Pazova, a full-day survey was conducted by counting and surveying the users of the public transport system, so that it was possible for the users to view the quality of service as rated and expected. A survey of users of the public transport system was conducted on a randomly selected sample, while the size of the selected sample was determined to represent a representative state of the basic set of users. The survey included all lines belonging to the territory of Stara Pazova municipality, and the results obtained relate to the 2017 cross-section.

The aim of such research is to look at transportation requirements, on the one hand, and transportation offers, on the other.

Within the survey, public transport users were asked a number of questions related to the existing and desired level of quality of transport service. The following tables and charts give an overview of the assessment of the existing level of quality of service as well as the desired level of quality of transport service.

The surveyed public transport users had the opportunity to evaluate the current state of the public transport system. Out of the total number of users surveyed, the largest number of users 34.08% gave a rating of 1 (not satisfying) for public transport in Stara Pazova, 29.97% of users gave a rating of 2 (satisfies), and 28.10% of users gave a rating 3 (good). 7.84% of the surveyed users gave great and very good grades for public transport in Stara Pazova.

Table 1. Users rating of public transport in Stara Pazova

Rating of public transport	**Number**	**Percent [%]**
Not satisfying	365	34,08
Satisfies	321	29,97
Good	301	28,10
Very good	42	3,92
Great	42	3,92
TOTAL	**1071**	**100**

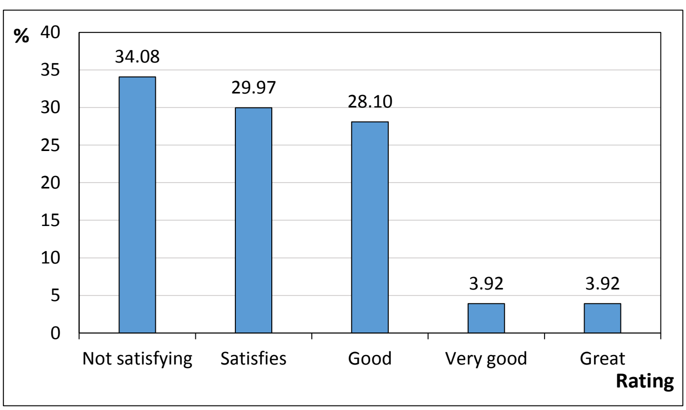

Figure 1. Graphical review of users rating of public transport in Stara Pazova

The surveyed users who were dissatisfied with the existing system were able to express the perceived deficiencies and rank them in the first, second or third place. As part of the survey, users were offered six of the most common disadvantages of public passenger transport (few departures, lines don’t work all day, large jam, long walk to the station, high ticket price, cleanliness of the vehicle).

Of the total number of surveyed public transport users, the largest number of users as the largest lack of public transport in Stara Pazova cites a few departures, as many as 630 users. While in the second and third place, users most often state the cleanliness of the vehicle (310 and 393 users surveyed). As a slightest drawback, users cite a long walk to the station and a high ticket price.

Table 2. User responses to shortcomings in public transport in the Stara Pazova

Client answer	**Few departures**		**Lines don't work all day**		**Large jam**		**Long walk to the station**		**High ticket price**		**Cleanliness of the vehicle**	
	Num.	**%**	**Num.**	**%**	**Num.**	**%**	**Num.**	**%**	**Num.**	**%**	**Num.**	**%**
1st place	630	58.8	80	7.5	113	10.6	18	1.7	50	4.7	180	16.8
2nd place	177	16.5	233	21.8	208	19.4	17	1.6	126	11.8	310	28.9
3rd place	143	13.4	155	14.5	162	15.1	54	5.0	164	15.3	393	36.7

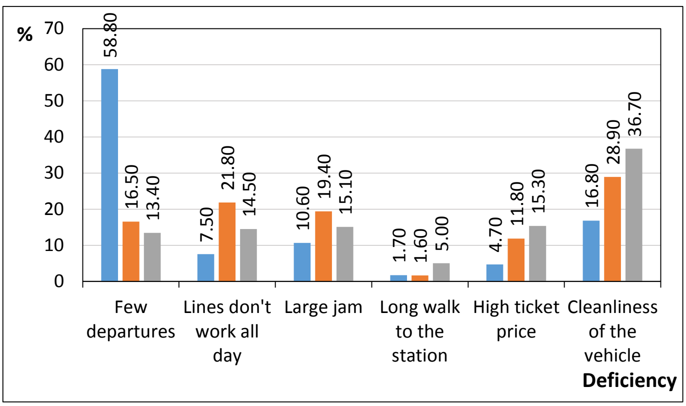

Figure 2. Graphical review of user responses to shortcomings in public transport in the Stara Pazova

The expected level of quality of service has been determined in relation to the shortcomings that users have shown in the survey through a series of questions. One of the questions was "Do you like the current number of departures?". Users who felt that the number of departures was not sufficient were additionally asked at what time, in their opinion, additional departures should be introduced. The data obtained were compared with departure times and capacity utilization and were used to design the new public transport system.

Of the total number of users surveyed, 39.68% indicated that their existing number of departures corresponded to them and were satisfied with the existing timetable, while 60.32% of those surveyed were dissatisfied with the existing number of departures because they could not meet their movement needs.

Table 3. Users response to the question: "Do you like the existing number of departures?"

Client answer	Number	Percent [%]
Yes	425	39,68
No	646	60,32
TOTAL	**1071**	**100**

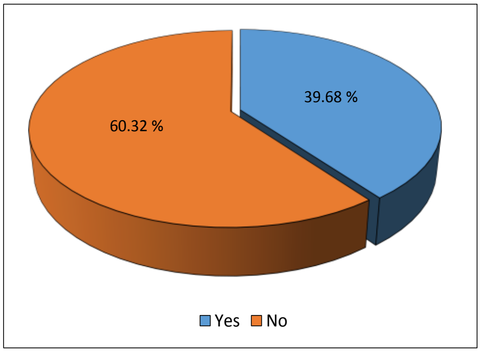

Figure 3. Graphic review of the users response to the question: "Do you like the existing number of departures?"

4. CONCLUSION

Research in the public transport system in the territory of Stara Pazova was carried out, among other things, to determine the characteristics related to the quality of service. The aforementioned surveys included the counting and interviewing of public transport passengers in the 2017 cross-section.

The user survey was conducted by direct interview of public transport users. The survey was intended to make the sample representative so that the data obtained would reflect the state of the whole system, while the respondents were randomly selected.

On the day of counting, 12.04.2017., a total of 6130 passenger rides were realized, on the same day, 1071 public transport users were surveyed, which represented 17.5% of the basic rally.

The analysis of the quality assessment of the existing state of public transport concludes that in 2017, the system with the lowest rating was 34.08% of users, while the highest rating was given by 3.92% of users, which gives an average rating of the whole system 2.14.

In order to be able to see the hierarchical order of the organization and measures in order to raise the level of quality of transport service, that is, special requirements of users, it is first necessary to define the goals and requirements that are set before the public transport system of passengers, the requirements of certain interest groups (city government bodies, carriers and users) according to the system.

The public transport system needs to be designed according to the needs of the users, in accordance with the legal framework, and the quality of services must be constantly monitored and controlled, and efforts should be made to create conditions for its permanent increase.

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THE E-BUS: ECONOMIC OR/AND ECO FRIENDLY ALTERNATIVE?

Key Words
Climate changes; Public transport; Electric buses; Standardization; Energy efficiency

Abstract
Analyzing the values of public transport systems energy indicators and metropolitan air pollution together with the branch specific economic forecasts, the authorities and suppliers can estimate future trends. To reduce the urban usage of personal automobiles it is needed to increase the proportion of electric public transport vehicles (Tramways, Trolleybuses, Electric buses), also it needs to increase the urban mobility satisfaction by increasing attractiveness and accessibility of networks, growing essentially the number of trips by public transport. All together these can ensure more livable cities.

1. INTRODUCTION

A. World climate change

Climate change is a cruel reality, news about the disasters are daily. Although the world's leading heads of state and government agreed to cooperate in the development, application and availability of climate-friendly technologies for developing countries. However, there are blockages. It is enough to refer to the United States 2017's 'turnaround', hopeful the temporary rejection of a treaty accepted by the majority will not trigger an avalanche reaction.

We know there are many environmentally friendly alternatives, this is why urgent action is needed, and climate protection must be one of the foundations for development goals. Regional and urban mobility is a key condition for economic and social development and the reduction in poverty. The transport sector therefore plays a key role in the development and maintenance of the economic and social foundations of both developed and developing countries.

B. Transport's energy consumption and air pollution

The continuous growth in the transport sector has increased concerns about the economic costs of energy supply as well as the impact on the environment. In the EU, the road transport sector is responsible for 26% of final energy consumption and 24% of CO2 emissions (2007). Energy use and emissions from the road sector continue to grow around 1.5 - 2 % per year [1].

The 2016 Report of the International Energy Agency (IEA) [2] found that the share of transport in world oil consumption has increased significantly over the few last decades. Figure 1 and Figure 2 show the transport sector energy needs and evolution comparing 1973 to 2014. If we take the absolute equivalent energy values, the increased use of electricity will help to replace the classic fuels.

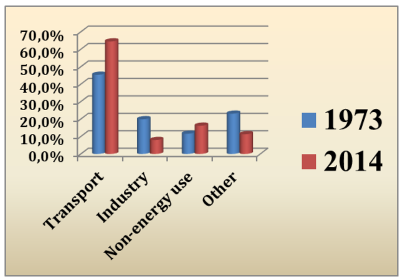

Figure 1. Oil consumption by sector (source: IEA) [1]

The values includes agriculture, commercial and public services, residential and non-specified others. During 1973-2014 oil production increased from 2,252 Mtoe to 3,761 Mtoe (1.67 times), same time the electric energy production increased 3.88 times (from 440 Mtoe to 1,706 Mtoe)!

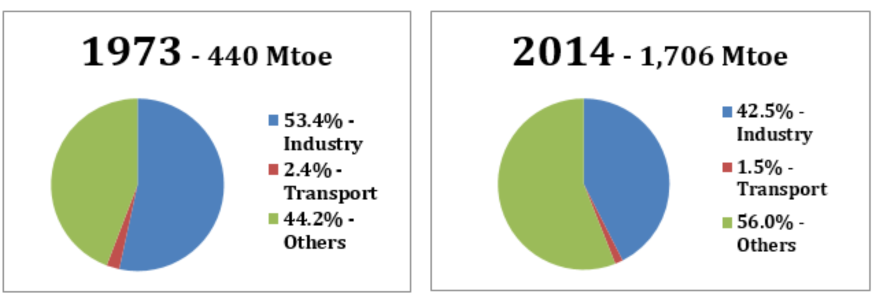

Figure 2. Electric energy consumption by sector (source: IEA)

The comparison marks the first oil crisis as a milestone, according to data from 1973. The share of transport accounted for 45.4% oil consumption in 1973. Nowadays, nearly two-thirds of crude consumption is in the transport sector, in 2014 the rate was 64.5%, value which prove a boom of oil sourced fuel engine transportation.

Although the share of electricity used in transport looks as decreased from 2.8% in 1973 to 1.5% in 2014 but is not exactly a recession of electric cars! If we take the absolute values, it is more than twice the amount of electricity consumed since the 1970's, in figures increase from 10.56 MTOE to 25.59 MTOE. Taking into account the significant advancement of energy efficiency in electric propulsion techniques, it eventually brings about more than two-three times the vehicle ratio. Electricity recommended to be used not only in public transportation (electric locomotives, metro & light rails, trolleybuses, soft freight logistics), in today's traffic are used to have hybrid or total electric private cars. Personal used zero emission cars help to solve the pollution issues in big cities, but about have no any effect on traffic congestion treatment… only one way to reduce travel time in highly crowded area is the public transport, mass transit on segregated lines (tram or metro, bus rapid transit).

2. IMPORTANCE OF THE PUBLIC TRANSPORT

A. Urban mobility

The UITP (International Public Transport Association), based in Brussels, jointly with the EU Commission, strongly recommends that European climate change and energy efficiency policies explicitly address the issue of urban mobility. One of the most important measures proposed is the development of a strategy to promote modal shift and high quality public transport systems [3]. One element of this is the need to develop sustainable urban mobility/transport plans across Europe for cities with more than 100,000 inhabitants (governed by the HG 191/2013 in Romania). Supporting investments in transport, addressing high energy efficiency and low greenhouse gas emissions as priority criteria accentuate the vital role of public transport. Unfortunately, it is often considered to be too costly an endeavor improving energy efficiency and reduced emissions.

Electric drives are able to solve the challenges of public transport:

•Reducing local pollution, whether comparing other used engine is gas, liquid or solid,

•The significant reduction of the CO_2 emissions,

•Compliance with lower noise emission levels,

•Future reduction of the oil base fuels production and possible inflation of oil prices,

•The possible decreasing of internal combustion engines used in public transport will not affect the development and increasing of urban mobility.

Electric public transport modes are especially defined by used vehicles. A comprehensive view of division of electric driven urban transport vehicle (Figure 3) is based on energy supply mode / energy storage possibility. The development of 'green buses' is an ongoing lengthy process, having started more than a century ago, and overtime has reached different stages of acceptance and appreciation.

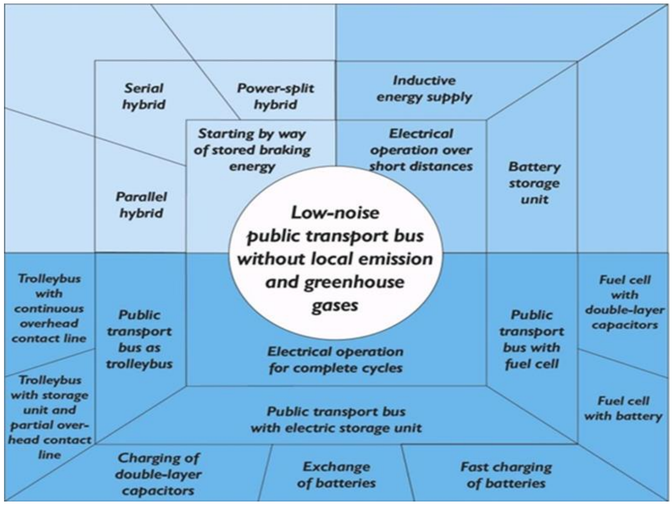

Figure 3. 'Green Bus' vehicles characterizations (source: UITP)

B. About electric drive vehicles

The best solutions for a high passenger flow with more than a few thousand trips per hour are the electric powered systems, whether it is metro or tram, trolley or the electric bus.

Some of the major challenges of the future are:

- what kind of electric energy we can supply to the vehicles;
- from which sources;
- what autonomy it is given by the energy storage;
- how long it takes to recharge it and with what kind of standard.

Energy can also be recharged on a moving or stationary vehicle: so-called **on-go** (generator by internal combustion engine, from outside electric network or as inductive charging), or **on-stop** (battery, supercapacitor). The flywheel mechanical facility helps to conserve energy and achieve efficient torque. The main advantage of electric propulsion is the power-torque characteristics. Energy can also be recharged on a vehicle on-the go (generated by internal combustion engine, from outside electric network as direct connection or as inductive charging), or on-stopped (charge of battery or supercapacitor). Recovery of brake energy is common in today's technology and can be reused immediately by other vehicles or reinjected back into the electric energy network. The flywheel method is a mechanical facility that conserves part of recovered energy. Many concepts have a main scope to achieve the most efficient torque for electric vehicles.

C. Where are the electric buses?

Assessing the present fleet in Europe in 2016 [5], oil-dependent transport systems cannot be replaced in a short time at a low cost, it needs substantial financing and it is an expensive undertaking for any Government. Price of Diesel buses almost remains same last decades, maybe small increased.

Table 1. Different bus supplier list prices along the world in 2017

Bus supplier (Diesel)	Country	Type	Unit price (USD)
King Long	China	XMQ6127	84,500
Mercedes MCV	Egypt	MCV C 120	158,000
Eurobus Diamond	Romania	BMC Urbino	216,500
Marcopolo Daimler	Brazil	Torino O 500-1726/59	274,500
Solaris	Poland	Urbino 12	325,500

Asking standard list prices from the suppliers (Table 1), based on the more used 12 m long urban 'solo' bus type, which depends on features, it start from 75,000 USD to almost over 350,000 USD in Diesel and increasing to several hundred thousand Dollars for the hybrids, not to mention the price of a 'super computerized', ultramodern electric bus which is up to 1,000,000 USD.

As we can see there is a very broad price spectrum. Prices depend on the type, brand, equipment, quality and maintenance services agreements but in the end the authority's budget will determine which manufacturer to sign a contract with.

An inventory made by UITP in 2015 (Figure 4) shows the distribution of buses characterized by engine types in European cities.

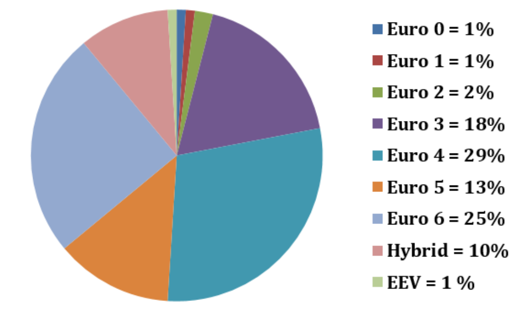

Figure 4. Bus fleets distribution by engines in European cities – 2015 (source: UITP)

As result of a comprehensive survey part of an EU Project [5] about fleets categorized by used energy source, can have the image how 'green' are the buses in Europe… Unfortunately, recently more than ¾ of fleets are diesel based internal combustion engines, the electric buses were only under insignificant value of 1.5 - 2 %. Figure 5 details the main values of used fuel, engine types and shows it has not changed significantly the last decade.

The same survey results show (Figure 6) data about potential intention of what type of bus will be purchased in the near future by operators or authorities.

Today, the electric buses represent less than 2% of the surveyed fleet. Happily, more than 34% of the respondents want to change towards more electric solutions, mainly hybrids and fully electric with batteries. The 'green vehicle' solution are mostly preferred, significant patterns are also evident for more CNG (23%), biodiesel and biogas (12%). The total proportion of other fuels (hydrogen, bioethanol, etc.) is less than 9%.

Energy optimization and environmental friendliness does not characterize today's inventory of bus types, although the automotive industry offers more and more technical solutions. The following areas have a special priority [6]:

- Energy recovery by regenerative breaking, heat recovery from exhaust system and energy or heat recovery from heating or cooling of the hybrid batteries
- Weight reduction using lighter more durable composite materials and redeveloping the structure of the vehicles using these new technologies
- Optimizing the traction by eliminating friction energy losses, adding more start-stop functions and using more efficient drive chains.

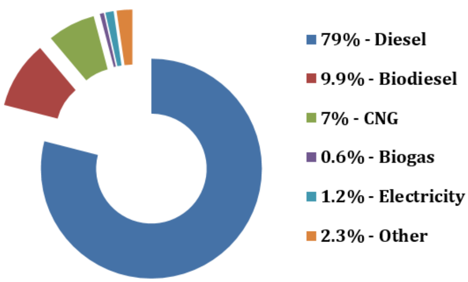

Figure 5. Bus engines in Europe – 2016 (source: EBSF 2)

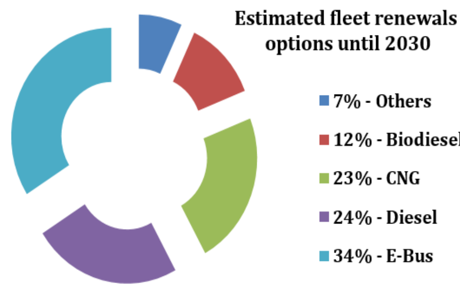

Figure 6. Respondents distribution according to future plans to change propulsion system ratio (source: EBSF 2)

3. THE ELECTRIC BUS (E-BUS)

A. Electric and Hybrid over Diesel

Fully electric powered buses are widespread and operate in large daily traffic areas in several large cities. Their polluting gas emissions are zero and the noise emission is lower than diesel buses. However, greenhouse gas emissions continue to depend largely on the production method of the electricity used, and the manufacturing process of the batteries.

In the long term, for the achievement of the EU's 2050 targets [3], electric buses show the best prospects, which might be supplemented by hydrogen fuel cell buses on longer routes. This is due to the high energy efficiency of the entire electric drive, which together with the potential of using renewable energy production methods can result in low greenhouse gas emissions and energy consumptions altogether.

B. European Union’s recommendations

The basic legislation regarding the four major transport sectors (air, rail, road and water) is the – “White Paper on Transport/Roadmap to a Single European Transport Area” (COM 2011/0144). The European Commission has issued a mandate “M-533” calling on CEN/CENELEC (the EU Commission for Standardization) to propose a standard for the classification of electric vehicles by end of 2019 [3].

"Key Performance Indicator" – KPI’s are utilized for a multitude of features that make the different characteristics comparable. According to the UITP recommendation, within the framework of the ZeEUS project, number of 187 different performance attributes have been selected and mapped.

After the analysis of these attributes, researchers from ZeEUS have reduced the number of KPI’s indicators through different categories, so the comparison will be easier and transparent [7].

C. Infrastructure of chargers

When switching to electric buses, conflicts between parallel or competing technical solutions must be avoided. From an efficiency point of view, it should be possible to connect as many vehicles as possible to the same charging apparatus or charging station. Existing tram or trolleybus network can be an excellent basis for the electric charging system [6].

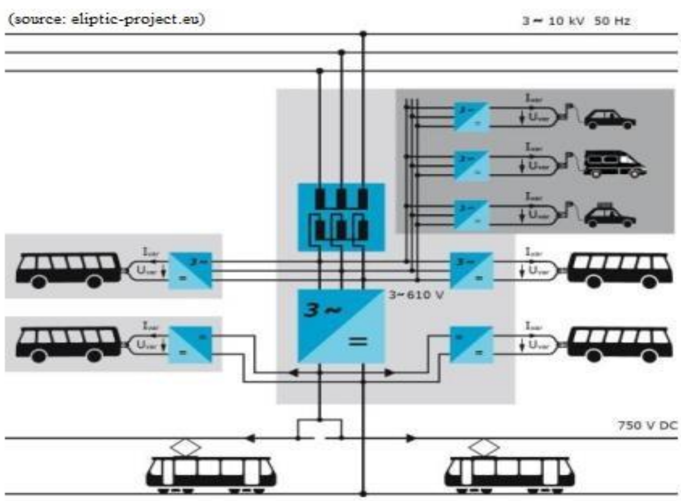

Figure 7. Power stations as optimal charger points

Figure 7 explains how a classic electric power supply network (the overhead line system work in parallel), can be easily converted to charging units of the electric bus fleet and other electric cars.

The possibility to link the usage of a bus battery on the route with the cell tests is given by comparing the number of routes performed or summing up the energy throughput of cycles, in order to divide it into a number of to equivalent full cycles. In Figure 8 the C-rate is set as voltage and current limits during the charging procedure, defining the timing. For the recharge process the available time of charging decide the power needs, number of recharging cycles will depend also of battery capacity to store the energy. The end of life criteria is the value of remaining capacity (less than 80% of initial).

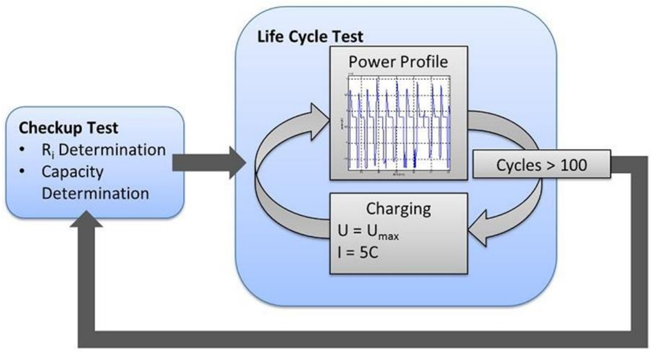

Figure 8. Battery recharging process (Life Cycle Test) (source: ZeEUS)

D. Survey for energy requirement

The capacity of the 600 V batteries and the charging cycle of the electric bus can be determined [4] by taking into account the available charging time and the amount of charging power required.

In order to select an electric vehicle, it is necessary to specify exactly what the customer desires. It must be decided whether environmental issues and other people-centered considerations are solid enough and acceptable for investing in a high-priced electric bus.

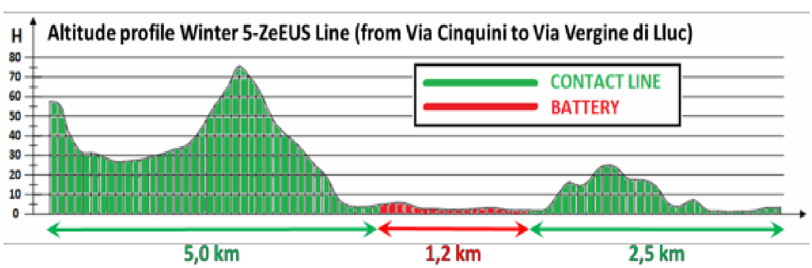

Figure 9. Elevation on Route 5 - Winter (source: ZeEUS)

Figure 9 and Figure 10 shows a bus route, namely Line 5 of the ZeEUS partner, Cagliari in Italy. Three main sections can be distinguished, two green areas (2.5 and 4.0 km) on a hilly district and a red section on a flat-lane. On the green sides overhead contact lines are needed for trolleybus operation. On the red area where city authorities do not allow overhead lines, it is possible and mandatory to run on battery mode.

Knowing the terrain condition makes it possible to determine the vehicles configuration, such as energy storage and energy sources.

Charging can be done in four separate ways. 4 modes of charge are used:

• battery cables;

• pantograph;

• armed connector;

• inductive charge.

Figure 10. Cagliari – Route 5 – Winter on map (source: ZeEUS)

The energy structure of vehicles can be analyzed with a SANKEY diagram. Figure 11 and Figure 12 show the SANKEY diagram for diesel and electric buses. The reduction of losses is one of the main priorities for increasing the efficiency of used energy, but the reversible energies are also important elements of operation [8], [9].

The thickness of the arrows indicates the ratio of the energy. The green arrow means the energy recycling of the internal combustion engine: heat recovery and reduced heat loss, proportionally greater drive force.

In order to optimize the efficiency of electric-powered vehicles, it is of utmost importance to recycle the recovered energy directly and efficiently in the electrical grid (green return arrow thickness is the amount of recovered energy to the system).

The thickness of the arrows indicates the ratio of the energy. The green arrow means the energy recycling of the internal combustion engine: heat recovery and reduced heat loss, proportionally greater drive force.

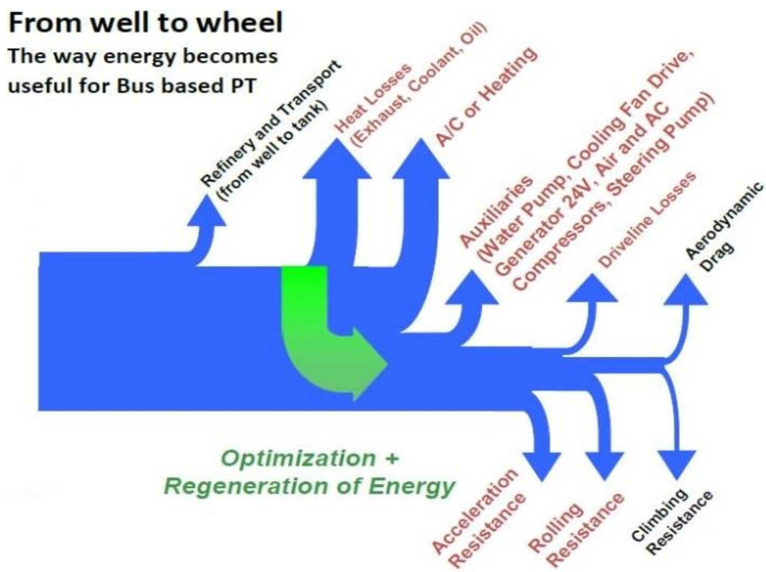

Figure 11. Sankey diagram for diesel buses (source: ELIPTIC)

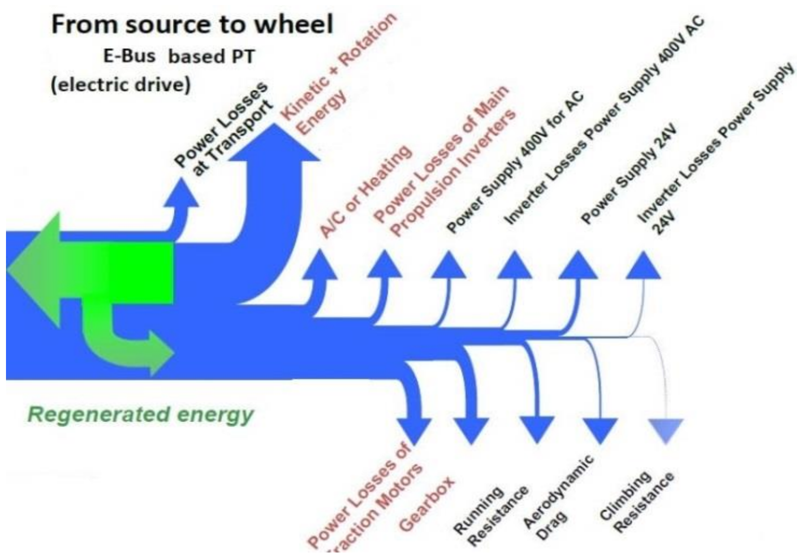

Figure 12. Sankey diagram for Electric buses (source: ELIPTIC)

In order to optimize the efficiency of electric-powered vehicles, it is of utmost importance to recycle the recovered energy directly and efficiently in the electrical grid (green return arrow thickness is the amount of recovered energy to the system).

4. CHARGERS FOR E-BUSES

A. Galvanic connection

Within the framework of the ZeEUS project [7], for the bus tested at the Bonn SWBV, Fraunhofer recommends the following measuring equipment: voltage converters LEM LV 100/SP47, current converters LEM ITN 600-S, GPS receiver, Compact-Rio data logger. This equipment has the possibility to monitor and register instantaneous power at a given GPS position. Territorial mapping of energy consumption can be used to calculate the route energy gain. Recharging durations are particularly important where charging is used at intermediate stops. At such a bus-stop there is a limited amount of time which can be spent on recharging. Within the test, direct energy consumption (EC_{Bus}) measurements are performed on a bus, calculated by (1), which can be compared to the consumption values measured at the charging stations.

$$\mathbf{EC}_{\mathbf{Bus}} = \int_0^t (U_t \; x \; I_t) \qquad [1]$$

Measuring at the same time the charge energy and knowing the initial charging ratio, after running the replenished electric energy to the same point, EC charge energy value can be obtained (as used full to full option). By allocating the charge energy to the energy consumed on the bus (effective), CEC energy efficiency coefficient can be calculated by (2):

$$\mathbf{C}_{\mathbf{EC}} = \frac{EC_{Bus}}{EC_{charge}} x100 \qquad [2]$$

B. Equipment, connector standards

The world-wide standard **IEC62196/2011** recommends the connectors.

- For American systems **- CCS 1** (but also accepted for CCS 2) for electric buses in North America
- For European systems - **CCS 2** (Combined Charging System) as a charging interface for Europe's electric bus manufacturers

Synergies between car and bus solutions are possible. Industry standards for chargers and inlets both in the United States and Europe are similars as recommended solutions.

Positioning the charging connector is essential to eliminate unwanted heat loss due to the high charging current. Figure 13 shows recommended charger positions for electric buses for a better space efficiency.

Today with the environmental condition obliging municipalities to think about solutions, the big challenge is how they can reduce the pollution in cities and how can ensure a livable and healthier environment for inhabitants increasing the urban mobility.

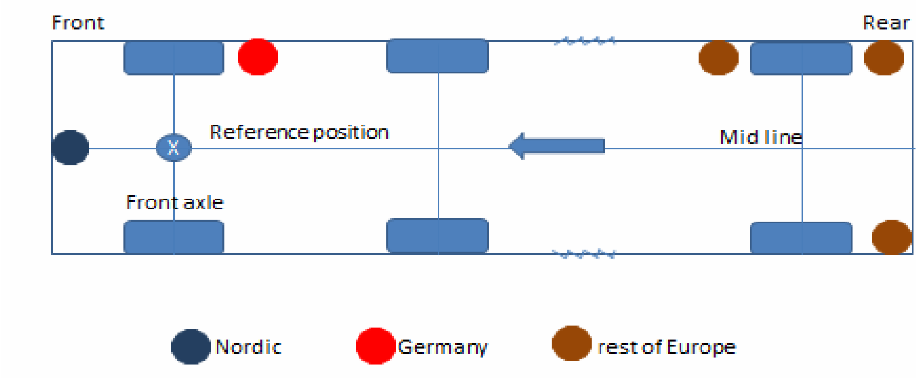

Figure 13. Recommended positions for chargers (source: ELIPTIC)

The 600 V battery and charging cycle of the electric bus can be estimated from Figure 14 and Figure 15 histograms [4], depending on available charging time and amount of charging power required.

There are several methods to calculate and approximate technical parameters of charging equipment. One of them is a graphical approach [4] as a histogram show dependency of the batteries capacity, weight and volume, power needs for bus, charging methods and the available time for that.

In order to select an electric vehicle, it is necessary to specify exactly what the customer can meet. The main issue, environmental and other people-centered considerations are solid enough for the argumentation of choice, is it recommended and acceptable for an electric bus?

First step is to decide the optimum selection on technical side next histograms can help on that.

Using the histograms operators can estimate the amounts of necessities knowing the input data given by needs interpretation and translation in technical values. It depends from routes difficulty and length, passenger flows, trip frequency (fast or slow charging), other parameters, which technical solution can be an optimum for the real application.

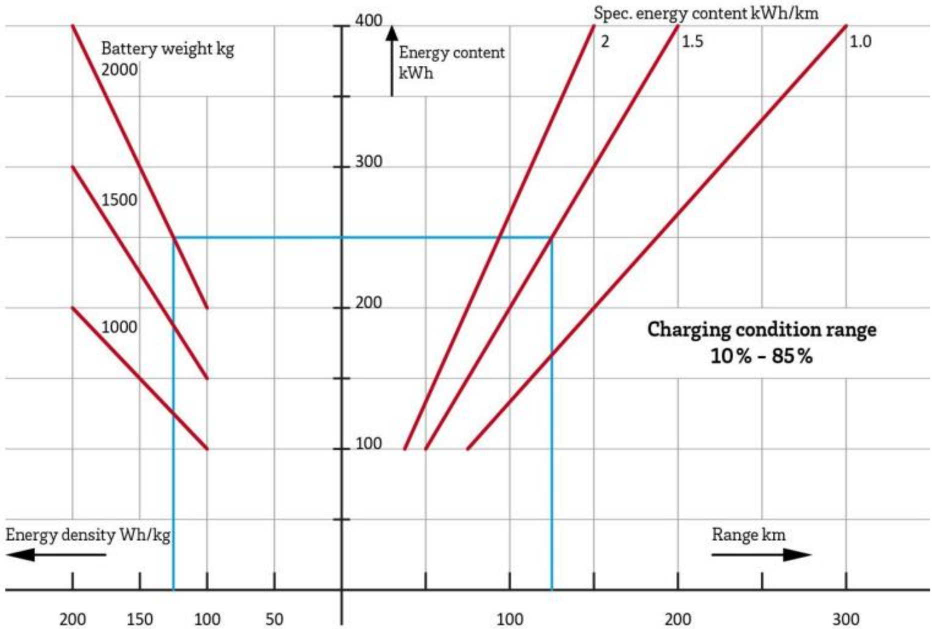

Figure 14. Recommended Rough estimation of the range for an E-Bus
(source: Müller-Hellmann)

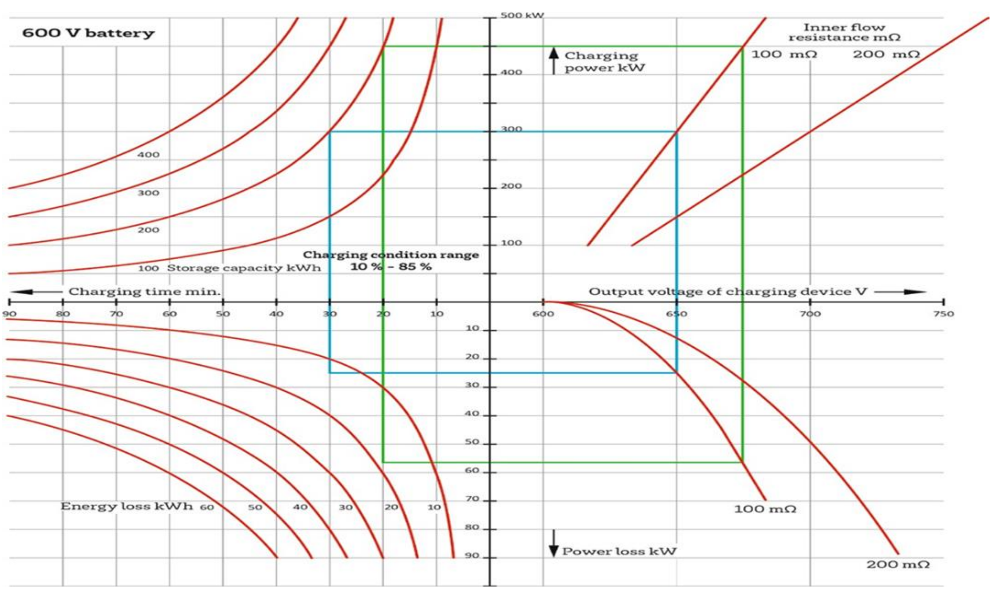

Figure 15. Rough calculation of the charging power needed in dependence of the charging time of a 600 V battery for a fully E-Bus (source: Müller-Hellmann)

5. CASE STUDIES

A. BELGRADE (Serbia): Eko 1 E-Bus Route

The new route EKO 1 [10] links the old and new Belgrade that crosses the crowded City Center using HIGER A6L E-Buses as in Figure 16.

Figure 16. Electric Bus Higer A6L charging in Belgrade (source: Chariot Ltd)

Analysis of the charge indicators by graphical representation of the measurement statistics defines the energy consumption range between 0.85 and 1.23 kWh / km, which varies according to field and operational impacts. The terrain features and outdoor weather (air conditioning or heating) determine the highest energy consumption, but also the traffic factors (crowded downtown, traffic jams, etc.). The volume of passenger flow has a strong influence itself as an important factor on energy usage. The daily average consumption is noted in Table 2 - the HIGER type Chinese buses have been running on the Route EKO 1 since the fall of 2016 (today similar buses runs also in other places: Sofia/Bulgaria, Graz/Austria and Tel Aviv/Israel).

Table 2. Daily statistics in Belgrade: average consumptions

E-bus No	(30°C) AC-on	(24°C) AC-off	(20°C) AC-off
2101	1.26	0	1.04
2102	1.14	1.01	0.89
2103	1.13	1.06	0.97
2104	1.14	0.97	0
2105	0.97	0.88	1.00
Average <kWh >	**1.128**	**0.98**	**0.975**

The energy consumptions were recorded in second part of September 2016. Important to observe, that consumption values show the AC – on the bus use more (10-12% up) electric energy, comfort condition will influence the total consumption.

B. ORADEA (Romania): Measurements and test results

In Romania the Chinese-made BYD electric bus was presented to the press and trialed by specialists from the public transport company OTL SA (Oradea Transport Local SA - www.otl.ro). Same, the Czech - made SOR E-bus was tested for a period of two weeks on different routes, namely Route 14, an urban cross city and another cross-border route to Biharkeresztes in Hungary, with a longer range of more than 80 km per one trip traveled distance.

Figure 17. The Czech Electric Bus model SOR in Bus Depot of OTL (source: OTL SA)

The 2015's November test runs and the measurements were designed to prepare for the acquisition of one or more electric buses. The measured values with FLUKE 345 were analyzed in a statistic Table 3, energy efficiency and power factors provided satisfactory results.

The values are very similar to the Belgrade example, around 1 kWh/km, with the average energy consumption 0.8728 kWh/km with the mention of operation without AC or heating. As a smaller capacity bus (10 m instead of 12 m) shows very good results for energy efficiency. Knowing the comparison of different OTL's networks (buses & trams), energy consumption (in TOE - Tone of Oil Equivalent) and the number of passengers carried, the tram systems energy-efficiency is very obvious [11]. The differences are essential; approximately one-third of energy consumption of the diesel engine-based bus system. Per ten thousand of passenger in 2014 the tram system used 0.34 TOE of electricity, while the fuel combustion bus system is 0.99 TOE, in 2015 energy consumption is similar 0.37 TOE to 1.00 TOE (a light increase by changed rules on heating and HVAC time extension). In 2016 the values are better thank to energy efficiency optimizations (fuel savings, brake energy recovering on trams).

Table 3. Daily statistics in Oradea: consumption data (source: OTL)

Date	Distance km/day	Charging [h]	Average kWh/km
1-Nov	80	4:10	1.0625
2-Nov	139	8:30	0.8705
3-Nov	123	7:20	0.8618
4-Nov	47	3:30	0.6835
5-Nov	82	2:10	0.9014
6-Nov	123	9:00	0.9024
7-Nov	47	4:20	0.7660
8-Nov	150	3:20	0.9467
9-Nov	113	3:00	1.0177
10-Nov	59	4:40	0.8644
11-Nov	128	3:50	0.8516
12-Nov	144	8:30	0.7639
13-Nov	93	6:10	0.9032
14-Nov	90	5:90	0.8922
15-Nov	79	6:00	0.7835

The values are very similar to the Belgrade example, around 1 kWh/km, with the average energy consumption 0.8728 kWh/km with the mention of operation without AC or heating. As a smaller capacity bus (10 m instead of 12 m) shows very good results for energy efficiency. Knowing the comparison of different OTL's networks (buses & trams), energy consumption (in TOE - Tone of Oil Equivalent) and the number of passengers carried, the tram systems energy-efficiency is very obvious [11]. The differences are essential; approximately one-third of energy consumption of the diesel engine-based bus system. Per ten thousand of passenger in 2014 the tram system used 0.34 TOE of electricity, while the fuel combustion bus system is 0.99 TOE, in 2015 energy consumption is similar 0.37 TOE to 1.00 TOE (a light increase by changed rules on heating and HVAC time extension). In 2016 the values are better thank to energy efficiency optimizations (fuel savings, brake energy recovering on trams).

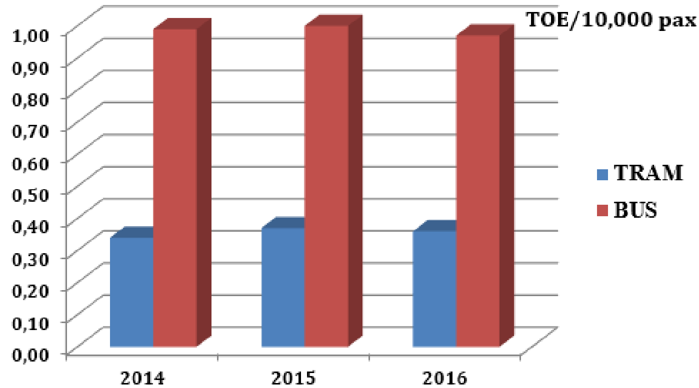

Figure 18. Average energy consumption per 10,000 pax during 3 years (source: OTL)

C. *CLUJ (Romania): First E-Bus fleet in operation in Romania*

In middle of June 2018 arrived in city of Cluj-Napoca the first 11 E-Buses from the future 30 pieces fleet of CTP SA's electric buses, purchased by Swiss Government loan (6,456,938 CHF) and Municipality local contribution (1,139,460 CHF) with condition of 5 years full warranty. The electric bus "Solaris EV Urbino 12" is fully equipped: low floor and 3 double slide doors, disability person access, AC & heating, ABS, EBS, ESR and full ITS equipment (GPS, APC, AVL, AFC, Wi-Fi, CCTV, passenger info displays). Maximum capacity is 27 seats and 51 standing passenger (total 78 pax), electric engine of 160 kW and batteries given an autonomy of 105 km in urban condition.

The electric buses will operate in the CTP's public transport network on the next routes:

- Route 27: Piața Gării – Cartierul Grigorescu (length 9,7 km)
- Route 28: Piața Mihai Viteazu – Cartierul Grigorescu (length 8,5 km)
- Route 30: Aurel Vlaicu – Cartierul Grigorescu (length 17,2 km)
- Route 32: Brâncuși – Piața Mihai Viteazu (length 6,6 km)

The buses autonomy of 105 km likely ensure the possibility to work one duty of 6-8 trips on mentioned routes. The charger disposals help to have the necessary availability of recharged energy.

The charger stations are disposed mixed 5 slow chargers (5-6 hours during the night) and 1 fast charger (5-10 minutes), two locations, Bus Depot "Grigorescu" and "Mărăști-IRA", completed by one-one fast and slow charger in the Bus Depot "Gheorghieni".

The tests were made by Technical Department of CTP SA Cluj-Napoca [13], using 7 of buses from the fleet of 11 electric buses during 5 days operating in public transport network in the real condition, using the AC, with passenger (from 02nd June till 08th July 2018). The measurement was made using the inbuilt energy counter of bus charger unit for recharged electric energy and the braking recovering energy counter built-in the bus. The registered values are in Table 4:

Figure 19. Fleet of electric buses of CTP SA – the "Solaris EV Urbino 12"

Figure 20. Charger stations: by cable (left) and by pantograf (right)

Table 4. Electric bus average consumptions in Cluj's operation

No	**E-Bus inv.nr**	**Total [km/period]**	**Energy consumptions Total [kWh]**		**Averages consumption [kWh/km]**
			Recharged	**Recovered**	
1	202	2264	2813	935	1.24
2	203	2280	2574	866	1.13
3	205	1845	2389	636	1.29
4	207	3536	4038	1437	1.14
5	208	3494	4186	1630	1.19
6	209	3971	4409	1579	1.11
7	210	3305	4007	1415	1.21
				AVERAGE	**1.188**

Taking into account the price of electric powered bus (E1) 625,500 USD (in the local currency exactly: 2,374,725 RON/E-Bus + VAT) need to mention that the purchase cost include the charger equipment and infrastructure for the 11 buses fleet. The operating, maintenance and energy costs must be calculated for the whole life cycle cost. To this end, it is worth adding ~ 185,000 USD for the battery replacement (A1), type Solaris High Energy (lithium–iron-phosphate – LiFePO4) for 200 kWh. Manufacturers openly admit that besides today's technologies there is a guarantee only of five years for today's electric vehicles batteries. A same size (12 m length) almost similar equipped Euro VI bus (D1), made by same bus supplier (Solaris) is available around 320,500 USD (Table I). Annual energy consumption (for fuel or electric) values are included in TABLE V, which help analyze difference between the Diesel and E-Bus. As presumption we assume the maintenance cost will approximate that is same value for both buses' life cycles.

Table 5. "Solaris" buses: diesel and electric comparison

Bus types "SOLARIS" / **Averages**	**E-bus EV Urbino 12**	**Euro VI / Diesel Urbino 12**
L- yearly average operation milage (km)	80,000	
E_u- average energy consumption (kWh/km)	1.1855	-
ENERGY consumption - total (kWh/year)	94,840	-
Ce_u - electric energy unit price (USD/kWh)	0.11	-
F_u- average fuel cons-umption (liter/100 km)	-	45
FUEL consumption - total (liter/year)	-	36,000
Cf_u- average fuel unit price (USD/liter)	-	1.51
C_{Atc} - Annual Energy Total Cost (USD/year)	10,433	54,360
CE $_{\mathbf{diff}}$ – annual energy cost difference (USD/year)	**43,927**	

Equation (3) calculates the annual cost differences (**CE**$_{diff}$) between the two buses:

$$\mathbf{CE}_{\mathrm{diff}} = [\left(\frac{L \times F_u}{100}\right) \times Cf_u] - (L \times E_u \times Ce_u) \quad [3]$$

Applying average values contained in Table V the yearly difference is in the amount of 43,927 USD.

$$\mathbf{T}_{inv} = \frac{(E1+A1)-D1}{CE_{diff}} \quad [4]$$

The Return of Investment (**ROI**) time (**T**$_{inv}$) is calculated by (4) taking into account the price difference between the E-Bus and diesel (E-Bus/625,500 USD +

Battery/185,000 USD = 810,500 USD and for Diesel Bus/320,500 USD) total difference 490,000 USD divided by 43,927 USD per year. The calculated amortization period is: **T_{inv} = 11.15 years**. As result and first conclusion, when the electric bus has an average life expectancy not more than 10 years as such it is not a desired investment for the only one economic reason!

6. CONCLUSION

"Everyone was laughing at BYD for making a toy…" recalled Isbrand HO, the Chinese Shenzhen-based company's managing director in Europe. "And look now. Everyone has one…" [14].

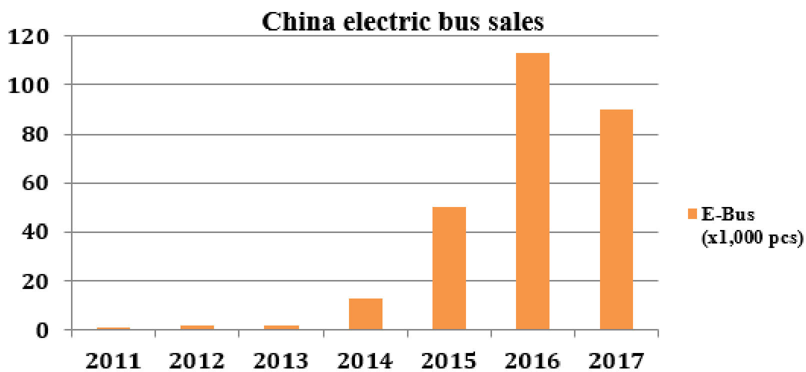

Figure 21. China electric bus sales last years (source: Bloomberg New Energy Finance)

Suddenly, buses with battery-powered motors are a serious matter with the potential to revolutionize city transport and add to the forces reshaping the energy industry. With China leading the way, making the traditional smog-belching diesel behemoth run on electricity is starting to eat away at fossil fuel demand. The numbers are staggering. China had about 99% of the 385,000 E-buses on the roads worldwide in 2017. For every 1,000 battery-powered buses on the road, about 500 barrels a day of diesel fuel will be displaced from the market according to Bloomberg New Energy Finance – BNEF calculations [14].

Although this paper is drafted as a technical study, it had to be completed with economic content in order to better understand the usage of E-Buses. There is a lot of money in the field of environmental protection, and governments more or less support the issues. An IMF (International Monetary Fund) study states that support schemes have a serious fiscal, welfare and environmental impact. According to calculations and simulations, with the withdrawal of major post-tax subsidies, globally the governments' revenues would have risen by 3,6% of GDP in 2015. Furthermore, and this is very important too, the mortality rates caused by air pollution would have been halved [15]. This decision is not made by engineers, but by politicians. Social backlashes, inflation and unemployment must be taken into account when shifting to eco-friendly industries. People need to be trained for new job markets.

The European Commission looks into a cost-effective way to make the European economy more environmentally friendly and energy-efficient. The – "Roadmap for a Low Carbon Economy", CE112 (2011), suggests that by 2050 the EU should reduce emissions by at least 80% below 1990 levels, with milestones being 40% by 2030 and 60% by 2040 [16].

Debate is open and engineers can argue whether the electric bus is environmentally friendly or not! This study had to take into account the whole process of manufacturing such a vehicle, which includes using rare earth materials. End of life costs are also higher for electric buses, given the higher hazardous material content. This is the main difference between Life Cycle Cost Management and Total Cost of Ownership, given that the owner should not only take on the costs and profits of the operation, but the vehicle's (or other products) owners are also responsible for the end operation, after-removal treatment costs.

As in Figure 21 in 2017 China E-bus sales has a small decrease. Many explanations we can have: other competitors, other suppliers conquered part of market with similar rate of price/quality. Maybe the operators/authorities are not full convinced that E-Bus will be the optimal solution? City governments all over the world are being taken to task over poor urban air quality. This pressure isn't going away, and electric bus sales must positioned to benefit.

Without energy, our society does not work. Our viable future lies in a much more balanced energy mix, and this will continue to play a role in fossil fuels in the long term, just as in the case of the rapidly growing proportion of renewable energy sources or the otherwise zero-carbon nuclear power.

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NEW MOBILITY SOLUTIONS TO FIGHT TRANSPORT POVERTY AND EXCLUSION IN EUROPEAN CITIES AND REGIONS

Key Words

Accessibility; Public transport; ICT; Transport poverty; Social innovation

Abstract

The lack of public transport options often means less access to goods and services, to job market, education, and recreational activities, which they all impact on the human wellbeing and social cohesion. People who do not have enough resources to access to more expensive mobility options could be automatically excluded from society. At the same time, other capabilities such as physical and mental health play a key role in social exclusion particularly in some deprived urban neighborhoods or remote rural areas across Europe. Vulnerable user categories such as mobility impaired and elderly people, youngsters, low income and unemployed persons, socially excluded or poorly integrated communities, migrants, etc. face a major risk. The social aspect of transport is key in addressing current societal issues such as migration, raising poverty, social exclusion, ageing society. The EU-

funded project INCLUSION (http://www.h2020-inclusion.eu/) is an addressing public transport accessibility, inclusivity and equity in a number of mobility conditions, including urban centers, deprived neighborhoods, remote rural areas and various user segments affected by some form of transport vulnerability or poverty. During its duration, the project is innovating the way transport is designed, organized, operated for the targeted user groups along three main investigation strands: Enabling technologies (ICT, ITS) through dynamic planning, optimization, operation; mobile Apps; IoT devices, wearables; social media; etc; New organizational and service provision forms such as vehicle sharing, co-ownership, liftsharing, flexible transport (DRT), combined mobility, MaaS; Social Innovation as a mix of new elements different from traditional transport economies based on the production and consumption of services/commodities. Innovative accessible transport solutions are being tested in Pilot labs in Belgium, Germany, Hungary, Italy, Spain and the UK with the purpose to finally transfer them to other prioritized areas across Europe.

1. INTRODUCTION

New mobility solutions to fight transport poverty and exclusion in European prioritized areas

The lack of public transport options often means less access to goods and services, to job market, education, and recreational activities, which they all impact on the human wellbeing and social cohesion. People who do not have enough resources to access to more expensive mobility options could be automatically excluded from society. At the same time, other capabilities such as physical and mental health play a key role in social exclusion particularly in some deprived urban neighborhoods or remote rural areas across Europe. Vulnerable user categories such as mobility impaired and elderly people, youngsters, low income and unemployed persons, socially excluded or poorly integrated communities, migrants, etc. face a major risk. The social aspect of transport is key in addressing current societal issues such as migration, raising poverty, social exclusion, ageing society.

The EU-funded project INCLUSION (http://www.h2020-inclusion.eu/) is addressing public transport accessibility, inclusivity and equity in a number of mobility conditions, including urban centers, deprived neighborhoods, remote rural areas and various user segments affected by some form of transport vulnerability or poverty. During its duration, the project is innovating the way transport is designed, organized, operated for the targeted user groups along three main investigation strands:

- Enabling technologies (ICT, ITS) through dynamic planning, optimization, operation; mobile Apps; IoT devices, wearables; social media; etc.
- New organizational and service provision forms such as vehicle sharing, co-ownership, lift-sharing, flexible transport (DRT), combined mobility, MaaS.
- Social Innovation as a mix of new elements different from traditional transport economies based on the production and consumption of services/commodities.

Innovative accessible transport solutions are being tested in Pilot labs in Belgium, Germany, Hungary, Italy, Spain and the UK with the purpose to finally transfer them to other prioritized areas across Europe.

A key aspect of the work is to investigate how novel transport solutions involving social innovation and ICT tools can help raise the level of accessibility, inclusiveness and equity of mobility in the reference areas and for the concerned users. This paper showcases innovative solutions from three pilot areas where ICT enabled social innovation is being developed or demonstrated. These offer a variety of technology-centered solutions ranging from delivery of completely new transport services, enhancements in operating performance of existing services, or improved understanding and awareness of user's needs and how to better cater for these.

2. EXAMPLES OF MOBILITY SOLUTIONS EMPLOYING ICT ENABLED SOCIAL INNOVATION

2.1. Barcelona Metropolitan Region: peri-urban areas and rural hinterland

Mobility planners want to improve transport accessibility in order that area residents may more easily attend cultural events in peri-urban areas of the Barcelona Metropolitan Region. Currently, public transport services are operated on a radial route structure linking peripheries and the metropolitan center. This does not meet the needs of citizens in the outskirts of Barcelona and neighboring towns, however, as services are inflexible and often infrequent, particularly at night.

The focus of this pilot initiative is to provide a safer, cheaper and more comfortable way for teenagers and young adults living outside the city to travel to a major music festival (Canet Rock) held overnight on the peri-urban fringe of Barcelona in Canet de Mar.

The solution applies information mining from Social Networks (Twitter) to identify the demand from potential users who want to attend the festival. This approach involves two different types of analysis: first, analyzing Twitter relationships of users connected with the "festival accounts core"; and second, analyzing non-structured data of Tweets. The social network data is combined with data on demographic distribution (highlighting the key geographic areas in the region), transport connectivity (between each geographic area and Canet de Mar), and historic data of festival attendees from previous years. This analysis enables planners to aggregate the mobility demand (event attendees) from different geographic areas which are poorly served by existing PT service provision and use this to propose the most suitable demand responsive tailored bus routes and bus-stop locations for the unserved demand.

From this analysis, 100 potential new stops have been identified - seventeen with high demand; thirty-three with medium demand; and fifty with low potential demand. The high and medium demand stops define the key points for the setup of new bus routes operated by BusUp (a PT service provider), while the low demand stops are included if they are located along any of the main routes. Having established the core routes, these are then publicized to other festival attendees via the festival website and Twitter account, allowing more attendees to book through the BusUp bus ride-sharing App/platform.

The Canet Rock festival will be held on 6th July 2019 and the effectiveness and satisfaction with the new BusUp bus ride sharing services will be evaluated and results reported in the final paper.

The innovation of information mining from Social Networks can provide a better comprehension of the demand and can radically improve the capacity of bus ride-sharing services, such as BusUp, to offer better tailored services and to better aggregate and serve the demand to large events (>10.000 attendees). BusUp currently serves more than 20 events in the EU and Latin America and the solution could be easily replicated to similar events (music concerts, sporting events, etc) elsewhere.

2.2. Flanders region

In Flanders, INCLUSION project partner Taxistop manages the “Less Mobile Stations service”, which reduces the barriers of participating in social life for less mobile elderly people by providing door-to-door transport. This service operates in 226 municipalities across the region, providing a service to 38,010 members using 2,846 volunteer drivers. Although a very popular service, two main problems exist: 1) attracting and retaining sufficient numbers of volunteer drivers to meet the demand; and 2) the long notice period required to book a trip. At present, users are required to book trips at least 2 days in advance of travel and, similarly, volunteer drivers are required to offer their availability as least 2 days in advance. The resulting services is not very responsive to user demands and, more significantly, rules out volunteers who may only know of their availability to offer their services on the day or night before. To overcome these problems, Taxistop have developed the MobiTwin App which provides the ability for both passengers to request trips and volunteer drivers to offer availability right up to the time of travel. The technology is making an already popular service more responsive to the needs of both passengers and volunteer drivers. For elderly members not able to use an App service, a friend or family member can use the App on their behalf and there remains the option to phone the Less Mobile Stations call center where staff can use the App on behalf of their clients. The MobiTwin App is being tested in two Less Mobile Stations service areas of Ghent, which is largely urban, and Oudenaarde, which is more rural in nature.

Enhanced ICT enabled social innovation features which can potentially be added to the MobiTwin App to further encourage more volunteer drivers will also be investigated. These include the introduction of gamification elements to encourage volunteers to maintain interest and enthusiasm in the service, and a form of dynamic pricing whereby increased rewards are offered to volunteers making themselves available at times of day when demand is greatest, or for agreeing to offer their services for trips which are of greatest social value (e.g. hospital appointments).

The MobiTwin App is being demonstrated from July 2019 and initial results will be available for inclusion in the final paper.

2.2. Budapest

In Budapest the aim of the INCLUSION project is to increase the service level for the people with reduced mobility. To reach this goal, project partner BKK, the public transport authority for the Budapest area, is introducing two connected pilot actions.

The first pilot action involves crowdsourcing information from groups of travelers with additional specific needs: blind and visually impaired, disabled, travelers with luggage or baby buggies, tourists, and foreigners staying in Budapest long-term. The jarokelo.hu webpage and App, which currently allows citizens to report everyday urban problems (i.e. uncollected rubbish, broken paving, pot holes, missing street bin and signs etc.), are being developed to allow these groups of travelers to report problems and issues they experience relating to any aspect of their PT journey. The crowdsourced information is collected, aggregated where relevant, and shared with authorities to act on. This information is also made visible to fellow travelers with common needs in order that they can benefit and learn from other's experiences.

With the use of the public crowdsourcing platform, a new social connection will evolve between the target groups and BKK who will gain a better understanding of the requirements and problems of the people with additional needs. This will then feed into the second pilot action: a new training program for public transport staff which is being developed and piloted in order to contribute to more competent and compassionate staff behavior and therefore a more inclusive environment.

The crowdsourcing app and staff training will be delivered between July 2019 and December 2019. In the longer term, BKK will use the aggregated crowd data to identify the most significant physical barriers and infrastructure problems highlighted to them, and can plan suitable infrastructure or service improvements needed to help raise the level of accessibility, inclusiveness and equity for the entire community.

3. CONCLUSION

The above examples of mobility solutions employing ICT enabled social innovation have been piloted through the summer of 2019 and initial results will be available by the end of October 2019. Final results and full evaluation will be completed by April 2020. A new key publication titled "Typology and description of underlying principles and generalizable lessons" will be made available as of November 2019. The aim of this publication is to help public and private stakeholders with an interest in improving the mobility situation for vulnerable user groups to determine the most suitable types of measure(s) for their context and needs. It is meant to provide inspiration and transferable know-how, based on the INCLUSION's analysis of the 51 case studies, while also building upon the knowledge base done at the beginning of the project concerning the identification of prioritized areas and user's needs.

ACKNOWLEDGMENT

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ANALYSIS OF TAXI TRANSPORTATION IN TOURIST CENTRES

Key Words

Urban traffic;
Taxi;
Transportation;
Liberalization;
Dubrovnik;
Split

Abstract

The liberalization of the taxi market in 2018 in the Republic of Croatia has resulted in an increase in the number of taxi vehicles on the roads. In coastal tourist centres, the demand for taxi transportation increases during the summer months. In order to meet the transport demand, taxi carriers with licenses have arrived from the continental cities to coastal cities. The paper will investigate the extent to which continental taxis affect congestion and the overall structure of the traffic flow. The purpose of the paper is to define a methodology for calculating the share of taxi vehicles in the traffic flow, which will allow their distinction according to registration marks. The aim of this study is to examine the proportion of vehicles with non-domiciled plates in the centres of the tourist cities of Dubrovnik and Split.

1. INTRODUCTION

The liberalization of the taxi market in the Republic of Croatia has resulted in a rapid increase in the number of taxi vehicles on the roads. The effect of a large number of taxi vehicles is particularly evident in coastal cities during the tourist season, when demand for taxi services is extremely high. Due to the increased demand for a transport service, part of the taxi drivers from the continental part of Croatia decided to provide a transport service in the coastal cities. The result is directly reflected in the newly generated traffic flow. The aim of this paper is to investigate the share of taxi vehicles in the total traffic flow, as well as the share of taxi vehicles of continental license plates providing transportation services in the coastal cities. The research was conducted in two cities, Split and Dubrovnik, and the paper presents the research methodology, generalized results, discussion and conclusion.

2. METODOLOGY

In the study of traffic flow structure, the method of counting was used. Counting is a methodological procedure that determines the number of elements or members of a set. In this case the elements or members of a set are defined groups of vehicles.

Consequently, the traffic flow structure is divided into eight groups of vehicles, namely:

1. City bus – public transport;
2. Tourist bus;
3. Passenger car;
4. Taxi (domestic registration plates);
5. Taxi (other registration plates);
6. Motorcycle / moped;
7. Van (cargo and passenger);
8. Truck / heavy vehicle.

The counting was done manually at the cross sections of selected roads. In total, ten counting locations were selected, six in the city of Split, and four locations in Dubrovnik. Counting was done in the morning and afternoon peak periods.

Vehicle flow q (vehicle / h) is the number of vehicles passing through a cross section of a road or one lane in a unit of time. By its structure, the traffic flow can be homogeneous or mixed. A homogeneous flow is considered to be a flow of a type of motor vehicle composed of vehicles of the same or similar technical characteristics. Thus, traffic flow can be: freight, passenger, special and other vehicles [5].

A mixed flow is considered to be a traffic flow consisting of several types of vehicles. In practice, the heterogeneity of such a flow is represented by the percentage of other vehicles (buses, trucks, motorcycles, etc.) in the traffic flow [2].

$$P_{taxiDOM} = \frac{\sum q - q_{bus} - q_{pcar} - q_{mo} - q_{hv} - q_{van} - q_{taxiOTHER}}{\sum q} \cdot 100\ [\%] \qquad [1]$$

where:

$P_{taxiDOM}$ - share of taxi vehicles of domestic registration plates

$\sum q$ - the sum of all vehicles in the traffic flow

q_{bus} - number of buses in the traffic flow

q_{pcar} - number of passenger cars in the traffic flow

q_{mo} - number of motorcycles/mopeds in the traffic flow

q_{hv} - number of heavy vehicles in the traffic flow

q_{van} - number of vans in the traffic flow

$q_{taxiOTHER}$ - number of taxi vehicles of other registration plates

$$P_{taxiOTHER} = \frac{\sum q - q_{bus} - q_{pcar} - q_{mo} - q_{hv} - q_{van} - q_{taxiDOM}}{\sum q} \cdot 100\ [\%] \qquad [2]$$

where:

$P_{taxiOTHER}$ - share of taxi vehicles of domestic registration plates

$\sum q$ - the sum of all vehicles in the traffic flow

q_{bus} - number of buses in traffic flow

q_{pcar} - number of passenger cars in the traffic flow

q_{mo} - number of motorcycles/mopeds in the traffic flow

q_{hv} - number of heavy vehicles in the traffic flow

q_{van} - number of vans in the traffic flow

$q_{taxiDOM}$ - number of taxis of domestic registration plates

For the purposes of this research, formula (1) is defined to express the share of taxis with domestic registration plates in the traffic flow and formula (2) to determine the proportion of taxis that do not have the domestic registration plates [4].

3. RESEARCH RESULTS

The collection of traffic data and its projections of traffic volumes are basic prerequisites for planning and managing road development schemes [3].

Data were collected at a total of ten locations and averaged data were presented for more convenient presentation. Data were collected at a total of ten locations and averaged data were presented for more convenient presentation. Complete data can be accessed in studies [6] [7]. Traffic counting was conducted in two periods of the day, the morning and afternoon peak periods. *Figure 13* and *Figure 14* show the share of each vehicle type in the total traffic flow for the city of Dubrovnik and Split during the observation period.

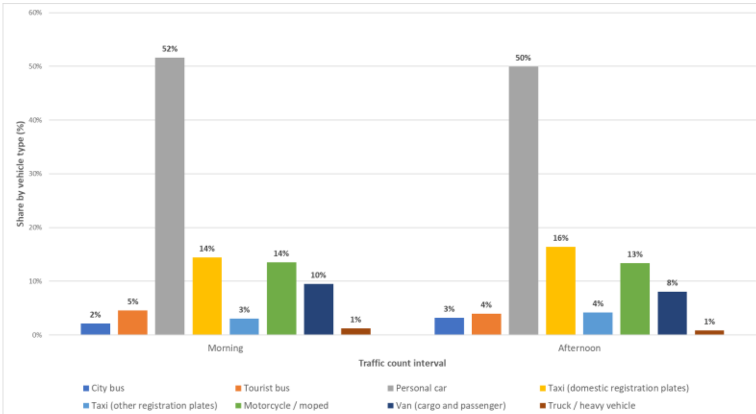

Figure 13. Share of vehicles by type, City of Dubrovnik [7]

According to data obtained from a field research in the City of Dubrovnik (*Figure 13*), passenger cars account for the largest share of vehicles in traffic, with a share of 50% in the morning and 52% in the afternoon periods. This is followed by the share of taxi vehicles with 17% in the morning, of which 14% are domestic registration plates and 3% of other registration plates. In the afternoon, taxi vehicles represent a share of 20% of total traffic flow, of which 16% recorded taxis refer to taxis of domestic registration plates, while 4% referred to vehicles of other registration marks. Of other vehicles, motorcycles / mopeds have a higher share in the total traffic flow with a share of 14% in the morning and 13% in the afternoon, and vans with a share of 10% of the total traffic flow in the morning and 8% in the afternoon periods.

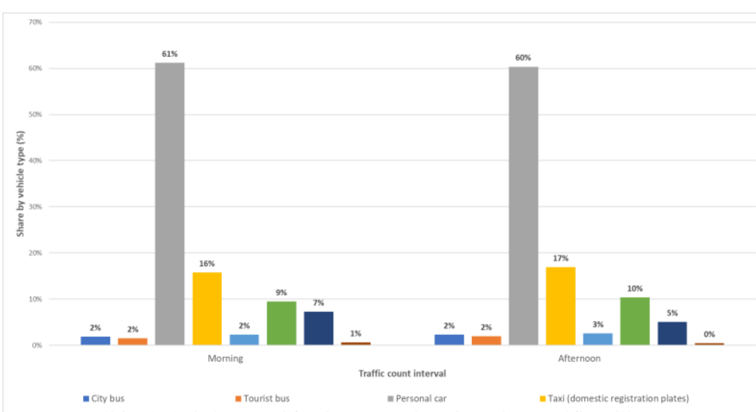

Figure 14. Share of vehicles by type, City of Split [6]

Figure 14 shows the results of the field research in the city of Split. It is evident that passenger vehicles account for the largest share in the total traffic flow, with 61% in the morning and 60% in the afternoon periods. As in Dubrovnik, the second highest share of vehicles in Split is represented by taxi vehicles, with 18% (16% of domestic registration plates and 2% of other registration plates) in the morning observation period, while in the afternoon, the share of taxi vehicles increased to 20% (17% of domestic registration plates and 3% of other registration plates) of the total traffic flow. This is followed by motorcycles / mopeds with a share of 9% of the total traffic flow in the morning and 10% in the afternoon periods, and vans with a share of 7% of the total traffic flow in the morning and 5% in the afternoon periods.

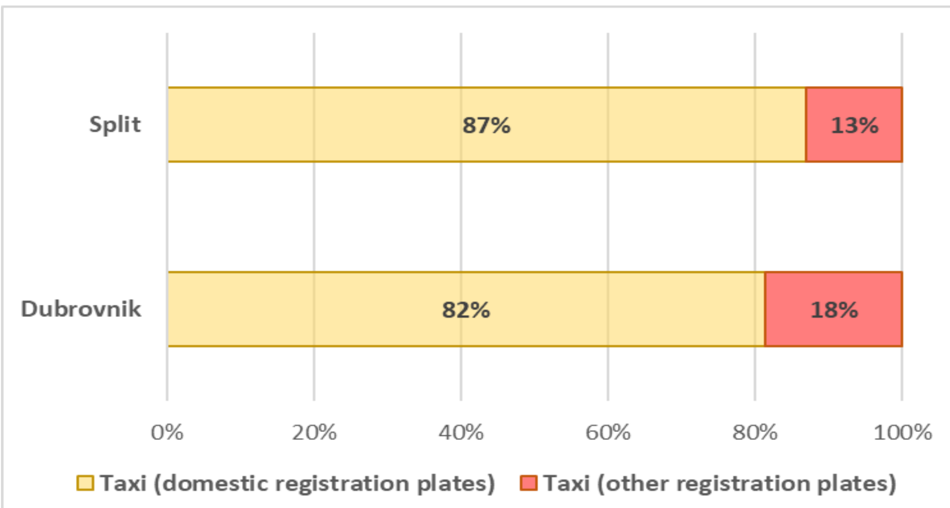

Figure 15. The share of taxis by registration plates [6] [7]

Observing the share of taxi vehicles according to vehicle registration marks, it was concluded that domestic taxi vehicles still represent a major proportion. The survey found that taxi vehicles of other license plates represent 18% of the total number of taxi vehicles in the city of Dubrovnik, while in Split the share is lower and amounts to only 13% of the total number or taxi vehicles in operation.

4. DISCUSSION

The data presented in this paper show the average results of all observed locations, and there are considerable discrepancies for certain locations. There are locations where the traffic flow with large differences in proportions when it comes to taxis is recorded, thus highlighting the location of "Ulica Domovinskog rata" in Split, where at peak time the share of taxi vehicles was as high as 40% (34% of the domestic registration plates and 6% of other license plates), thus becoming the primary form of traffic in the city. There are also similar locations in Dubrovnik, an example of which is the “Pile” location, where the share of taxi vehicles in the peak hour reaches 34% of the total traffic flow, of which 28% are taxis of domestic registration plates, and 6% of taxis of other registration plates.

There is a great need for continuous monitoring and collection of traffic flows and other indicators of mobility. The reason for this is to obtain urban mobility trends that would result in better decision-making and urban policies for cities [1].

5. CONCUSION

Although there are concerns about the rapid increase in the number of taxi vehicles as a result of market liberalization and the arrival of a large number of taxi vehicles from the continental area of the Republic of Croatia to the coastal area for the purpose of providing transport services, this share still represents about 3% of the total traffic flow in the cities researched. When viewed as a share of the number of taxi vehicles of other registration plates compared to domestic registration vehicles, the ratio continues to favor domestic taxis. The share of taxi vehicles with domestic registration plates in Dubrovnik represents 82%, while in Split 87% of the total number of taxi vehicles, which concludes that a large number of taxi drivers coming from the continental territory of the Republic of Croatia is still not a critical segment in the total traffic flow, and therefore cannot be a main cause of traffic congestion in the observed areas.

It was concluded that future research should monitor the structure of traffic flow, as one of the important traffic indicators, on an annual basis, in order to enable comparison and quality decision-making in the direction of improving the urban transport system.

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INCREASING MOBILITY OF POPULATION IN SUBURBAN SETTLEMENTS THROUGH OPTIMIZATION OF PUBLIC TRANSPORT LINES

Key Words

Public transport; Rural settlement; Optimization

Abstract

People who live in the suburbs, largely rely on the cities for jobs, shops and other facilities. They choose to live in and around cities, in urban city centers, in quiet areas, depending on the needs they have. Road construction in cities and low-income areas is the most important task in creating the conditions for designing efficient transportation solutions. It is well known that rural residents realize less movement, but in doing so they cross longer distances from the beginning to the end of the journey. Therefore, the topic of the paper is related to the optimization of the operation of two lines in the public urban passenger transport system in Niš, rationalization and improvement of transport on the line where there are higher transport requirements in relation to the number of departures. The study also refers to a real understanding of the needs of residents of the two suburbs using PT (line 7 and 27Lb) because of the possibility of linking and connecting two lines

into one line with the central part of the city, to improve living conditions in the suburbs. Also, the aim of the research is to reduce exploitation, ie more rational use of resources (vehicle costs, working, etc.) that can be better utilized.

1. INTRODUCTION

Building roads in cities and areas with low revenue is most important task in creating the conditions for designing efficient transport solutions. Urban planning and designing for cities with middle and higher level of revenue, is critical to reduce distances and increase accessibility to transport solutions. Urban planning and designing should be focused on connecting people and places, making cities more accessible to inhabitant, but not just on increasing in the length of the roads or increasing extent of movement of people and goods. Now, the most of cities are built to make pretty inefficient use of infrastructure when most residents going in the same direction.

Increasing sustainability of public transport systems may be achieved by increasing the share of public transport and non-motorized modes of transport (walking and cycling) and reducing private transport. Of course, it is encouraged by the fact od switching to a non-motorized mode, however, it can be confirmed that such models are the best for local trip and that such motorized traffic plays an important part during long distance trip.

There is a lot of ways to accomplish city travel. Different models of travel are conditioned for different purposes, but all of these trips are part of an urban transport system. Cars are ideal for wide specter of travel purposes, including long distance travel, transporting more than one person, or heavy cargo, which is not available with other models of transport. When everyone drives car, by either choice or lack of options, the roads in every city become more congested [one]. Public urban transport is ideal for transporting many people's o key locations, without using a lot of space for lanes and parking places.

Traditional public transport means the movement of vehicles on a fixed route, fixed stops and according to a predefined time schedule of departures. Therefore, the main disadvantage of this mode of transport is the incompatibility of passenger requirements. This practically means that rural residents, if they do not have another transport alternative, have to adapt their transportation needs to the defined way of public transport functioning. In this way, many residents are forced to give up certain travel, and it is often the case that this implies the abandonment of job search outside the place of residence, the abandonment of education, health care, cultural and sporting events, and the like [2,3].

Public transport can reduce social and economic inequalities by improving the mobility of residents. Many of them are without cars and jobs near the areas where they live. Such jobs serve us an important source of income for those who face with limited employment opportunities. Finally, using public transport residents make lower household costs and it releases resources for other uses.

Only 32% of all rural municipalities have access to public transport services, so if 28% of communities which have limited access to public transport are taken into account, it becomes clear that the remaining 40% of population in suburban areas is left without an option for public transport [4]. A recent survey has determined that 92% of Canadians thinks that public transport makes their community a better place for living [5].

The purpose of the labor is to optimize the operation of lines 7 and 27lb in the system of public urban transport in Niš, for rationalization and improvement of transport on the line where more transport requirements than the number of departures are. The research was also conducted to realistically insight needs of residents of the two suburban settlements for the use of public urban transport, due to the possibility of connecting two lines into one single line, with the central part of the city, in order to improve the living conditions in the suburban settlements.

In the beginning of labor, the introduction explains the importance of the existence of a public transport system in suburban settlements and how it works. Also, it include some of the authors researches on mobility in suburban settlement. The second chapter describes the operation of the line 7 and 27lb in the system of public urban transport in Niš. The third chapter contains the results of the researches of transport requirements on this lines. Looking for public urban transport services.

2. FUNCTIONING OF LINE 7 AND 27LB IN PUBLIC TRANSPORT SYSTEM IN NIS

Looking for public urban transport services should be proportionate to the accessibility it provides: better accessibility should reflect greater demand. It is considered from the point of view of how much potential passenger (residents) really have the opportunity to realize transport needs from suburban settlements according to the contents or activities that are mainly concentrated in the central city center.

Line 7 (Pavle Stojković's Square – Medoševac) as a urban line connects the suburban settlement with the downtown and it is 2.9 km long ,while line 27lb (K. Aleksandra's Square – Popovac) is defined as a suburban line and it is 7.3 km long (Figure 1). At line 7 the turnaround time is 30 minutes and at the line 27lb the turnaround time is 50 minutes. During the day, two vehicles operate on these lines.

Vehicles that operate on line 7 and 27lb are solo vehicles, with a capacitance of at least 70 passenger. However, on line 7, the contract stipulates between the Public transport direction and operator that on line have to operate a Type A solo vehicle containing minimum of three doors, which two of them are at least 1.00 m wide.

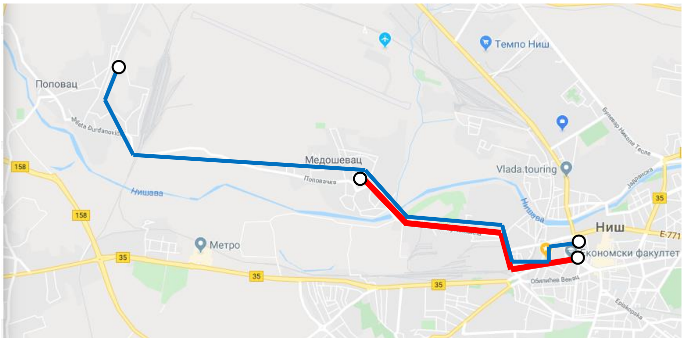

Figure 1. The route of the lines 7 i 27Lb

The line 27lb stipulates that it have to operate a type B solo vehicle, intended for suburban traffic, which has seating and staying position, with a minimum of two doors that do not need to be double-leafed and with a minimum capacitance of 70 passengers.

3. RESEARCH OF TRANSPORTATION REQUIREMENTS ON OBSERVED LINES

Due to the constant changes in the urban structure resulting drom the construction of residential, business and other zones and building or their reconstructions the locations of the sources and destinations of passengers in the urban area are changing and therefore the characteristics of the passenger flows and their respective value are changing.

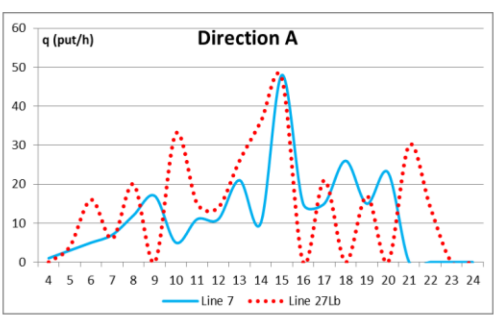

Figure 2. Passenger flow in direction A

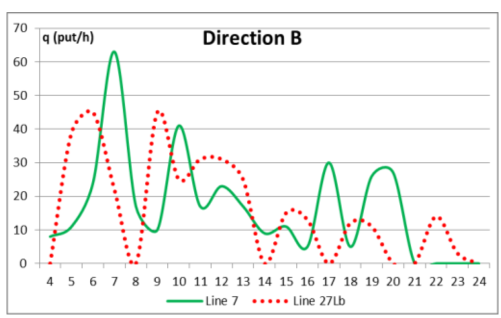

Figure 3. Passenger flow in direction B

The numbering of passengers in the public transport system was made from 07.08 to 18.08.2019. year, at working days, Saturday and Sunday. The results obtained after processing the data, passenger flow (Figures 2 and 3), passenger change factor, flow unevenness…, for the working day (Table 1 and 2) are shown below.

Table 1. Research results for line 7, direction A

Time of departure	P	q_{max}	q_{sr}	l_{srv}	η_{sm}	n_p	NTR
4:50	1	1	0.2	639.2	1.0	4.6	639
5:20	3	3	0.6	639.2	1.0	4.6	1918
6:00	5	5	2.8	1626.4	1.0	1.8	8132
7:01	3	3	0.2	213.1	1.0	13.9	639
7:30	4	4	1.3	970.9	1.0	3.0	3884
8:00	7	7	3.8	1587.0	1.0	1.9	11109
8:50	5	5	2.2	1272.4	1.0	2.3	6362
9:40	17	16	9.8	1709.4	1.1	1.6	29060
10:20	5	5	3.1	1805.5	1.0	1.6	9027
11:22	11	11	5.3	1422.3	1.0	2.1	15645
12:11	11	11	6.5	1747.0	1.0	1.7	19218
13:09	15	15	8.7	1710.9	1.0	1.7	25663
13:40	6	6	3.0	1479.2	1.0	2.0	8875
14:45	10	10	6.2	1832.2	1.0	1.6	18322
15:15	20	20	11.6	1708.3	1.0	1.7	34167
15:46	28	28	17.6	1861.3	1.0	1.6	52117
16:30	15	15	10.0	1966.1	1.0	1.5	29491
17:20	15	15	9.4	1859.0	1.0	1.6	27885
18:05	14	14	9.1	1920.4	1.0	1.5	26886
18:45	12	12	7.5	1855.5	1.0	1.6	22266
19:26	15	15	9.0	1770.5	1.0	1.7	26558
20:00	8	8	5.3	1966.1	1.0	1.5	15729
20:30	15	15	9.5	1877.6	1.0	1.6	28165

P – number of passengers; q_{max} – maximal flow of passengers; q_{sr} –average passenger flow; l_{srv} –median driving length; η_{sm} –passenger change factor; n_p –flow unevenness along the line; NTR – neto transport work (passenger km).

Table 2. Research results for line 27lb, direction A

Time of departure	P	q_{max}	q_{sr}	l_{srv}	η_{sm}	n_p	NTR
5:25	4	4	0.3	520.0	1.0	13.7	2080
6:15	16	16	2.8	1228.5	1.0	5.8	19656
7:20	8	6	1.4	1215.6	1.3	4.4	9725
8:20	22	20	7.0	2257.5	1.1	2.9	49665
10:15	34	33	18.4	3856.8	1.0	1.8	131130
11:15	17	15	8.0	3342.8	1.1	1.9	56827
12:21	17	14	8.4	3511.2	1.2	1.7	59691
13:30	26	26	13.1	3609.6	1.0	2.0	93848
14:40	37	36	18.5	3573.1	1.0	1.9	132206
15:45	47	47	20.3	3081.2	1.0	2.3	144817
17:45	24	21	10.7	3177.5	1.1	2.0	76259
19:00	18	17	8.2	3239.0	1.1	2.1	58303
21:30	31	30	15.7	3622.3	1.0	1.9	112292
22:40	14	14	6.4	3259.5	1.0	2.2	45632

The 7 and 27lb lines can be optimized into a single line, where users of public transport from Medoševac would have reduced comfort of traveling, but from the economic aspect, relevant savings are achieved in terms of vehicle exploitation, manpower and other basic assets of work (fuels, lubricants ...). It should be noted that this would also reduce the pollution of the ecological system by the exhaust gases that greatly affect to global warming of the planet. This also leaves the possibility of transferring the vehicle to work on another city line, which is more frequent, where it is really necessary to increase the frequency of the vehicle to reduce the interval. The line could be formed as a city line, even though it operate to a suburban settlement, because it would use some of the existing two terminuses located in an urban city area.

The terminus at line 7 in direction A is Pavle Stojkovic's Square, and the 27lb line in direction A is King Aleksandar's Square. These two terminals are less than 100 meters away from each other and could easily integrate the terminus because of their proximity, which is acceptable on the passenger side, since they would not need to walk longer. It is suggested that this terminus should be located on King Aleksandar's Square as there is a larger street space where a bus can be stopped and parked. Other city lines pass at this stop, so again it will be more convenient for public transport users, because of the easy and efficient transfer, and because there are more eaves at the bus stop that protect passengers from atmospheric precipitation.

4. CONCLUSION

The population in suburban areas is constantly declining and this trend will continue in the coming period. Retaining the existing population (households) is the basic task of any suburban development planner in one city territory. Increasing accessibility to basic living needs and amenities is a major prerequisite for survival and possible return of residents.

In order for rural areas to be competitive for life and attractive for economic investments, it is necessary to provide adequate infrastructure and quality public transport, apropos accessibility to transport. Due to the specificities decided by the rural communities, their transport requirements are also specific, and their deeper understanding is needed in order to take correct measures for the social, economic and environmental development of rural areas.

The survey was carried out in the summer, that is, according to the summer regime of the schedule, where the schedule is reduced in regard to the winter regime, respectively to the regime when educational institutions do not work and when the holiday season is over. From the obtained results it can be noticed that the utilization of the transport capacity on the line 7 is very small, there is no drastic number of transport requests throughout the day, it should also be noted that the route of the line with 27lb is partially the same. The routes of the line 7 and 27lb also use lines 27la and 28, but not completely.

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INTEGRATION OF PUBLIC PASSENGERS TRANSPORT SYSTEM AND CYCLING

Key Words

Public passengers transport; Bicycle; Multimodal transport; Integration

Abstract

The integration of public passenger transport (PPT) and cycling is a good approach to solving problems in cities. A bicycle as a mode of transport can be a way of accessing the PPT, especially at distances beyond the user's ability to walk to the station. Global experience has shown that the integration of PPT and cycling leads to increased use of PPT and reduced use of cars, and consequently traffic congestion in cities. Therefore, PPT can play an important role in improving spatial accessibility and enhancing the quality of the environment.

1. INTRODUCTION

In view of the increasing demands of passengers, nowadays, it cannot be ignored that there are problems in public passenger transport (hereinafter referred to as PPT). Road networks are facing increased traffic congestion, sometimes even traffic jam, and the quality of accessibility for economically important content is significantly decreases. On the other hand, it seems that PPT systems are unable to cope with changes in the passenger transport market and to respond to customer demands. That is why capacity building, promoting PPT and integrating cycling represents are a good approach to problem solving in cities.

When talking about cycling, the simple construction of the bicycle and its wide applicability have led to its use in daily life. Based on the analysis, it is estimated that there are over one billion bicycles in the world, however, this data does not rank place the bicycles among the most used means of transportation. Cycling as a mode of travel has expanded rapidly in both developed and underdeveloped countries. This type of activity is becoming more and more relevant in Europe, given the high price of derivatives, it is expected that this trend will continue. A bicycle, on the one hand is a means of transport and on the other, plays a major role in a healthier lifestyle in humans. In addition to its environmental and health benefits, it is often used for relaxation and sports purposes in free time.

In many cases, cycling can be combined with other modes of transport. Combining this most often occurs in the form of bicycle integration with the PPT system, which is nowadays show a highly current multimodal transport. Whether privately or publicly owned, bicycles within the transportation system itself form an important link in the travel chain.

Before commencing the journey, each passenger makes a series of plans that relate to the calculation of the time required to arrive from a departure point to a destination with available transportation options, finances with the choice of a different transport network. There are certain distances where it is more economical for cyclists to travel one part of their travel by another mode of transport. The complete infrastructure system, as well as the existence of parking and other facilities with accessories for storing and care bicycles, should allow customers to make the best decisions regarding the choice of travel modes. The integration of bicycles and public passenger transport systems could be an effective approach to solving part of the problem of people mobility.

The paper presents the characteristics of bicycles and regular PPT systems that are important for the physical integration of these two modes of transport. The paper also provides a comparative analysis of the experience of developed cities in Europe in integrating bicycles and regular PPT systems.

2. MULTIMODAL TRANSPORT

Multimodal transport is representing the use of two or more different modes of transport for one trip between which the passenger must make a transfer. The mode of transport can be defined according to the type of vehicle or organization of transport of passengers. The part of the trip that is traversed by one mode of transport is calling the section of travel. Typical examples are trips where a bicycle is used to access a railway station or to trip from a railway station to a final destination.

Transfer is a key segment of multimodal transport, because passengers have to change mode of transport. Transfer increases the trip time and trip costs, thereby seriously damaging the quality of the transport service.

Walking is always part of the trip and passengers must always walk to and from the public interchange station, car and parking lot, and the distances are usually short. Walking can be considered a basic component at the beginning and end of any trip, so it is not considered a special mode of trip. By definition,it does not represent a particular mode of trip and does not enter into the definition, unless the walking part exceeds major part of the total distance in relation to the total length [1].

Multimodal transport consists of: Transport service integrator and transport service organization. The transport service integrator decides about choice on the modes of transportation used for a particular trip. The role of the transport service integrator is usually performed by the passenger himself, but can also be performed by a third countenance, most often the agency. The organization of PPT services can be organized at the city, regional or national level, while the commercial transport services (car, bicycle, etc.) are organized by the passenger himself, that is, passenger determines the trip times and the route of trip [1].

3. INTEGRATION MODEL OF BICYCLE AND PPT

Multimodal trip can be defined as a "chain", which links travel to different modes of transport. Spatially observed travel of each customer in the PPT system consists of at least three components (simple trip):

- Access system – moving (often walking) from home-basic leg to bus stop.
- In-vehicle travel time PPT.
- Trip from bus stop to activity-basic leg [2].

If two or more PPT regular lines are used for the trip then the trip chain is further complicated. PPT is not door-to-door, apropos PPT users must travel from the home-basic to the PPT bus stop and finally from the PPT stop to the destination. The integration of cycling with the PPT system enables users to access the PPT system and leg from bus stop to final destination is realized by bicycle. Travel time is reduced when the PPT system has a ROW B dependency or an independent ROW A route [2]. The well-executed integration time travel becomes competitive with the passenger car, which is especially emphasized in major cities where congestion and deficit of parking area to car. Access to the system (home-basic leg) and moving from the exit bus stop to the destination of the trip are the components in the PPT "chain" trips of which passengers has the most benefit after integrating the bicycle and the PPT. Full integration of bicycle and PPT systems must include all three forms of integration: physical, tariff and logical. Physical integration is a basic form that must be fulfilled for multimodal trips to be feasible. Physical integration must, first and foremost, provide adequate means and infrastructure (vehicles and bus stops) and associated services in depending on the size of the customers requirements. Depending on the technical characteristics of the PPT, different variants of multimodal trip are also possible. The first option implies that the bicycle is transported along with the passenger. Such vehicles have space for accepting bicycles in the vehicle (as on figure 2) or there is a system for accepting bicycles outside the vehicle (as on figure 1). In the first option, the customer is able to access the system and travel to the destination by bicycle [4].

Figure 1. Bicycle on bus


Figure 2. Bicycle in train

In another option, the passenger parks his bicycle at the PPT station. In this option of immediate the PPT station it is necessary to provide adequate infrastructure for the safe parking of bicycles or ancillary services that will enable bicycle rental [4].

In accordance with the previously stated for the successful integration of bicycle and PPT, it is necessary to provide suitable vehicles, specialized PPT stations and additional services at the PPT stations. In integrated systems, at the PPT stations there are three kinds of services:

- Rental bicycles: Bicycles that are managed by a specific company and are rented and returned to the same location (mostly for tourist purposes);
- Shared bicycles: An important form of public transport, shared bicycles allow for trips linked to public transport and increased public transport range and are similar to rental bicycles, but organized on a larger scale. Kiosks or stations are located throughout the city to allow users to circulate shared bicycles. Often rented for short periods of time through a membership system, bike-share serves both tourists and commuters;
- Bicycle taxis (pedicabs): Three-wheeled human-powered vehicles that operate as feeders to public transport.

On another hand at the PPT station the following is necessary:

- Bicycle parking: Secure parking of adequate capacity for PPT users and other bicycle users;
- Bicycle stations and objects: Enhanced bicycle facilities in key locations with various services, used as a multimodal transfer station. Services may include key card access bicycle parking, locker rooms, showers, rental, and retail facilities.

During the public transport travel PPT must provide:

- Bicycles on buses: Provision of bicycle racks on the front of or within buses (as on figure 1), where public transport relies mostly on bus-based systems or in them (as on figure 2);
- Bicycles on rail systems: Provision of space and permission to enter rail vehicles in specific times and locations, for large cities with rail-based systems (in major cities with a rail passenger transport system) [4].

When passenger decide trip time and how to make the trip, they take into account: time, simplicity and cost of service. Delays and transfers increase travel time. Estimate and calculating delays is an important part of structuring overall trip. If the PPP service is frequent, the waiting time will be minimal. If finding bicycle parking takes a long time, the transfer time should be longer. Cycling time only from home-basic to destination can be equally to a trip that includes transfer, especially for short trips (as on figure 3) [4].

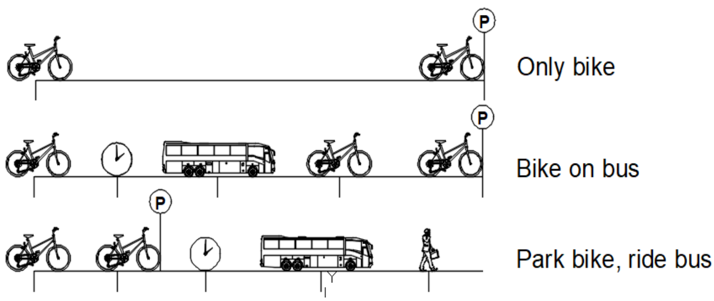

Figure 3. Comparison of the temporal structure of different variants of multimodal trip [4].

Bicycle trip exponentially increases the gravitational area around an integrated PPT station. Ten minutes is used as an acceptable time to access the system PPT high quality of service (BRT, LRT, or Metro). Man can walk about 800 meters in 10 minutes moving at an assumed speed of 5 km/h. However if access to the PPT system performed by bicycle (assumed speed of 15 km/h) at the same time the user exceeds a distance of 2.5 kilometers. If a bicycle is used, the length of acceptable access to the system is increased by three times, while the gravitating area is increased ten times (as on figure 4) [4].

In line with the above, the benefits of integrating bicycles into the PPT system are:

- Door-to-door service, competitive to the passenger car;
- Greater gravitating area of the PPT station;
- Reducing traffic congestion in cities;
- Reduced need for car parking area;
- Less delays;
- Transportation in case of bad climatic conditions;
- Transport in case of a technical failure on a bicycle;

Transport in case of heavy topography characteristics [5].

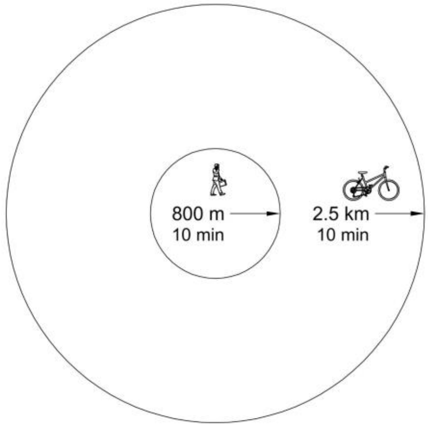

Figure 4. The gravitating area of the bicycle relative to the pedestrian [4].

4. THE WORLD EXPERIENCE OF INTEGRATION

Depending on the PPT and cycling integration model, as well as from the share bike previous representation in the mode distribution of trips, different effects have been recorded around the world of PPT and bike integration. In this chapter experiences of individual countries are presented and cities from Europe and North America.

In Table 1 presents the share of bicycles in the mode of distribution of access to the PPT system for different cities and countries in Europe. According to the data presented, there is a large difference in the effects of integration depending on the PPT subsystem. The railway and other high-speed subsystems of the PPT have a greater share of integration with cycling than in the bus subsystem. An exception is the United Kingdom, which can be attributed to the fact that the data for bus PPT and bicycle trips are related to the Park & Ride system and not to the classic bus subsystem.

Table 1. Percentage of bicycle use in modal distribution access to PPT system [6;7;8;9]

PPT subsystem	Netherlands	Germany	United Kingdom	Denmark
Regional train	30	16	3	25
Suburban train	-	10	-	22
BRT	14	-	-	12
City bus	6	4	4	4
Metro	1	5	-	-
Total for all subsystems	27	13	2	26

According to other research [10] between 1995 and 2018 PPT trip is increased to 38% in the US and 48% in Canada. However, according to [11] in Canada over the short period from 1996 to 2006 the number of bicycle trips increased by 42%. The capacity of bicycle parking lot in the United States in 2008 was 24,178 at railway stations and 9005 at bus station. In the same period, Canada recorded a bicycle parking capacity of 2,892 parking lot at train stations and 481 at bus station. Between 2006 and 2008, bicycle parking offers increased 67% in Canada and 26% in the United States. Extremely great influence on the development of Bike & Ride system integration in North America is achieved by promoting the concept of mounting a bicycle rack on the front outside of the bus because the bus PPT has a 60% share of the total number of trips [5].

Another important aspect of the development of the integration of cycling and PPT is the license and provision of access and conditions for the transport of bicycles inside the PPP vehicle. PPT systems that allows bicycles to be transported inside the vehicle are most often LRT, metro and suburban railway, which is not sufficient and other PPT systems should be encouraged. There are some solutions for PPT systems that provide a special car or space for storing and transporting bicycles during passenger travel. Also, there are various structural solutions such as: special hooks, brackets, special surfaces near the door [5].

The Netherlands is a good example of using a bicycle for everyday travel [12]. The Netherlands has been developing cycling since 1970, when it was decided to increase the percentage of non-motorized transport. By 1978, the Netherlands had nearly doubled its cycling network capacity from 9282 km to 18948 km [13]. On the other hand, until 1990, the integration of the bicycle and the PPT system was not level high. Only the railway stations had equipment and facilities for parking and bicycle guard. In the early 1990s, a program was launched to systematically upgrade and extend existing parking lots at all railway stations [6]. As disadvantage of PPT stations is reflected in the small number of bicycle parking lots. Estimates show that only 10-20% of stations are equipped with bicycle parking equipment from all stations PPT in the Netherlands [7].

5. CONCLUSIONS

Multimodal transport based on the integration of PPP and cycling is a good instrument for solving enormous traffic congestion in cities. To encourage PPT users to use the bicycle as a mode to access the system PPT and trip to the final destination, above all, the physical integration of these two modes of transport must be executed. Physical integration is primarily about providing basic conditions for secure bicycle parking at a PPT station but also transporting the bicycle by PPT. Installation of these facilities should be done at key locations in the PPT system according to user requirements. The further growth and development of the use of bicycles in PPT systems in addition to the physical is favorably influenced by other types (kinds) of integration, that is, tariff and information integration.

An analysis of the available experiences of European and North American countries has shown, that the degree of bicycle use in multimodal trips with PPT directly depends on the development of infrastructure facilities that enable and facilitate the successful integration of the two modes of transport.

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7th INTERNATIONAL CONFERENCE
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SMART BUS STOPS

Key Words

Smart cities;
Bus stops;
Smart technologies

Abstract

The importance of well-organized and set bus stops at appropriate locations is of great importance for the city. Cities are striving to provide a quality lifestyle for their residents and to become smarter and more fit. Passenger terminals, as an important segment of the transportation system, must be integrated into the concept of a smart city. In recent years, there have been various initiatives to improve public spaces such as bus stops with the aim of providing quality customer service. The application of modern technologies makes it possible for viewpoints to become smart and to make waiting times for public transport vehicles a useful activity.

1. INTRODUCTION

The more decades-long trend of moving population from smaller communities to cities is still present. There are several reasons for population migration to cities, such as, for example, rural underdevelopment, greater opportunities offered by cities in terms of education, employment and generally quality of social life. Due to the increasing of population, cities are trying to adequately adapt to the changes that have occurred and to organize the housing, movement and functioning of the population in general as effectively as possible. The population migrations continue and do not tend to change in the form of shrinking urban populations, and it is a reason that city governments will need to work even harder and more efficiently. As a result, various "smart strategies" that are implemented in different fields are becoming increasingly important, so that smart cities will set standards in major metropolitan areas around the world in the near future.

2. SMART CITIES AND IOT (INTERNET OF THINGS)

The term IoT is networking of objects over the internet. Different networked objects are intended to provide support for people in their everyday lives and at the same time generate an enormous amount of structured data, which can be used for analyses and optimisations [1]. The essence is that the smart city takes into account all the basic elements that make up the urban tissue, in order to avoid conflicts (social, economic, financial, environmental and cultural), with the aim of improving the environment and quality of life in general.

The smart cities are using IoT devices, as sensors, lights and counter for collect and analyze data [2]. Therefore, IoT is considered to be one of the most important data providers. The collected data is used later to improve infrastructure, various utilities, etc. Smart cities provide a more efficient and quality lifestyle for their residents. Although there is no clear definition of "smart city", the goal for smart city initiatives is usually aimed at implementing seamless integration of communications infrastructure, sensor and mobile technologies. They are using applications that provide access to a variety of public services for citizens. Cities in North America and Europe are leading the effort in implementing smart technologies to address urban issues such as traffic jams and high energy costs, using opportunities such as the use of solar energy in street lighting, smart traffic lights at intersections, smart buildings, smart bus stops, etc.

3. BUS STOPS AND SMART TECHNOLOGIES

The smart bus stop is an urban instalation who can offer real time information by establishing linkages with buses through GPS tracking and RFID tags. LED displays at bus stops display different data as bus number of arriving buses, arriving times for buses, buses routes, etc. More developed systems can even display the available seats on the next bus. The smart bus stop actually improves the bus travel experience because its ability to communicate with users through the bus route guide, displaying digital maps, searching for destinations, viewing weather forecasts, etc. Interactive touch screens in the bus shelter function as city dashboard and act as an interface of city with the users. It makes waiting for a bus no longer cumbersome or unreliable, but rather a fun activity [3].

The IoT is an integral part of the concept of smart cities and has widely used, which has found its place within bus stops also. With new IoT technologies, bus stops have the potential to improve, providing a better experience for passengers as well as creating value for companies and public transport providers. The integration of the IoT on buses enhances the way information is presented to the public by displeys. Information in focus includes digital advertising, public announcements, or other information regarding significant events. The location and time of presented information are key factors under consideration, in order to effectively convey relevant information to the target audience. Moreover, the use of sensors can generate data analytics that describe the traffic flow by city carriers, providing useful information for public transport service providers. Different scenarios are being considered, whereby smart bus stops can be useful. Small

scale prototype has been developed to illustrate the proof of concept for the proposed solution. The prototype demonstrates dynamic social media advertising and demonstrates the prediction of daily migrations from sensory data. In addition, prototype testing is conducted to evaluate its functionality. Other benefits, such as reducing energy consumption of devices such as lights, screens and smart heating systems for bus stops, are being considered.
An example of a smart bus stop is shown in Figure 1.

Figure 1. Smart bus stop [4]

The bus stop from Figure 1 offers many integrated functions, such as the sale of public transport tickets via integrated payment devices, locking of bicycles, sale of food and beverages, monitoring of air quality and noise levels, security camera, heated benches and seats, Wi-Fi connection, advertising space and accessibility of various information via Smart Kiosk. All the information and services are easily accessible even for children and disabled people. Stereo speakers enable easy access to necessary information even for visually impaired citizens. Smart Kiosk integrated in the bus stop offers an additional vast amount of information available for citizens. The interactive Kiosk is a computer terminal providing access to information and applications for communication, commerce, entertainment or education [4].

Generally speaking, smart bus stops can make a significant contribution to improving the services offered to customers. Travel is very easy for all travelers. The opportunity to find significant tourist attractions and sites can be offered tourists in major cities. all the important city news and current events could be relayed to citizens. On the other hand, one should not forget the fact that bus stops are located at all strategically important locations in the city. Because of this, bus stops are important for different advertisers.On this way the advertisements are accessible to all public transport users, pedestrians and even drivers passing next to bus stops by their vehicles. New methods of interactive advertising are becoming more current and renting ownership to bus companies is becoming more common.

3.1. Smart bus stops in Serbia

The application of smart bus stops is only beginning in Serbia. Some cities were given the first smart bus stops, with a tendency to increase their numbers. There is a Petro-mont company from Novi Sad, that manufactures smart bus stops.

PetroSOLAR bus stops are smart bus stops, which increase traffic safety and increase passenger care. Each bus stop is energy independent because it is powered by solar energy entirely and have the following elements integrated in the basic variant: solar cell with battery, standalone LED lighting, free chargers for mobile devices and WiFi routers for wireless internet. These bus stops can integrate many additional elements, in addition to the basic elements, such as: LED displays, interactive monitors or billboards, roto and print advertisements, etc [5].

There is possibility for a special upgrade for these bus stops. The bus stops can to be networked in a unique city BUS STOP system, which is able to monitor and provide information on bus routes, expected bus arrival times, or information on air quality, temperature , humidity. As an option, it is possible to install kinetic floorboards that generate electricity from pedestrian walkways. Each smart stand is powered solely by solar energy and does not require any additional wiring to function, and it is ideal and cost-effective solution for installation in numerous off-site and inter-city locations [5].

Figure 2. Smart bus stop in municipality Voždovac, Belgrade [6]

4. CONCLUSION

Bus stops, as an important segment of the transportation system, must be integrated into the concept of a smart city. This is primarily intended to enable the use of smart technologies to enable real-time data collection, which is analyzed and forwarded to passengers, the public transport management center, drivers, etc. This means that bus stops should be a source of innovation, adjusted to local specifics, which can add value and turn them into an example of a successful business model. In the context of a smart community, bus stops equipped with smart technologies can revive, enhance customer experiences and open up new business opportunities.

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GROUP OF ARTICLES 4
Traffic safety

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THE IMPORTANCE OF AGING AND REACITON TIMES FOR TRAFFIC SAFETY

Key Words

Professional drivers;
Reaction time;
Age;
Traffic safety

Abstract

Reaction time is very important driver's trait, especially reaction time on visual stimuli. Adequate reaction on visual stimuli is inarguably a fundamental component of safe driving because driving relies heavily on vision for its successful execution. Professional drivers are considered to be very important part of the active working population, so there is a need for continuous improvement of operating efficiency and safety in driving. To assess the effects of natural process of aging on reaction times among professional drivers and their relationship with traffic safety. Study was carried out in the Institute of Occupational Health Novi Sad, Department of Occupational Medicine, Faculty of Medicine, University Novi Sad. Participants in this study were active professional drivers with a valid driver's license. Reaction times of 278 male professional drivers were tested using a hardware-software system for determining the speed of response to psychomotor simple and complex audio-visual stimuli. Our results showed a positive correlation between ageing and speed of response. Study suggested that the natural ageing process clearly slows down reaction times which can be an important factor for traffic safety. Traffic regulatory agencies should ensure that all professional drivers undergo basic visual reaction time tests. This could serve as a very strong tool in ascertaining the eligibility of an individual for professional driving.

1. INTRODUCTION

Safety is an important consideration in many human activities, but it has particular prominent role in traffic. The primary goal of transportation, the effective movement of people and goods, becomes better by increasing speed. A substantial proportion of technological innovation has focused on increasing traffic speeds, led to the traffic crashes. Every type of traffic transportation involves some risk of material harm and more important - loss of human lives. Road safety becomes a major social concern, due to its emotional and economic impact on society. In this concern, there is the need to accurately assess the cognitive functions associated with driving safety [1]. According to the WHO in 2016 low-income countries had the highest mortality rate due to road traffic injuries. Road traffic injuries were also among the leading 10 causes of death all over the world [2]. As driving is associated with independence, it is important to understand for traffic safety what skills are required to drive safely and how to assess them. Motor vehicle accidents are inherent in traffic and usually are the result of many different reasons that occur (including human error). Driving is a complex task, requiring the concurrent execution of various cognitive, physical, sensory and psychomotor skills. During comprehensive driving evaluations, some of the measurable components of driving ability include reaction time and the ability of motor answer. Reaction time is important when perceiving and reacting to risks or unexpected situations when driving [3]. Professional driving is a predominantly male occupation. The requirements for fitness to drive are not harmonized to the full extent in the European Union [4-7].

Reaction time

How quickly a person responds to a stimulus depends on his reaction time (RT) thus it determines the alertness of a person, which is a prerequisite in certain occupations like driving. Driving requires executive functions for attention, multi-tasking, and quick reactions. A comprehensive driving ability assessment is a clinical evaluation that can performed specialist of occupational medicine, in order to assess a professional driving ability. Assessments involve assessing several dimensions of driving ability. RT is one of these dimensions and is a key component of driving ability [8] and one of the most commonly used assessments in driving evaluations [9]. The common use of RT as a component of driving assessments clearly positions RT as a widely accepted and key element of driving ability. RT is an index of the processing ability of central nervous system and is a simple mean of determining sensory-motor associations and performance of an individual. It is the measurement of a behavioural response, in time units, from the presentation of a given task to its completion. Simple reaction time (SRT) and complex reaction time (CRT) are two types of reaction times. SRT are those where subjects must respond to simple stimuli such as light or sound while CRT are those where subjects have to select a response from a set of possible responses [10]. SRT are the most common kind in driving because the stimulus is reasonably expected and the driver has already decided (and practiced) what he will do when the stimulus appears. Simple reaction time is often a matter of habit. Such reaction times normally take about 250ms to initiate action. The changing of a green traffic light to yellow in a driver's visual field and the typical driver's reaction to it would be an example of a simple reaction. A complex stimulus is a situation that requires a decision for response to multiple stimuli, such as needing to react to a specific stimulus when other visual or auditory input is being given. CRT generally calls for a choice among several possible responses. Here, the decision related to the most appropriate response has not been made in advance. Even situations involving little ultimate choice can fall into this category. Complex reactions are slower than simple reactions. How long a complex reaction takes depends on how complex the stimulus is, how many choices there are for reaction, and how often the individual has been in a similar situation. Normally, such reactions can take from 500 – 1500ms or more. SRT gives an indication of the individual’s physical ability to react, while CRT is a measure of ability that is more applicable to real-life driving situations. Bilban and al found a positive correlation between age and SRT, with response time increasing significantly after 65. Drivers’ reactions may differ when reacting to more complex stimuli – such as reaction on three different stimuli (red, green and yellow light). Differences in reaction times across ages were due to a decrease in processing ability attributable to age [11]. Other researchers tested SRT as measured by the amount of time it took participants to press a button in response to a visual stimulus. Findings showed a median reaction time of 236 ± 32 ms for drivers under 30 years of age, and a median RT of 262 ± 81 ms for drivers between the ages of 30 and 55. These findings indicate a difference between reaction times of young and old drivers, too [12]. Researcher in domain of driving skills (Marc Green) performed a systematic review of studies involving reaction time. Green’s paper examined studies following one of three paradigms: simulator studies, controlled road studies, or naturalistic observation, that also focused on reaction times. Green’s review found that older drivers tend to respond about 100 to 300 ms more slowly than younger ones. He also found that response times are the shortest when the reaction is expected and certain, with average timing across all ages being 600 to 750 ms [13]. One study found CRT to be significantly related with accident involvement for all drivers [14]. Together, these findings indicate that older drivers’ longer CRT may be related to an increased risk for accident involvement.

The study described in this paper will contribute to our knowledge about driving by measuring driving reactions that involve peripheral input and measure of the physical answer in order to mirror the actions used in real-life driving situations. This study will also contribute information about the relationship between SRT and CRT as well as the effects of age on these relationships. The outcomes of this study explored the relationship between SRT and CRT of professional drivers. Results also provide information about how varies in a simple or complex situation, and with age.

2. MATERIALS AND METHODS

Participants in this study were active professional drivers with a valid driver's license. Professional drivers in Serbia have to meet health requirements. There is an obligation for professional drivers to conduct a health re-examination every third year to obtain a medical certificate for the approval and extension of a professional driver's license [15]. Health examinations were performed in Institute of Occupational Health Novi Sad, Department of Occupational Medicine, Faculty of Medicine, University of Novi Sad, Serbia. Testing was carried out in the period February 1st up to September

30th 2018. Exclusion criteria were: subjects younger than 22, older than 65 years and driving experience as professional driver less than one year. Participants included in the study gave written informed consent after comprehensive information detailing the study. Participants' information and data were collected with the use of self-structured questionnaire. The questionnaires included questions related to age and professional driver experience (in years), workplace (truck, bus, delivery van and taxi drivers) as well as the use of alcohol, medicines, the presence of head injuries and other health disorders that may affect the value of RT.

Health examination consisted of the following: health-history, work-history, access to the available medical reports: previous health examination reports and copy of the general practitioner patient's medical record, clinical examination, resting electrocardiogram, spirometry, Romberg test, audiometry, as well as laboratory analysis: sedimentation rate, complete blood count, blood glucose and urinalysis. Consultative examinations of psychologist, psychiatrist, and ophthalmologist were conducted. Determination of a simple reaction time was based on the driver's reaction to a single simple stimulus - light. Driver's reaction was to press a key at the time of the appearance of a stimulus. The research of a complex reaction consisted in a specific type of stimulus - the light colour, has been assigned with a specific manipulator on which the driver should press with a hand.

Reaction time testing was carried out using a MERREX analysis system, a hardware-software system for determining the speed of response to psychomotor simple and complex audio-visual stimuli. MERREX uses LCD colour display for performance stimuli, connected with two ergonomic handles with pressing buttons. Complex visual stimuli are representative of stimulus - the distribution of light forms on dark display in the sense of testing the colours - red, green and yellow and measuring the response time to stimuli. The occurrence of stimulus is not predictable. Response to the stimulus is manual in nature, such as pressing or releasing a button according to the changing of lights. Designed system accuracy of measuring the response time is extremely high and amounts to +/- 2ms; maximum response time is 1500 ms respondents. This delay is representative of driving situations where quick decisions are required, most being taken within 1500 ms [13,16]. The study protocol included two types of tasks. Both tasks contained 20 attempts of the response and after adequate practice of a few attempts, the tests were carried out.

<u>Task I:</u> Measuring of simple reaction time (SRT) by the occurrence of the red circle in a random sequence of appearance. SRT was represented the elapsed time of the moment of occurrence red circle to moment registered pressure-button. During the test were registered total speeds of all responses to occurrence red circle (20 independent measurements and their average value)

<u>Task II:</u> Measuring of complex reaction time (CRT) in the occurrence of three different colours (red, green or yellow circle) in random sequence and random spacing appearance. CRT was represented the elapsed time of the moment of appearance of the red, green or yellow circle to the moment registries pressure the appropriate handle-button. During the test were registered total speeds all responses to the occurrence of all colours in a random arrangement (20 independent measurements and their average value)

Under this mode of stimuli presentation, the mean value of total speed SRT, the mean value of total speed CRT was used as performance measurements. Statistical analysis was performed using statistical software STATISTICA.

3. RESULTS

A sample consisted of 278 male professional drivers. Age mean (42.36 ± 10.44), range 22 to 65 years, driving experience (12.44 ± 9.57), range 1–43 years. Workplace structure: truck 149 (53.59%), bus 26 (9.35%), delivery van 41(14.75%) and taxi drivers 62 (22.30%). Statistical data for dependent variables related to reaction time are shown in Table 1.

Table 1. Mean values and standard deviations (M±SD) for dependent variables related to reaction time

Variable	M	SD	Confidence -95.0%	Confidence 95.0%	Minimum	Maximum
Total SRT	304.28	58.49	297.38	311.19	202.65	649.40
Total CRT	656.07	131.40	640.56	671.58	404.45	1053.70

Note: Total SRT= total simple reaction time, Total CRT=total complex reaction time

In order to examine whether there exists an effect of age on dependent variables, we chose 10-year interval and categorise professional drivers into four age groups: 22-32 years with 58 (20.86%), 33-42 years with 88 (31.65%), 43-52 years with 78 (28.06%) and 53-64 years with 54 (19.42%) drivers.

Table 2 shows mean values and standard deviations for dependent variables in age group.

Table 2. Mean values and standard deviations (M±SD) for dependent variables related to reaction times in age groups

Variable	Age				
	22-32 n=58 (20.9%)	33-42 n=88 (31.6%)	43-52 n=78 (28.1%)	53-64 n=54 (19.4%)	Total N=278 (100%)
Total SRT	278.9±32.5	298.3±49.9	308.8±56.1	334.7±79.7	304.3±58.5
Total CRT	610.5±117.7	616.4±107.0	699.6±137.0	706.8±137.8	656.1±131.4

Note: Total SRT = total simple reaction time, Total CRT = total complex reaction time

Statistically significant differences between age groups for dependent variables were found and showed in figures: Total SRT, ($F(3, 274)=9.8326$, $p<0.001$), (Figure 1), Total CRT, ($F(3, 274)=11.768$, $p<0.001$), (Figure 2).

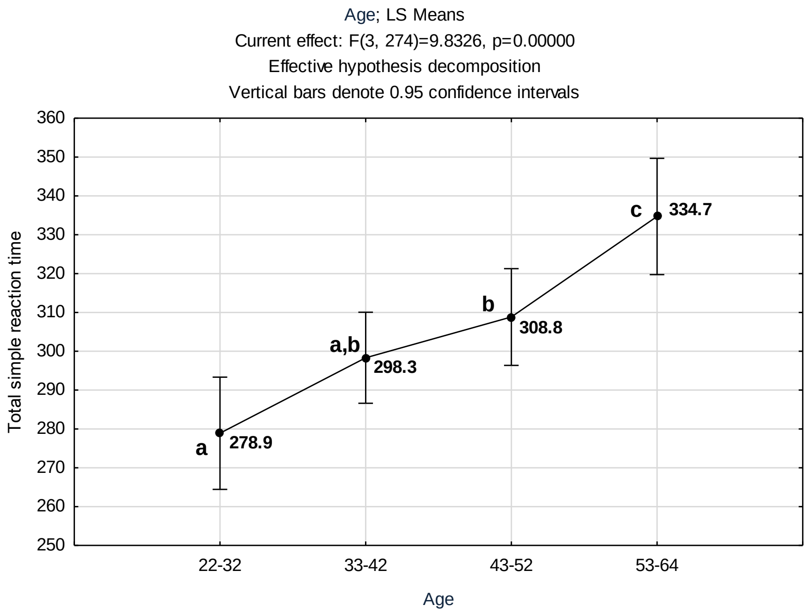

Figure1. Total simple reaction time (SRT) in age groups

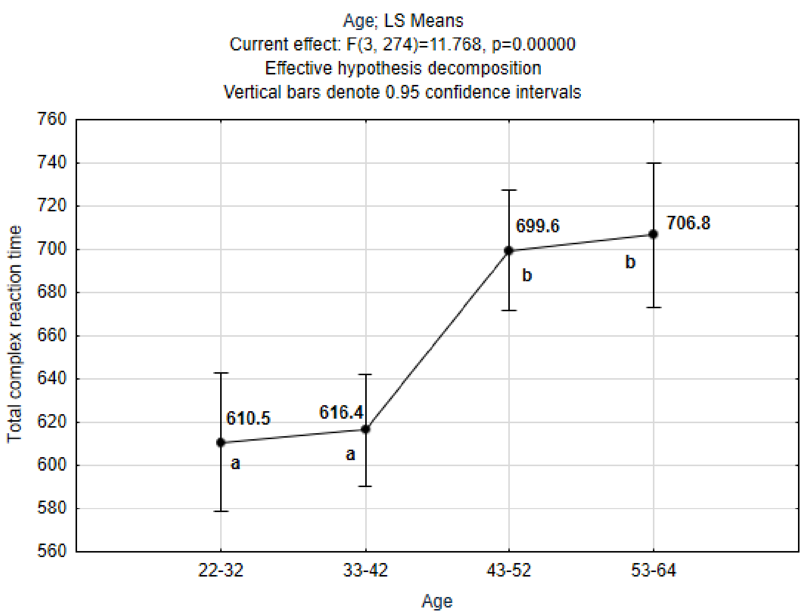

Figure 2. Total complex reaction time (CRT) in age groups

4. DISCUSSION

There are various cognitive skills that relate to the ability to drive; these include processing speed, attention and perception.

This study assesses part of driving efficiency of professional drivers by measuring SRT (one stimulus) and CRT (three stimuli) in the domain (cognitive, perceptual and motor skills) that are relevant to driving safety. The results clearly demonstrate that a correlation between age and the reaction time exists. Increased age is often related to slowed cognitive abilities, which can impair driving.

Processing speed is the cognitive ability that is most closely associated with involvement in a motor vehicle collision [17]; speed of processing slows significantly with age [18]. It has been shown to be a relevant factor impacting other cognitive abilities such as memory, reasoning and psychomotor ability; so as processing speeds slow, so do a variety of other cognitive functions. Processing speed can slow everyday functioning, and is particularly necessary for skills like driving [18]. Increased age was also found to correlate with whether drivers passed or failed; indicating that age and perception may be the best predictors of unsafe driving [19]. One study found that for drivers aged 55 and older, poor cognitive ability was predictive of future at-fault motor vehicle collisions, indicating that cognitive abilities are directly related to driving abilities [20].

Processing speed and visual attention have been shown to deteriorate with age [17,18]. Age-related cognitive deficits may be linked with deteriorating driving ability [18-22]. Few studies found that aging can be associated with delayed RTs, particularly in complex situations [8, 11,12,13, 23]. Thus, it would be reasonable to expect that older drivers would have slower RTs than younger drivers in all situations, and that older drivers' RTs will increase disproportionately (as compared with younger drivers) with increased complexity of the task.

These findings support the concept that age related changes might influence the ability to process and react to all stimuli. Depending on the value of a driver reaction time accident may depend on the extent of any fault of a driver.

5. CONCLUSION

- Our results support the concept that age related changes might influence the ability to process and react to all stimuli.
- All participants, had reaction times that increased with aging. Older drivers' increased times SRTs and CRTs than the younger, suggesting an effect of aging on processing speed of information.
- Viewed functionally, the importance of SRT is limited, as drivers rarely react with certainty to a single stimulus; however, CRT, with a reaction to multiple stimuli, is more frequently applied in daily life, and particularly, in driving.
- The findings described throughout this paper contribute to our foundational knowledge about driving skills. However, driving safety is about many psychophysical functions, not just age, and assessment of driving safety with this in mind.

- There is a need for studies that examine RT in situations that are more representative of driving. Driving simulators may be important tools in the future for both driving evaluation and intervention, it is critical to increase the use of simulation in driving research.
- For all of us as professionals in own domain, it is imperative that we recognize driving as the risky and important occupation and address it accordingly.
- And finally, the findings of this study provide information as may relate to driving assessment and further interventions.

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EXCLUSIVE PEDESTRIAN PHASES AS A MEASURE TO IMPROVE PEDESTRIAN SAFETY ON SIGNALIZED INTERSECTIONS

Key Words
Pedestrians; Signal plan; Signalized intersections; Traffic safety

Abstract
Signal phases exclusively for pedestrians, i.e. exclusive pedestrian phase, demonstrate the idea of giving the priority to pedestrians at intersections located in area that attracts pedestrian flows, like central city zones. In this way pedestrian flows are served in safer way because the conflict between pedestrians and turning vehicles within the same phase are eliminated. However, other cities' experience indicates that although exclusive pedestrian phase are envisaged to be safer form for pedestrian flow serving, the effects of their implementation could be opposite. This paper describes conditions for introduction and the way of an exclusive pedestrian phase implementation within a signal plan. Based on the example of signalized intersection with signal plan containing exclusive pedestrian phase, the advantages and disadvantages of this solution were analysed from the perspective of pedestrians and other road users. Also, the locations in domestic conditions, which are convenient for implementation of this type of signal plan, were identified.

1. INTRODUCTION

Pedestrian safety is one of the main concerns of urban road safety having in mind that pedestrians are the most numerous group of vulnerable road users.

Traditionally, pedestrians use pedestrian crossings to cross the street safely but some complex urban traffic environment can make this action difficult. When it comes to signalized intersections, traditional signal plans imply that pedestrians are served simultaneously with left- and right-turning vehicles. That means that driver-pedestrian conflict still exists, although it is considered acceptable, so it is up to driver to give priority to pedestrians. At signalized intersections with intense pedestrian flows attracted by many facilities located in their neighbourhood, like central city zones, pedestrian trajectory around an intersection consists of three of four pedestrian crossings and sidewalks between them, which cause significant time delays and make pedestrians feel like second-in-queue road users. In order to enhance pedestrian level of service and safety, in some cities signal phases exclusively for pedestrians were implemented.

This papers deals with exclusive pedestrian phases and their potential to improve pedestrian safety on characteristic signalized intersections.

2. EXCLUSIVE PEDESTRIAN PHASE CONCEPT DESCRIPTION

Signal phases exclusively for pedestrians, i.e. exclusive pedestrian phase (EPP) or "Barnes Dance", demonstrate the idea of giving the priority to pedestrians at intersections located in area that attracts pedestrian flows. They imply that a signal plan consists of phases where one of them is reserved only for pedestrian and other ones for vehicles. During EPP pedestrians may cross the intersection transversely and diagonally. On the other hand, it is prohibited that vehicle enter the intersection during this phase, even for right-turning vehicles. In this way pedestrian flows are served in safer way because the conflict between pedestrians and turning vehicles within the same phase are eliminated and they need less time to cross all intersection legs at their travel route.

The idea of exclusive pedestrian phases originates from the first half of last century. First intersection where this idea has been implemented was located in New York. It was a pilot project. Since pedestrians were very satisfied with this solution, EPP were later implemented at more intersections. However, drivers were unsatisfied due to the greater time delays.

Today those phases are present in many countries, such as USA, Canada, Australia, New Zealand, Japan, the Netherlands and United Kingdom. They are a part of signal plans for busy intersections, like those located near bus station, rail station and attractive adjacent objects.

EPP implementation requires that some criteria must be satisfied. It is not enough just to have intense pedestrian flows – there is a need to provide enough space for pedestrian accumulation on sidewalks during signal phases for drivers.

There are two types of their implementation into signal plans:

- Regular implementation – when EPP is present in every cycle, at any time of day, and

- Irregular implementation – when EPP is present only sometimes or at certain time of day, in situations when a lot of pedestrian are expected at the intersection.

3. EFFECTS OF EXCLUSIVE PEDESTRIAN PHASE IMPLEMENTATION

Table 1 summarize advantages and disadvantages of EPP implementation from pedestrians' and drivers' point of view. Advantages and disadvantages are considered by comparing simultaneously serving of turning vehicles and pedestrian with exclusive pedestrian/driver phase. The huge advantage of this solution is the elimination of pedestrian-driver conflict. That means the minor risk of pedestrian accidents, faster left and right vehicle turnings and shorter pedestrian paths. Research from London indicates that EPPs can reduce the number of pedestrian casualties by 38%. However, the introduction of an additional, EPP implies longer signal cycle, which means greater time delays, i.e. waiting time for all road users. This triggers driver frustrations so rear-end collisions happen more often. Also, long waiting time causes more traffic offences.

Table 1. Advantages and disadvantages of EPP implementation

Road user group	Pedestrians	Drivers
Advantages	• Eliminated conflict points with drivers • Shorter trajectory over an intersection	• Eliminated conflict points with pedestrians • Faster driving of turning vehicles through the intersection
Disadvantages	• Greater waiting time	• Greater waiting time • More rear-end accidents

4. RESEARCH METHODOLOGY

The analysis was conduct in two stages. During the first stage it was investigating whether the exclusive pedestrian phase implementation is justified from vehicle and pedestrian time delay point of view. Based on the evidence from other countries, in the second phase a literature review was done with emphasis on road safety level on intersections having EPP implemented.

The first part of the analysis is conducted by running numerical simulation under following considerations:

- An isolated four-leg signalized intersection is considered (see Figure 1),
- Each intersection leg has one lane per direction,
- Tradition traffic signal plan consists of two phase, where main-road traffic flows with pedestrian flows across the side road are served in first phase and side-road traffic flows with pedestrian flows across main road are served in second phase,
- All lanes are 3.5 m wide and corner radii are 6 m,

- New traffic signal plan consists of three phase, where main-road traffic flows are served in first phase, side-road traffic flows are served in second phase and all pedestrian flows are served in third (exclusive pedestrian) phase,
- During EPP pedestrians are allowed to cross the intersection diagonally and horizontally,
- It is supposed that one half pedestrian flows need to cross only one street and second half needs to cross two streets,
- Traffic flows are homogenous, consisting solely of passenger cars,
- It is supposed that traffic flow distribution is the same at all approaches: 50% of vehicles go straight, 25% turn left and 25% turn right,
- It is supposed that pedestrian volume is the same on each pedestrian crossing,
- Two situations were considered: the ratio of main-road and side-road traffic volume was 3:2 and the ratio of main-road and side-road traffic volume was 4:1.

Vehicle time delay is calculated using Webster's formula [1] while for pedestrian delay it was used the model proposed by Marisamynathan and Vedagiri [2]:

$$D_{Avg} = D_{WT} + D_{CT} + D_{VIT} \qquad [1]$$

where D_{WT} = average waiting time delay during non-green phases per pedestrian, D_{CT} = average crossing time delay during all phases per pedestrian and D_{VIT} = average-vehicular pedestrian interaction time delay during all phases per pedestrian.

Pedestrian level of service is determined according to categories proposed by Sahani, Devi and Bhuyan [3].

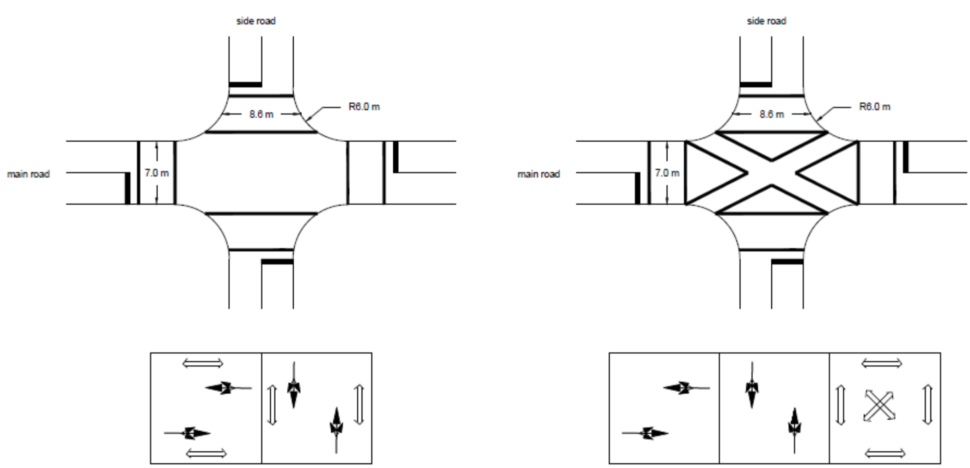

Figure 1. Intersection layout with different signal plan types: tradition signal plan (left) and EPP signal plan (right)

5. RESULTS

The data for the first analysis stage were obtained by numerical simulation. Main-road traffic volume, side-road traffic volume and pedestrian volume were varied while other factors kept constant. Table 2 summarize some results. The most important ones are following:

- Under above-mentioned conditions, vehicle time delay in the EPP signal plan is greater than delay in the traditional signal plan.
- Pedestrian time delay in the EPP signal plan is greater than their delay in the traditional signal plan because of the longer waiting time.
- From both vehicle and pedestrian time delay perspective, it is not justified to implement the EPP signal plan.
- There are ranges of vehicle and pedestrian volumes at which vehicle level of service in the EPP signal plan is one level below than in the traditional signal plan, so these cases could be considered reasonable for EPP implementation.

Hence, under simulated conditions, there is no such a combination of vehicular and pedestrian volume that makes the EPP implementation reasonable.

Table 2. Numerical simulation results

Total vehicle volume [veh/h]	Total pedestrian volume [pedestrians/h]		Traditional signal plan		EPP signal plan	
			Vehicle delay [s]	Pedestrian delay [s]	Vehicle delay [s]	Pedestrian delay [s]
350	A	2000	21	61	33	29
	B	760-1880	10-20	28-58	20-32	27-29
500	A	1720	20	49	33	33
	B	680-1680	10-20	24-49	21-32	30-33
800	A	1120	20	24	31	41
	B	480-1040	10-19	17-23	25-30	39-41
1000	A	800	23	22	32	49
	B	200-760	11-20	16-20	29-31	48-49

A – Maximal total pedestrian volume for which EPP is reasonable [pedestrians/h] (cycle ≤ 120 s).

B – Total pedestrian volume range at which vehicle level of service in the traditional signal plan is one level above than in the EPP signal plan.

The data for the second analysis stage couldn't be obtained from Serbia because there is no an intersection with implemented exclusive pedestrian phase (to the best of authors' knowledge). Consequently, it was analysed the evidence on EPP safety effects from worldwide.

According to pedestrian crash number and vehicle interaction severity prediction models for a sample of signalized intersections in Connecticut with either traditional signal plan or EPP signal plan [4], the probability of pedestrian conflicts decreases when pedestrians cross during EPP and increases when jaywalking or cross during vehicle green phase while EPP is available. Also, compared with traditional signal plan intersections, those with EPP signal plan tend to have fewer pedestrian-vehicle crashes, but these crashes are more severe. This implies that EPP is only safer for pedestrians who wait for the green signal, not for violators.

6. DISCUSSION

Here obtained results indicate that EPP is not applicable for an intersection under considered conditions if the idea is to keep vehicle level of service. On the other hand, if the idea is to allow vehicle level of service to be one level below than in traditional signal plan, there are ranges of vehicle and pedestrian volume that satisfy this criterion. However, these results should be interpreted carefully because of numerous limitations. Here it was considered only an intersection with one lane per direction on each leg, with the same traffic flow distribution per allowed travel directions on each leg. The results may be different for different intersection geometry and different shares of turning vehicles. Also, it was supposed that one half of pedestrians have a need to cross the intersection diagonally, which is not always true. Pedestrian delay model was adopted and not calibrated according to local conditions. Also, when calculating minimal pedestrian green time it was supposed that 4 pedestrians start to cross the street simultaneously from one pedestrian crossing side (pedestrian crossing at considered intersection is 4 m wide), but this parameter was not check in real conditions. Those shortcomings are very likely to have a great impact on the results obtained here.

However, a simulation model for actuated controlled intersection, developed and calibrated based on field data from China, indicates that EPP is unsuitable for intersections with high vehicle volumes (>550 veh/h/approach), as well as when the pedestrian diagonal ratio and the vehicle turning ratio both reach 0.6 or more, EPP signal plan is recommended; otherwise, a traditional signal plan is recommended [5]. The importance of the share of pedestrian crossing the intersection diagonally in total pedestrian volume is also emphasised in Ma & Liu [6]: with the increase of diagonally-crossing pedestrian share, the performances of EPP signal plan are better than those of traditional signal plan. An economic model of safety and operational performance of these two signal plan types indicates that EPP is more suitable under high vehicle turning ratios and high pedestrian volumes [7]. There are also multi-approach methods for selection of an appropriate signal plan types. For example, Ishaque and Noland [8] have determined the suitability of various pedestrian phase types based on proportion of pedestrians to car users and the comparative value of time for pedestrians.

Although it was expected that an EPP signal plan will be pretty much safer than a traditional signal plan, the worldwide evidence indicate that the safety benefits are lesser than expected. It appears that an EPP should only be implemented at locations where it is more likely that pedestrians will obey traffic rules, where there are some conditions making greater risk for pedestrians and with significant vulnerable pedestrian share (children, old people and physically-impaired people) is greater old and physically-impaired people. Safety paramount is a key criterion for implementing EPP [9], but the safety effects depend on pedestrian behaviour as it appears that safety benefits tends to be reduced because pedestrians act like they have a right to cross the street when parallel vehicular flows are served [10]. Contrary to the intuitive expectations, an EPP is recommended for intersections with low pedestrian volumes [4]. On the other hand, some researches indicate that EPP safety effects are very positive in small towns [11].

7. CONCLUSIONS

Although the results of this paper indicate that in many cases it is not justified to replace a traditional signal plan with an EPP signal plan, it doesn't mean that this idea should be rejected, especially because this research has a lot of limitations. Ultimately, if we consider pedestrians and drivers equally important road users, there is a room for setting the criteria in different way. Exclusive pedestrian phases are applicable in cities where pedestrians tend to comply with traffic rules, at locations with great number of pedestrians, especially vulnerable ones. In this case, they will create "a mass" during EPP making their safety improved by the idea on "safety in numbers".

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ANALYSIS OF TRAFFIC ACCIDENTS OF YOUNG DRIVERS IN URBAN AREAS AND MEASURES TO INCREASE SAFETY

Key Words

Traffic accidents; Young drivers; Traffic safety

Abstract

Traffic accidents are considered the first cause of death of young people, that is, young drivers. Therefore, this problem needs to be given a lot of attention. Traffic accident which include young drivers must be analyzed as an element of the system, and it is necessary to analyze and investigate potential solutions and improve all elements in order to improve the system itself. In the Republic of Croatia, for the first time in 2004, the term "YOUNG DRIVER" as a driver of a motor vehicle up to the age of 24, who holds a driver's license issued in the Republic of Croatia, was introduced into the Road Traffic Safety Act. The share of young drivers in the population in the Republic of Croatia is 4.3%. Young drivers make up about eight percent of road users, causing a total of 9.6% of traffic accidents, or 12.5% of those with fatalities. This paper will deal with traffic safety in other countries, especially in the surrounding countries. According to statistics related to road accidents, young drivers are over-represented and are at greater risk to themselves, passengers and other participants than other drivers.There is a need to respond in a timely manner and to adopt optimal measures to improve the safety of young drivers in road traffic and thus for the safety of other road users. The aim of this paper is to outline measures that would reduce the number of road accidents involving young drivers, especially in urban areas.

1. INTRODUCTION

Traffic accidents are considered to be the first cause of death for young people, young drivers, so this issue needs to be given close attention. Considering the characteristics of traffic safety as a system, it is necessary to analyze and improve all the elements in order to improve the system itself. Traffic accidents of young drivers also need to be analyzed as an element of the system and to explore potential solutions. The aim of the research is to analyze the state of traffic safety and to propose possible measures for improving the safety of young drivers. Given that traffic safety is applicable throughout Europe, this paper will deal with traffic safety in other countries, and especially in the surrounding countries. According to statistics related to road accidents, young drivers are over-represented and are at greater risk to themselves, passengers and other participants than other drivers.

It is questionable how young drivers are, after passing the driving test, truly ready to participate safely in the traffic system and deal with dangerous traffic situations. It is necessary to react in a timely manner and to take the necessary measures to improve the safety situation of young drivers in road traffic. Therefore, the main topic of the paper is to highlight the problem of young drivers on the roads, and the aim of this paper is to present measures that would reduce the number of traffic accidents involving young drivers.

The term “young driver” is defined differently in the surrounding countries law. Thus, for the first time in the Republic of Croatia, it is mentioned in the Road Traffic Safety Act 2004 and today it designates a driver of a motor vehicle until the age of 24, who holds a driver's license issued in the Republic of Croatia. In the Republic of Slovenia, the term refers to the driver of a motor vehicle until the age of 21, for the first two years after obtaining a driver's license, regardless of age at the time of passing the driving test. The legislation of Montenegro does not even recognize the young driver's institute. Of all the countries observed; Croatia, Slovenia, Bosnia and Herzegovina, and Montenegro for young drivers are the most restricted in Croatia and Bosnia and Herzegovina. According to the national legislation, each country has its own guidelines, but it is common that all the countries observed have introduced a permissible alcohol limit of 0.0 g / kg. The only exception is Montenegro, where a limit of 0.3 g / kg is allowed for drivers of all ages and levels of driving experience.

2. ANALYSIS OF THE SITUATION IN THE EUROPEAN UNION

In 2017, the European Road Safety Observatory (hereinafter referred to as "ERSO") published a Traffic Safety Basic Facts report summarizing European Union-wide traffic safety statistics from 2006 to 2015, with a special issue dedicated to the demographic group of young people, ie individuals aged 18-24.

In the observed period, 52 852 young people were killed in road accidents, representing 16% of all traffic related deaths in the European Union.

Table 1. Number of young people killed in traffic from 2011 to 2017, by country [1]

	2011	2012	2013	2014	2015	2016	2017
BG	-	-	-	-	-	-	-
CZ	129	96	96	100	103	65	68
DE	737	611	493	496	473	435	394
EL	163	143	112	114	112	101	-
HR	81	48	58	36	45	42	48
IT	496	423	404	369	379	352	306
HU	73	42	50	59	61	47	44
AT	76	84	56	59	72	56	46
RO	251	231	220	177	207	195	196
SI	17	19	22	9	16		
SK	-	-	-	-	-	-	-

The data show that in the decade studied, a dramatic fall in the number of deaths occurred in all EU countries, almost halved, which is particularly evident from the example of Estonia, which reduced the death toll by 86% in the observed period. The most common cause of accidents is speeding, or speed unsuitable for road conditions. The second most common cause of accidents is driving in the opposite or prohibited direction. Not taking any action is a third cause of accidents, which means that the driver did not react at all for any reason to avoid a collision.

Regarding the vehicle in which the car accident occurred, most of them occurred in the passenger car (65% of all accidents). According to the classification of the roads on which the accident occurred, only 7% of accidents occurred on motorways and expressways, 92% of accidents occurred off the highways and expressways (of which 62% accidents occurred on rural roads and 30% on urban roads) while we do not have data for 1% of road accidents.

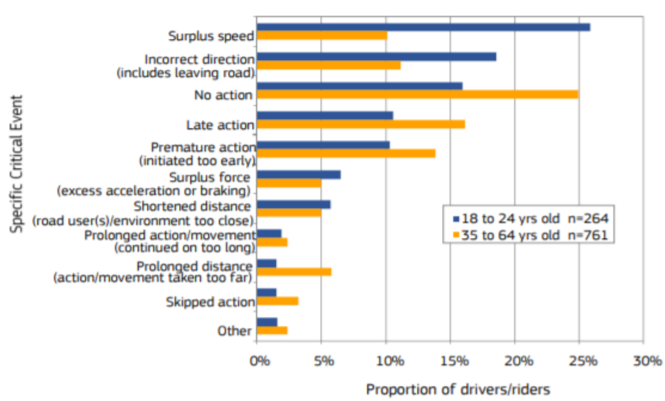

Figure 1. Overview of causes of traffic accidents, young drivers (18-24 years) and other populations (35-64 years) [1]

Table 2. Traffic accidents in the period from 2006 to 2015 by type of road [1]

	MOTORWAY	NON-MOTORWAY		UNKNOWN	TOTAL
		RURAL	URBAN		
BG	4%	66%	29%		157
CZ	2%	86%	12%		103
DE	11%	72%	17%		473
EL	6%	38%	55%		112
HR	4%	36%	60%		45
IT	7%	53%	40%		379
HU	10%	54%	36%		61
AT	8%	72%	19%		72
RO	2%	38%	60%		207
SI	13%	56%	31%		16
SK	5%	59%	36%		59
EU	**7%**	**62%**	**30%**	**1%**	**3.636**

By gender, 82% of all deaths are young men, which is explained by the fact that men drive motor vehicles more often, choose to travel longer distances more often, and present more aggressive driving. When analyzing the time of a car accident, they most commonly occur between 8 pm and midnight, from 4am to 8am and between 4pm and 8pm. In the observed decade, road accidents most often occurred on weekends, when the highest number of road accidents occurred between 7pm and 5am on Fridays and from midnight to 6am in the night from Saturday to Sunday. When analyzing the months of 2015 in which the highest number of accidents occurred, the period July and August (21%) was highlighted, while the lowest number of accidents occurred in January and February (13%), however, these data differ by country.

Table 3. Distribution of traffic accidents by country and month, 2015 year [1]

	Jan/Fab	Mar/Apr	May/June	Jul/Aug	Sep/Oct	Nov/Dec	Total
BG	8%	16%	15%	28%	18%	15%	157
CZ	15%	23%	13%	19%	17%	14%	103
DE	13%	15%	18%	19%	19%	15%	473
EL	16%	16%	14%	21%	23%	10%	112
HR	13%	9%	20%	27%	20%	11%	45
IT	12%	13%	16%	23%	18%	18%	379
HU	13%	11%	28%	20%	13%	15%	61
AT	7%	13%	11%	38%	18%	14%	72
RO	13%	16%	11%	18%	16%	25%	207
SI	0%	13%	6%	19%	38%	25%	16
SK	14%	12%	14%	20%	22%	19%	59
EU	13%	15%	16%	21%	18%	16%	3.636

3. ANALYSIS OF THE SITUATION IN THE SURROUNDING COUNTRIES, WITH REVIEW OF THE REPUBLIC OF CROATIA AND THE REPUBLIC OF SLOVENIA

Researching statistics on road accidents for young drivers in the surrounding countries by examining publicly available documents, it is noticeable that not all countries conduct the same level of statistical analysis. eg. Slovenia conducts the most detailed analysis with the largest number of parameters [2].

In 2005, when the term was introduced, young drivers were involved in 11 954 car accidents. In 2018, young drivers in Croatia participated in 3454 road accidents, resulting in 33 deaths and 1878 injuries [3]. Compared to 2017, positive developments were observed, i.e. a decrease in the number of accidents by 81 accidents, a decrease in the number of injured persons by 56, but unfortunately, an increase of 3 killed more than in 2017.

In Slovenia, during 2018, young drivers participated in a total of 3721 accidents, of which 2294 were hidden. 744 accidents resulted in minor injuries, 79 more serious and 15 with fatalities. Alcohol consumption (702 accidents) are the most common causes of accidents.

According to the data of the Slovenian Traffic Safety Agency, young drivers are generally involved in the largest number of car accidents during the weekend, from 11 pm to 6 am, while the most common causes of accidents are alcohol-fueled driving and non-compliance with traffic rules [5].

Figure 2. Number od traffic accidents caused by young drivers [4]

4. MEASURES FOR REDUCING NUMBER OF ROAD ACCIDENTS WITH YOUNG DRIVERS

Road user behavior is determined by a combination of factors, including the road infrastructure, road traffic regulations, levels of traffic law enforcement, in-vehicle-enforcement, in-vehicle safety technology, behavior of other road traffic participants and traffic education. As this paper deals with young drivers, only behavior of traffic participants and traffic education is analyses further. Young drivers represent a greater risk everywhere and therefore prevention needs to be better addressed. It is crucial to understand young driver’s mind and motives.

Research shows that attitudes about safety are formed at an early age, long before legal driving, and therefore it would also be important to target children and young adolescents. It is necessary to start educating those groups as early as possible, adjusted to their cognitive development. Early campaigns need to be introduced at even kindergarten level as a first step of shaping responsible traffic participant. Those campaigns need to be followed by more extensive ones as target group's age elevate. Interdisciplinary approach needs to be used while creating campaigns and should include various professionals like traffic experts and children psychologist to create campaigns that will result with maximum effect.

Besides that, some experts advocate the principle of "sustainable safety" [6] on roads is based on the thesis that the entire transport and transport system is based on human constraints. The road infrastructure prevents the use of roads that involve large differences in direction, speed and mass and directs the user towards safe behavior.

The vehicles are built to simplify the task of driving and offer crash protection. Road users are educated and informed and their behavior is regularly tested. “Sustainable safety” is based on the five principles, and two of these five principles are based on the “self-explanatory road” and “forgiving road environment” [7].

5. CONCLUSION

Traffic safety is a combination of human being, vehicle and road. These factors are interdependent and in order to maximize traffic safety, attention must be paid to each of these factors. This paper focused on the human factor, more specifically on the category of young drivers. Obtaining a driver's license is wrongly perceived as the last step in training to operate a motor vehicle independently. Statistics say that young drivers are a particularly vulnerable category. In order to educate a safe, defensive and attentive driver, it is important to begin to instill a knowledge of traffic culture from an early age. Thus, a candidate for a driver or a young driver will have increased competencies when faced with a driving test and self-driving situation. After a brief cross-section of statistics for the European Union and in the surrounding countries, and the proposal of measures to increase the safety of young drivers, this paper reiterates the need to introduce a transport culture from an early age, but also to understand that the education of young drivers is a process that different professions need to approach in synergy, interdisciplinary. Only by acting together will the educational process result in the creation of a responsible driver, which will also reduce the frequency of traffic accidents and indirectly the number of casualties and fatalities in traffic.

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ANALYSIS CHARACTERISTIC OF HAZARDOUS LOCATIONS IN URBAN ENVIRONMENTS

Key Words

Traffic accident; Hazardous location; State road; Urban environment

Abstract

International experience, as well as previous research in the Republic of Croatia, shows that successful identification and remediation of hazardous locations results in a significant reduction in the number of traffic accidents, especially those with the most severe consequences. One of the most important steps in the process of identifying and remediation hazardous locations is the direct inspection of the location on the ground by an expert team, which in the most relevant way identifies deficiencies on the road and related equipment. Total of 117 locations have been inspected in the Republic of Croatia in the past year, which represented potentially hazardous locations on state roads, of which 61 is in located in urban areas. Based on the reviews of potentially hazardous locations in urban areas, significant data were collected on the condition of the road and related equipment, the results of which were analysed in detail and presented in this paper. Based on these results, remediation measures have also been proposed, which enable increased road safety and reduced traffic accidents.

1. INTRODUCTION

The areas of the road transport network where there are a constant number of traffic accidents, in comparison with other areas of the road transport network, with human consequences or with serios material damage, are called hazardous locations. In such parts, the risk of traffic accidents is significantly increased, and such locations present some impediment to improving road motor road safety. Therefore, it is very important to identify such locations in the road transport network in a timely manner and, with appropriate analysis and subsequent remediation, to enable smooth flow of traffic in such areas while increasing traffic safety for all users.

One of the best ways to prevent road accidents is to identify potentially hazardous locations in the road transport network and to repair them. In accordance with the new Methodology, which is in line with current legislation, guidelines and recommendations of the European Union and aims to identify the hazardous locations where the cause of traffic accidents was due to a lack of traffic and technical characteristics of the road, the company Hrvatske ceste d.o.o. in 2017, it initiated the process of identifying potentially hazardous locations on the state road network in the Republic of Croatia, identifying a total of 135 potentially hazardous locations where an average number of traffic accidents occurs. International experience shows that the most relevant results in identifying hazardous locations are achieved by reviewing such sites on the ground. Therefore, based on the results of the identification, a process of self-examination of identified potentially dangerous sites in the field was initiated to determine whether these were indeed hazardous locations and what elements of the road infrastructure could be rehabilitated in order to increase traffic safety on the observed area of the road transport network. Of the 135 potentially hazardous locations identified, a total of 117 locations were approached on the ground.

2. RATE QUALITY CONTROL METHOD

The identification of potentially hazardous locations in the previous years in the Republic of Croatia, namely from 2004 to 2016, was done by a methodology that was based on a numerical definition, whereas from the beginning of 2017 a new methodology has been applied or adopted, which is based on a statistical survey of each location of traffic accidents in relation to the previous methodology, and in line with international experience and recommendations. The new methodology was used in this study to identify locations where an above-average number of traffic accidents occur over the three years 2014-2016 through the next five steps.

In the first step, at the beginning of the identification of a hazardous location, it is necessary to define on the basis of which parameters the hazardous location will be identified, or if the hazardous location are searched only on the basis of traffic accidents in which serious consequences occurred, all locations where traffic events occur should be identified on the defined network accidents with severe consequences in the last three years. In addition to the type of traffic accidents, given their consequences, it is necessary to define other characteristics of dangerous places, and this most often refers to the characteristic of the road (straight road course, bend, intersection, etc.).

In the second step of identifying a hazardous location, it is necessary to determine the method of segmenting the shares into fixed parts, which in the case of this study was a 300 meter segment within which all traffic accidents belonging to that segment were analysed, whether one or more characteristic of road network.

The third step is the statistical examination of the hazards of each location where traffic accidents occurred by default parameters, which involves defining the rate of traffic accidents. It can be defined as the ratio between the number of traffic accidents and the measure of exposure in the observation area and shows the number of accidents in relation to the traffic load on a section of road, in units:

$$C_R = \frac{PN}{M} \qquad [1]$$

where is: C_R – crash rate

PN – total number of traffic accidents

M – average traffic volume at the site in the observed interval

The average volume of traffic over a period of one year at the observed location, which is also referred to in an international literature, and location exposure, is calculated according to the expression:

$$M = \frac{Q \cdot 365 \cdot d}{1.000000} \qquad [2]$$

where is: Q – AADT (traffic demand)

d – the length of the observed location [km]

If the rate of traffic accidents for an intersection account is then calculated using the formula of the average traffic volume in one year at the observed location:

$$M = \frac{Q \cdot 365}{1.000000} \qquad [3]$$

The calculation of the critical level of occurrence of a traffic accident for each location based on the average rate of traffic accidents across all locations is characteristic of the next step of identifying a dangerous location. The critical level of traffic accidents is calculated by the expression:

$$C_{CR} = CR_A + k \cdot \sqrt{\frac{CR_A}{M}} + \frac{1}{2 \cdot M} \qquad [4]$$

where is: C_{CR} – critical crash rate

C_{RA} – critical crash rate average

k – coefficient of confidence level (Table 1.)

Table 2. Coefficient k values for different levels of significance

Significance level	k
90 %	1,282
95 %	1,645
99 %	2,323

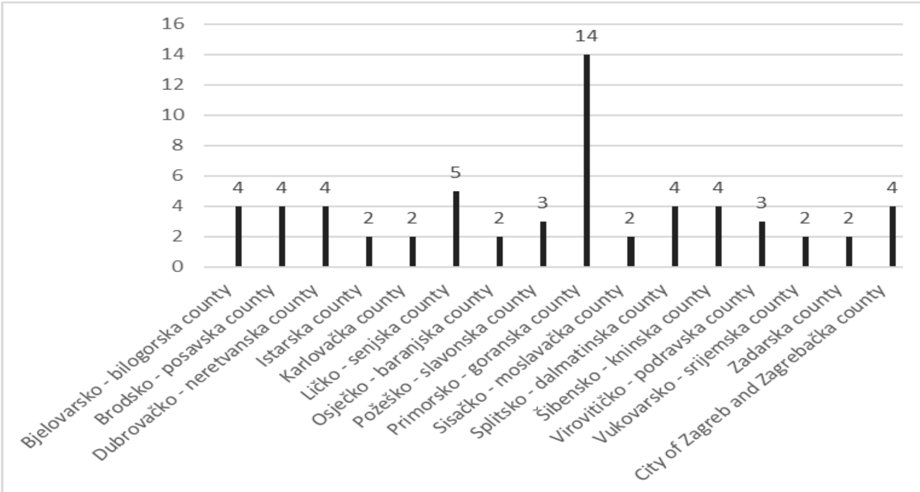
If the rate of traffic accidents exceeds the critical level defined by this method, it is considered that traffic accidents, statistically, do not happen by accident, but are potentially hazardous. In case the traffic accident rate does not exceed the critical level, the location is not statistically potentially hazardous.

In the last part of the model, the identified potential hazardous sites are ranked according to the ratio between traffic accident rates and the critical level of traffic accidents.

3. REVIEW OF POTENTIALLY HAZARDOUS LOCATIONS IN URBAN ENVIRONMENTS

Analyzing the total number of traffic accidents on all state roads of the Republic of Croatia in the period 2014-2016, a total of 135 potentially hazardous locations were identified, of which 117 were inspected on the ground, while five identified potentially hazardous locations were in the process reconstruction or execution of works. The seven identified potentially hazardous locations were characterized as border crossings where no analysis was possible due to the lack of detailed inspection and photographing, as well as the six identified potentially hazardous locations that were inspected as part of earlier studies of potentially hazardous sites. Analyzing the identified potentially hazardous locations in urban areas most commonly related to cities and populated areas, a total of 61 potentially hazardous locations (52.00%) were identified from a total of 117 potentially hazardous locations at which a site inspection was performed. Remaining number of potentially hazardous locations inspected in the field refers to non-urban areas and a total of 56 (48.00%).

Based on 61 identified, inspected and analyzed potentially hazardous locations in urban areas, as can be seen in Graph 1, it emerges that identified potentially dangerous places are located in 16 of the total 20 counties in the territory of the Republic of Croatia, since the City of Zagreb and the County of Zagreb were characterized as one county for the purposes of this study. The largest number of identified potentially hazardous locations in urban environments is in the Primorsko – goranska county (23.00 %), followed by Ličko – senjska County (8.00 %) and Bjelovarsko – bilogorska, Brodsko – posavska, Dubrovačko – neretvanska, Splitsko – dalmatinska, Šibensko – kninska and the City of Zagreb and Zagrebačka county, which identified the same number of potentially hazardous locations (6.50 %) in urban environments. A detailed account of identified, reviewed and analyzed potentially hazardous locations in urban areas by county is presented in Graph 1.



Graph 1. Detailed view of identified potentially hazardous locations in urban environments by county

The identification of potentially hazardous locations was made on the network of state roads of the Republic of Croatia, which is 7 097.70 km long and covers a total of 190 state roads. From 61 identified, inspected and analysed potentially hazardous locations in urban areas, it is evident that identified potentially dangerous places are located on a total of 28 out of 190 national roads in the territory of the Republic of Croatia. The largest number of identified potentially hazardous locations in urban environments is located on state road DC8 (23.00%), which is also the longest state road with heavy traffic load throughout the year. This is followed by state road DC1 (8.00%), state road DC2 (6.50%), state road DC5 (5.00%) and state road DC423 (5.00%).

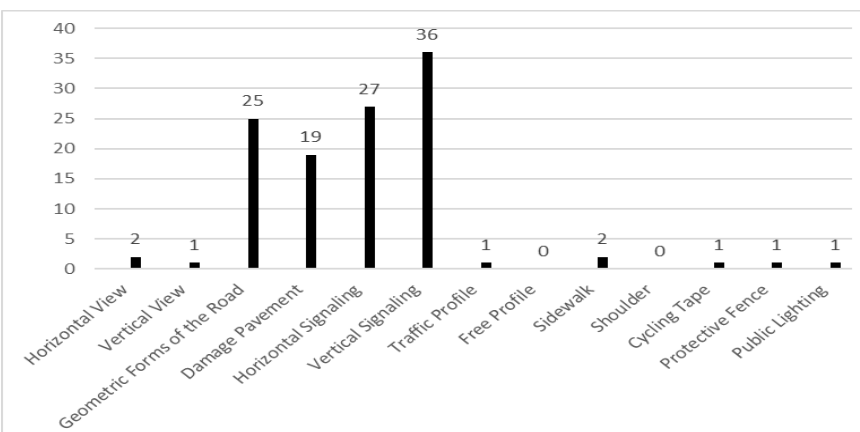
4. ANALYSIS OF THE RESULTS

Based on the review of identified potentially hazardous locations in urban environments and the analysis of traffic and technical characteristics of the road, three categories were defined, which based on the said analysis identified the identified potentially dangerous places, each separately as:

- a hazardous location requiring measures to increase road safety,
- a location where it is justified to take measures to increase traffic safety,
- a location that does not currently require remedial action or increased traffic safety.

A total of 61 identified locations that represent a potentially hazardous locations in urban environments are divided into three categories, so a total of 15 locations (25.00%) belong to the category of hazardous locations requiring measures to increase road traffic safety, 29 locations (47.50%) belong to the category of locations where it is justified to take measures to increase traffic safety, while 17 locations (27.50%) belong to the category of locations that do not currently require remediation action or increased traffic safety. If we compare the locations in urban areas with the locations of identified potentially hazardous locations in non-urban areas, we obtain a similar division into categories, so that a total of 14 locations (25.00%) belongs to the category of hazardous location requiring measures to increase road safety, 34 locations (60.00%) belong to the category of locations where it is justified to take measures to increase traffic safety, while 8 locations (15.00%) belong to the category of locations that do not currently require remediation or enhancement of traffic safety

When inspecting identified locations of potentially hazardous urban locations in the field, measurements were made of the geometric elements of the road and the analysis of road equipment. The observed characteristic deficiencies for the purposes of this study are divided into 13 indicators in order to gain a better insight into the characteristics of the locations examined, which aim to identify the deficiencies of the road - technical characteristics of the road that could have led to the occurrence of the traffic accident, which are referred to in Graph 2. According to the results of the survey, 44 identified potentially hazardous locations in urban environments identified deficiencies as these sites belong to the first or second category that require or justify measures to increase road safety. The observed deficiencies of the inspected locations on the ground are not necessarily the causes of traffic accidents over the three-year period at the locations in question but are identified as defects of the road or its equipment at the specific location. Graph 3. shows the most commonly observed deficiencies at identified locations of potentially hazardous locations in urban environments.



Graph 2. Deficiencies observed in roads and related equipment when inspecting identified locations of potentially hazardous locations in urban environments

Analysing the 61 inspected identified locations in urban areas where at least one defect was observed, Graph 2, the results show that the most observed deficiencies relate to vertical signaling (82.00%). Following in the order of the identified deficiencies are irregularities related to horizontal signaling (61.00%), followed by geometric forms of the road (57.00%) and pavement damage (43.00%), which make up the set of four most commonly observed defects at the examined locations identified potentially dangerous places in urban areas.

5. CONCLUSION

The aim of the presented study was to identify potentially hazardous locations in the network of state roads of the Republic of Croatia on which an average number of traffic accidents occurs, and which require timely identification or remediation in order to increase road traffic safety. Based on the new Methodology and the results of the study, which identified 135 potentially hazardous locations in the national road network in the three years 2014-2016, a process of reviewing all identified field sites was initiated, of which 117 were inspected in the field. A field survey identified a total of 61 identified locations (52.00%) of a potentially hazardous locations located in urban environments, most commonly referring to the center of cities traversed by the state road network in the Republic of Croatia. The remaining number of potentially hazardous locations inspected outside the urban environments are 56 (48.00%).

Looking at counties, the largest number of identified potentially dangerous sites in urban areas is located in Primorsko – goranska county (23.00 %), then follows Ličko – senjska county (8.00 %), and Bjelovarsko – bilogorska, Brodsko – posavska, Dubrovačko – neretvanska, Splitsko – dalmatinska, Šibensko – kninska and City of Zagreb and Zagrebačka county which identified the same number of potentially hazardous locations (6.50 %) in urban environments. If one looks at the state roads separately, the largest number of identified potentially hazardous locations in urban environments is on state road DC8 (23.00 %) which is also the longest state road with heavy traffic load all year long. This is followed by state road DC1 (8.00%), state road DC2 (6.50%), state road DC5 (5.00%) and state road DC423 (5.00%).

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PEDESTRIANS' CROSSING SPEED AND INFLUENTIAL FACTORS

Key Words

Pedestrians;
Speed;
Road crossing;
Influential factors

Abstract

The pedestrians' behavior and their speed while crossing the road was the subject of interest of the numerous studies in previous years, for a few reasons. In order to improve the pedestrians' safety, better understanding of the pedestrians movement characteristics during roadway crossing is necessary. Also, pedestrians' crossing speed is the input data for the signalized intersection cycle determination, in term of the pedestrians green cycle duration. Thus, in this paper is performed literature review, some of the influential factors are identified, and previously reported results about pedestrians' speed differences are compared and detailed discussed.

1. INTRODUCTION

According to the Global Status Report on Road Safety, the number of road traffic deaths reached 1.35 million in 2016. Road traffic injuries are now the leading cause of death for children and young adults aged 5–29 years, and 8th leading cause of death for people all ages. Particularly risky are vulnerable road users, including pedestrians, cyclists and two-wheelers. Globally, pedestrians represent 23% of all road traffic deaths [1], which leading to the conclusion that described problem is obvious.

Zeger et al. [2] reported non-significantly different crash rates between marked and unmarked crosswalks on two-lane and multi-lane roads while investigated pedestrians behavior in 30 cities across the United States. In contrast with this, there is some findings that risk of the collision is significantly higher during unmarked roadway crossing by pedestrians compared to the crossing at marked crosswalks [3]. However, in order to cross the road safely in both cases (marked crosswalks and unmarked roadway crossings) pedestrians are faced with a complex task to estimate oncoming vehicles moving in term of their distance [4-6], and speed [7]. Pedestrians crossing speed is also an important factor which affects safe or risky road crossing in term of pedestrians vehicles time-spatial interactions during illegal and non-signalized crosswalks crossings.

On the other hand, pedestrians speed is the key factor for pedestrians green cycle duration on the signalized intersections. A better understanding of pedestrians crossing speed can reduce vehicle time losses and provide pedestrians safety, at the same time.

Thus, in this paper will be investigated pedestrians crossing speed in term of its value, but also will be identified some influential factors and tendencies for speed variations among pedestrians, based on the previous findings.

In this paper are presented some studies which investigated pedestrians crossing speed in the various traffic conditions mentioned above (signalized crosswalks crossings, non-signalized crosswalks crossing and unmarked roadway crossings).

2. BASIC FINDINGS REPORTED IN PREVIOUS STUDIES

Tarawneh [8] conducted research on the 27 crosswalks at 12 signalized intersections in the city of Amman (Jordan). Based on the collected data from nearly 3500 pedestrians crossing, the author found some factors affecting the moving speed of the pedestrians, such as age, gender, group size and street width.

Analysis of the results collected during TCRP-NCHRP reported by Fitzpatrick et al. [9] also identifies some influential factors on pedestrians speed. The data set included data from 42 sites in the 7 states across USA (Arizona, California, Maryland, Oregon, Texas, Utah, and Washington) with a sample size of 2522 pedestrians. Authors investigated the potential gender, age, group size, vehicle volume, speed limit and median refuge influence on pedestrians' speed. Results of this study that all the described factors, except gender, are statistically significant, but the practical difference is reported only at age, group size and vehicle volume. Authors found factor gender non-significant, in contrast with previous research made by Tarawneh [8].

Montufar et al. [10] conducted 8 months duration study in the city of Winnipeg (Canada) with a purpose to identify potential pedestrians speed differences during normal walking and road crossing on signalized intersections, taking into account age and gender of the pedestrians and the season effects (winter or summer). Based on the 1792 pedestrians moving observations (1104 during the summer and

668 during the winter), they found statistically significant differences between normal walking speed and crossing speed, regardless of age and gender. Older pedestrians walk faster when they are crossing the road (1.36 m/s on average) than when they are walking normally (1.14 m/s on average). There are also clear differences between the average walking speeds of older male and female pedestrians. Older males walk faster than older females in both, normal walking conditions and crossing conditions, no matter of the season. Like it can be concluded from the described above, age and gender differences have also been reported.

The most of the studies we found are focused on pedestrians' speed while crossing the signalized crosswalks. There is some study [11] that makes a comparison between the pedestrian's speed during signalized and non-signalized crosswalks crossings. They conducted research on 4 locations in Kuala Lumpur (Malaysia), with a total sample size of 1579 crossing observations. The results showed that there is a significant difference of pedestrians crossing comparing these two types of crosswalks and authors concluded that the average pedestrians' speed on the signalized crosswalks (1.31 m/s) is lower from the one on non-signalized (1.39 m/s). Their results also indicate that there are pedestrians' gender and age impact on crossing speed, while the influence of factors lighting (daytime or nighttime) and race don’t exist.

While investigated pedestrians illegal road crossing on the 4 overpass locations in Izmir (Turkey) with various speed limits (50 km/h and 70 km/h) Demiroz et al. [12] found that pedestrians' speed during illegal road crossings is influenced by gender and speed limit. By analyzing the speed of 345 pedestrians they found that pedestrians moving faster while crossing the road with a higher speed limit, probably because feel more risky. In contrast with Tarawneh [8] Demiroz et al. [12] reported a non-significant connection between pedestrians crossing speed and group size. Their finding showed that the average crossing speed of individuals pedestrians was 1.21 m/s, while groups’ speed found to be 1.20 m/s.

Based on the 2694 pedestrians crossing observations on the 8 signalized crosswalks in Izmir (Turkey) Onelcin and Alver [13] identified age, gender, group size, but also age and group size interaction as influential factors on pedestrians crossing speed. They also found that items carrying affects the pedestrians crossing speed. Pedestrians without any items have reached an average crossing speed 1.32 m/s, while the pedestrians with some kind of item were moving with 1.28 m/s on average, which indicates that items carrying affects the reduction of pedestrians crossing speed.

Muley et al. [14] investigated the pedestrians speed at 3 signalized crosswalks in the city of Doha (Qatar) in term of crosswalks length influence on the pedestrians' entry speed, crossing speed and exit speed. Results of their study showed that crosswalks length affects all investigated pedestrians speed (entry, crossing and exit), which is similar to the results reported by Tarawneh [8] who found that pedestrians' speed is correlated with street width. Both of them concluded that pedestrians' speed is higher on the longer distances.

According to Guo et al. [15] factors age, gender and group size affects the pedestrians crossing speed. The research was conducted on the two-stage pedestrian signalized crosswalk in Zibo City in China with a sample size of 1025 crossing observations in total. Different from others, this authors investigated the potential impact of two-staged crossing (first and the second phase on the roads where directions are separated by middle island) and also the pedestrians moving direction on theirs crossing speed. Results showed that there is no statistical significance in pedestrians' speed depending on moving direction, but it is significantly depending on the crossing stage. Pedestrians speed was higher during second stage crossing (1.59 m/s on average) comparing with the first one (1.31 m/s on average).

Shaaban [16] also reported age, gender, group size and items carrying differences while investigated pedestrians road crossing on the 3 signalized intersections in Doha (Qatar), with a sample size of 1423 crossings in total. In contrast with all previous studies which identified gender as influential factors, he found that females moving faster while crossing the road, compared with males. According to Shaaban [16], speed of younger pedestrians and pedestrians individuals is higher than the older ones and pedestrians in the group, respectively, which is in line with previous findings.

Table 1. Summary of the pedestrians speed influential factors

References	Sample size	FACTORS								
		Gender	Age	Group size	Road width	Traffic volume	Crosswalk type	Items carrying	Speed limit	Walking type
Tarawneh, 2001	nearly 3500	+	+	+	+	/	/	/	/	/
Fitzpatrick et al., 2006	2522	-	+	+	/	+	+	/	+	/
Montufar et al., 2007	1792	+	+	/	/	/	/	/	/	+
Goh et al., 2012	1579	+	+	/	/	/	+	/	/	/
Demiroz et al., 2015	345	+	/	-	/	/	/	/	+	/
Onelcin & Alver, 2017	2694	+	+	+	/	/	/	+	/	/
Muley et al., 2018	211	/	/	/	+	/	/	/	/	+
Guo et al., 2019	1025	+	+	+	/	/	/	/	/	+
Shaaban, 2019	1423	+	+	+	/	/	/	+	/	/

*(„**+**“ Affects pedestrians’ speed), („**-**“ Do not affects pedestrians’ speed), („**/**“ Not investigated)

Like it can be seen from Table 1, the most frequently investigated potential factors are gender, age and group size, respectively. Those factors are also the most frequently confirmed, so their influence on pedestrians crossing speed will be detailed discussed below.

3. ANALYSIS OF PEDESTRIAN'S SPEED DIFFERENCES DEPENDING ON INFLUENTIAL FACTORS

3.1. Gender as an influential factor

Numerous studies have investigated pedestrians' gender influence on their speed while crossing the road [8-13,15,16]. All the mentioned studies have been confirmed the gender influence, except Fitzpatrick et al. [9]. Results from almost all described studies showed that males pedestrians are moving faster while crossing the road comparing to female pedestrians. There is only one exception study which reported the opposite speed tendency in term of pedestrians gender [16]. Results from those studies have been extracted and presented graphically on figure 1. Since Montufar et al. [10] investigated pedestrians' normal (during sidewalks moving) and signalizes crosswalk crossing, it is important to note that we take into considerations only road crossing speeds. The slowest pedestrians' speed for both genders has been reported by Demiroz et al. [12], while the fastest crossing pedestrians speed was found by Montufar et al. [10]. These results are surprising, considering that Demiroz et al. [12] explored illegal pedestrian road crossings on the overpass locations, so it was expected faster moving.

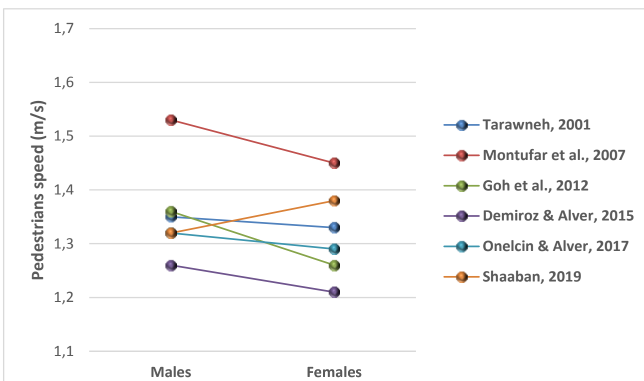

Figure 1. Pedestrians' crossing speeds depending on gender

3.2. Age as an influential factor

The results of all studies analyzed in this paper [8-11,13,15,16] showed that the slowest pedestrians are the oldest ones, which is not surprising considering their limited sensory and psychomotor abilities.

The problem with the comparison of age-related pedestrians' speed characteristics was various defined age categories by the authors. For example, Montufar et al. [10], defined only two age categories, such as younger (between 20 and 64 years) and older pedestrians (65 years and older). On the other hand, Tarawneh [8], defined five age categories (<20; 21-30; 31-45; 46-65; >65 years). Since the most analyzed studies contained three age groups, we made the comparative analysis with this number of age groups (younger, adult and older), respecting the years of the age categories suggested by previous authors.

Other problem is in relation to pedestrians age determination, thus the methodology of most studies contained pedestrians age characteristic extraction from the video records, so the accuracy of determined pedestrians age depends on the authors' subjective abilities.

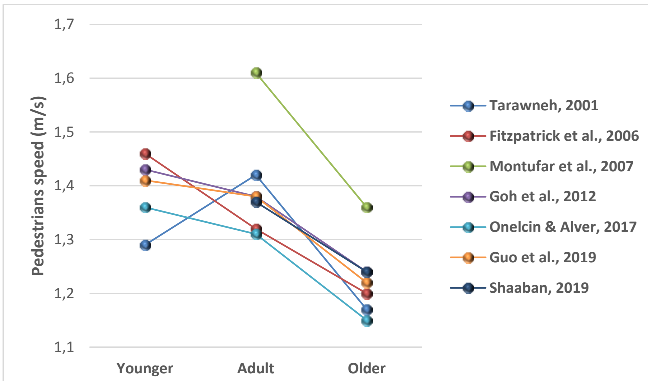

Figure 2. Pedestrians' crossing speeds depending on age

From figure 2 it can be seen that there are clear speed reduction tendencies with age increasing. An exception is results reported by Tarawhen [8], who found that adults crossed the road faster than younger pedestrians, in contrast with other studies. The only one exception in term od speed value is noticed in the study conducted by Montufar et al. [10], who reported higher speed for both adult and older pedestrians, compared with other authors.

3.3. Group as an influential factor

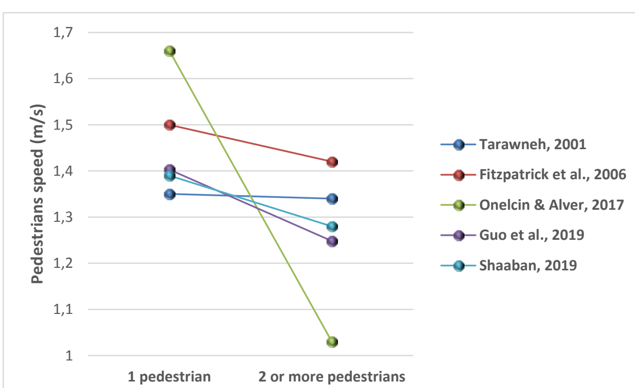

Figure 3. Pedestrians' crossing speeds depending on group

From figure 3 it can be seen that the results of all studies showed that pedestrians cross the road slower while they are moving in a group. Results reported by Onelcin and Alver [13] differ from the other studies in term of speed values. They reported the highest speed of individual pedestrian (1.66 m/s), and the slowest for group od pedestrians (1.03 m/s), comparing with other studies.

3.4. Summary of the pedestrians speed values

In table 2 is presented the descriptive statistics of the pedestrians' speed values depending on factors, including all the results of the studies analyzed in this paper.

Table 2. Descriptive statistics for pedestrians' speed value depending on influential factors

Factors	Categories	PEDESTRIANS SPEED (m/s)			
		Mean	**SD**	**Min**	**Max**
GENDER	**Males**	1.36	0.08	1.26	1.53
	Females	1.32	0.08	1.21	1.45
AGE	**Younger**	1.39	0.06	1.29	1.46
	Adult	1.4	0.09	1.31	1.61
	Older	1.23	0.06	1.15	1.36
GROUP	**1 pedestrian**	1.46	0.11	1.35	1.66
	2 or more pedestrians	1.26	0.13	1.03	1.42

Also, previously reported results are extracted and analyzed using paired t-test (factors gender and group) and ANOVA test (factor age). The input data were the averaged speed values reported by analyzed studies [8-16], with respect on speed differences between pedestrian categories.

Table 3. Paired T-test and ANOVA test results

	Mean (Pairs)	**95% CI**		**t (F)**	**Sig. (2-tailed)**
		Lower	**Upper**		
Paired T-test					
GENDER	0.037	-0.022	0.096	1.601	0.170
Paired T-test					
GROUP	0.197	-0.111	0.505	1.778	0.150
ANOVA					
AGE	/	/	/	9.537	**0.002***

*(α=0.05)

Paired T-test showed that there is no statistically significant difference between male and female speed (Sig.=0.17), as well as individual pedestrians comparing with pedestrians in a group (Sig.=0.15) On the other side, there is statistically significant crossing speed differences between the younger, adult and older pedestrians. Post-hoc Tukey test indicates that older pedestrians speed is significantly slower than the other ones.

4. CONCLUSION

Like it is described above, the most frequently investigated and also confirmed pedestrians crossing speed influential factors are gender, age and group size, which indicates that their influence is obvious. Although the authors of the previous studies reported statistically significant speed differences between males and females pedestrians, such as individuals versus pedestrians in a group, we found non-significant speed differences based on average pedestrians' speed reported by previous authors. On the other hand, we found statistically significant speed differences between age groups, primarily at the older pedestrians' speed.

It is important to note that all the analyzed studies treated only normal pedestrians crossing, leaving out of the analysis some extreme movements, such as slow-moving or running. The purpose of normal pedestrians crossing extraction is taking into consideration the highest percent of the pedestrian's movements and their speeds. Since pedestrians speed plays an important role in the green cycle length determination on pedestrians signals on the signalized intersections, it must include tendencies for pedestrians' speed variations as much as possible, with the aim to provide pedestrians safe road crossings. On example, all the analyzed studies in this paper reported that older pedestrians speed is significantly lower than the other ones, thus this facts also need to be considered for green cycle length determination. On the other hand, if the signalized intersections are located in the area with a higher percentage of the younger pedestrians (on examples university areas), designers should take into consideration younger pedestrians ability to move faster and determine the green cycle in accordance, to minimize unnecessary vehicle time losses.

One more interesting finding in this term is pedestrians' speed differences depending on road width [8], i.e crosswalk length [14]. This findings are underinvestigated, but can also be very important factors for green cycle length determination. Thus, the detailed examination of the road width influence on the pedestrian's speed during signalized crosswalk crossings is a suggestion for future research.

Also, there are some findings [9,12] that pedestrians crossing speed varies depending on road speed limits on the non-signalized crosswalks, which also requires more intention in the future, primarily because of pedestrians safety improvement.

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IDENTIFICATION OF INFLUENCING ATTRIBUTES FOR THE TRAFFIC ACCIDENT SEVERITY PREDICTION MODEL

Key Words

Traffic accident prediction; Feature selection; Swarm optimization; Neural network

Abstract

This paper deals with identification of the most influencing input attributes related to the accuracy of the prediction model. It is assumed that the prediction model may be represented by any machine learning-based models, including artificial neural networks, fuzzy models, etc. Selection of influencing attributes is based on particle swarm optimization (PSO) combined with neural networks. The role of neural networks is to estimate fitness of each particle during the search procedure implemented using a PSO algorithm. The presented feature selection method represents the first step in the prediction model design which is applied on the accident severity prediction. The method is applied on a dataset characterized with weak correlation between the model's inputs and output representing an accident severity. The proposed approach has shown the ability to identify subsets of factors that have an influence on accident severity prediction. Selection of appropriate inputs improves the prediction model accuracy.

1. INTRODUCTION

Growth in road traffic intensity as consequence has a rapid increase in road accidents. Identification of the most influencing factors related to traffic accidents represents a basic phase in analysis of accident causes and their consequences.

Artificial neural networks (ANN) are the most frequent machine learning techniques employed in traffic accident severity prediction. Back-propagation neural networks were applied in [1, 2]. Ogrenci [3] predicted accident severity with Multilayer Perceptron (MLP) neural networks. Moreover, Support Vector Machines (SVM) were used for crash severity prediction [4], and traffic fatalities prediction was improved with an SVM model parameters optimization using hybrid particle swarm optimization [5]. In order to design more accurately, a robust and interpretable prediction model with reduction of input data by proper selection of key variables, should be performed [6].

Feature selection is a process of taking a subset of features from the initial set without transformation. Generally, feature selection methods are classified in three groups of approaches: wrappers, filter approaches and their combination. The wrapper approach uses a machine learning algorithm, repeatedly called by a data re-sampling technique, while the filter approach looks for features which have a stronger measure of association to the output variable.

This work describes the problem of finding fetures that are most influential as a problem of searching feature space. As a search technique, the Particle Swarm Optimization (PSO) algorithm was used [7]. The PSO algorithm uses a particle swarm made out of a vast number of particles in a candidate population that represent feature subsets. In each PSO iteration the particles „learn“ from one another and refresh their knowledge in relation to the current and best solution, as well as the best solution for the whole swarm. Every particle in the swarm is presented with its position and speed. Fitness of every particle in this PSO algorithm implementation presents an estimation of the crash severity estimated using an MLP type of ANN.

In the second section, the attributes selection method is described using a hybrid PSO–ANN approach. The third section contains results of the attributes selection method applied on the traffic accident dataset. In the last section, concluding remarks are given.

2. FEATURE SELECTION USING PSO+ANN ALGORITHM

The feature selection algorithm presented here is based on a Particle Swarm Optimization (PSO) method, which is combined with an artificial neural network (hereinafter referred to as the PSO+ANN algorithm). Input of the ANN is a candidate subset of features, and it is trained to predict crash severity. The calculated prediction error is presented as fitness of the particle and it has an influence on the current position of the particle (feature subset), the direction of the particle, and preferably also on the entire swarm. Therefore, the used hybrid method of feature selection using the PSO+ANN algorithm is characterized with the following:

- Number of particles, i.e. population size, defines how many neural networks will be used during the search for the best feature combination.
- Every neural network has a different combination of input variables in one generation, but their number is constant.
- During the search of the solution space, synaptic weight coefficients of all neural networks are iteratively adapted with an aim to achieve a minimal error.
- The search method using the hybrid PSO+ANN algorithm has ended when the given number of generations is achieved.

Particle swarm optimization algorithm was first described by J. Kennedy and R. C. Eberhart in 1995 [7]. The main idea of the method resulted from an association with social behavior of an individual from a flock of birds or fishes. PSO is a stochastic search algorithm based on a population of adaptive solutions by simulating the behavior of individuals in the swarm. The PSO approach has become popular because of the simplicity of the basic PSO algorithm implementation [8] and because it is characterized by low computational complexity [9].

The position of a particle denoted by vector $\boldsymbol{x_i}$ (in iteration t) is changed by adding the speed vector $\boldsymbol{v_i}$ in the current position:

$$\boldsymbol{x_i}(t) = \boldsymbol{x_i}(t-1) + \boldsymbol{v_i}(t). \tag{1}$$

Speed vector $\boldsymbol{v_i}$ defines where will the i-th particle move in the next iteration, considering a previous best positions, as well as the „experience“ of the most successful particle from the swarm:

$$\boldsymbol{v_i}(t) = W\boldsymbol{v_i}(t-1) + C_1 r_1 (x_{pbest_i} - \boldsymbol{x_i}(t)) + C_2 r_2 (\boldsymbol{x_{gbest}} - \boldsymbol{x_i}(t)), \tag{2}$$

where r_1 and r_2 are random values in the interval [0,1], W is the inertion coefficient, while C_1 and C_2 represent constants for controlling the influence of the best local solution for a particle $\boldsymbol{x}_{pbest}$ and global best solution for particle $\boldsymbol{x}_{gbest}$, respectively. In each iteration of the PSO algorithm, particles “learn” from each other and find new solutions on a better location in the solution space. The local best position (*pbest*) and the global best position of all particles (*gbest*) have an influence on every particle in the PSO set of solutions, besides the current moving direction of every particle.

Feature selection is ranking features based on importance using the PSO+ANN method defined by a 100 particles (individual solutions) and 50 iterations. The complete algorithm is repeated 20 times, in order to reduce the stochastic nature of the search method. Inertia coefficient W =0.754 was adopted, while a value of C_1=C_2=1.5457 was adopted for the personal (C_1) and global (C_2) learning coefficient. Values of the best particles, i.e. particles with the best combination of input variables are used in forming the importance index of the following form:

$$\sum_i^m \sum_j^n \left(1 - \frac{c_{ij} - c_{min}}{c_{max} - c_{min}}\right), \tag{3}$$

with the meaning: m – number of repetitions; n – number of variables; c_{ij} – value of the solution for the i-th repetition in which the j-th variable participated; c_{max} – the weakest achieved result; and c_{min} – the best achieved result.

3. RESULTS OF FEATURE SELECTION OBTAINED WITH THE PSO+ANN

The accident dataset used for this study contained traffic accident records from year 2008 to 2011 in the urban area of the city of Novi Sad [10]. The dataset comprised of the official statistics on traffic accidents, with a total of 42 features and 752 traffic accidents, from which 798 were pedestrian casualties. All factors involved in accidents are classified and labeled, including consequences which consist of four classes: fatalities, major injuries, minor injuries and without injuries.

A neural network with one hidden layer and fitness function in the form of the mean absolute error between the real and estimated output was embedded in the search method using the PSO algorithm. In case of five input variables, neural network has eleven neurons on the hidden layer and one output neuron with the meaning of variable *Consequences*.

Different cases for a variable set of input variables were considered. When considering the choice of the best five features, the PSO+ANN algorithm has selected variables shown on Figure 1. The initial set with 25 input variables corresponds to the variable list given on the ordinate in Figure 1. Bars shown above the number of the corresponding variable represent a variable's importance index (3). Based on the importance index, a subset of variables [9, 11, 20, 24, 25] can be selected, i.e. [*Gender, Behavior, Age group, Pedestrian crossing, Road crossing*]. Interestingly, a combination of features [11, 17, 20, 24, 25] was achieved using the PSO+ANN algorithm, i.e. [*Behavior, Gender group, Age group, Pedestrian crossing, Road crossing*], with a minimal fitness value of 0.026.

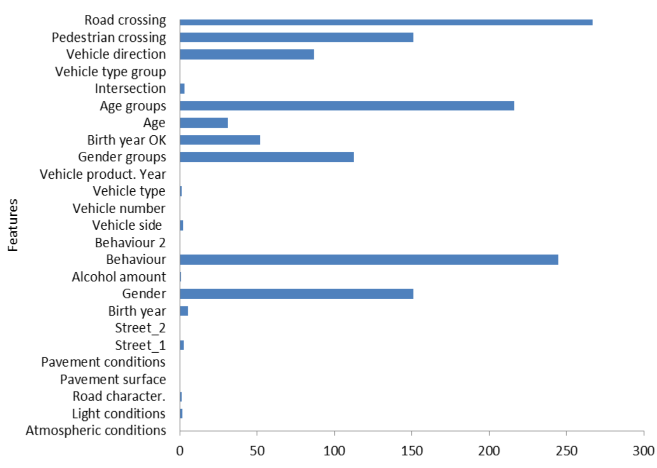

Figure 1. Selection of five features using the PSO+ANN algorithm

As an illustration of PSO+ANN algorithm convergence, Figure 2 shows 50 iterations of a randomly selected single run of PSO execution. The algorithm converged towards the best combination of features [9, 11, 20, 24, 25] in a first few iterations, i.e. [*Gender, Behavior, Age group, Pedestrian crossing, Road crossing*], where after the seventh iteration it still minimized the fitness, but with the same feature combination. The achieved solution represents one of the best solutions.

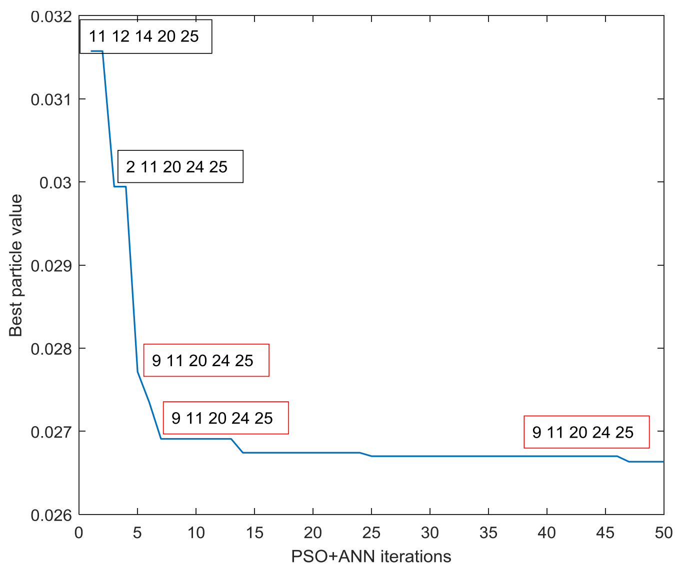

Figure 2. Convergence of the PSO+ANN algorithm during selection of five features

4. CONCLUSION

The feature selection method in the form of a specific realization of the hybrid algorithm for optimizing the swarm of solutions with artificial neural networks (PSO+ANN) has shown that it enables choosing independent input variables necessary for generating the prediction model. Specificity of the PSO+ANN algorithm realization is defined by: (a) the method is composed of an environment which is based on the PSO search rules and generates a large number of variable subsets; (b) it uses neural networks for fitness functions estimation; and (c) the entire method is repeatedly executed in order to reduce the stohastic characteristics in the PSO+ANN algorithm and easily identify the most frequently selected variables. The analysis of the feature selection PSO+ANN algorithm's results has shown that the most suitable subset consists of the following five variables: *Gender*, *Behavior*, *Age group*, *Pedestrian crossing*, and *Road crossing*.

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FACTOR STRUCTURE OF THE DRIVING ANGER SCALE AMONG SERBIAN DRIVERS

Key Words

Road accident; Driving anger; Risky behavior; Factor structure; Road safety

Abstract

Driving anger is situational personality trait that may predispose individuals to risky and aggressive driving behaviour on the roads. In this paper we examined factor structure of the original DAS in Serbian driving conditions. The study was cross-sectional in design, and carried out in the sample consisted of 380 regular drivers. We conducted CFAs of the data on the DAS, comparing five competing models. The results shown that the five-factor and bifactor solutions offered the best fit to the data relative to the other models. However, in absolute terms, neither of these models offered an acceptable representation of the data. The results were discussed and compared with findings of the previous research.

1. INTRODUCTION

Road accidents remain one of the most prevalent causes of injuries on a global level. They are also estimated to be the most dominant cause of premature mortality and the eighth leading cause of all deaths globally. According to the estimations of the World Health Organization (WHO), more than 1.2 million traffic fatalities occur on the world's roads every year. Over 90% of fatal injuries occur in low-income and middle-income countries (WHO, 2015). In the Serbian context, there were 8.4 fatalities per 100,000 inhabitants in 2015 compared with 2.5 in the best-performing countries, such as Norway, Sweden, and the United Kingdom (ITF, 2017). It is now well recognized that the behaviour of road users is an important contributing factor in both accidents and fatalities (Moyano-Díaz, 1997; Bendak, 2005; Zhang et al., 2013).

Previous studies have shown that various human factors such as gender, age, driving skills and styles, personality traits, and socio-cognitive factors play an important role in predicting traffic violation behaviours (Dahlen et al., 2005; Rhodes and Pivik, 2011; Taubman-Ben-Ari and Yehiel, 2012; Delhomme et al., 2012; Bachoo et al., 2013; Jovanović et al., 2017). One personality trait that may predispose individuals to risky and aggressive driving behaviour is anger. It has become apparent that anger can be paramount in predicting driving behaviours. A growing body of research indicates that large amounts of anger are more likely to cause several risky and aggressive behaviours pertaining to driving. Naturally, accidents are also more likely to occur. (Dahlen et al., 2005; Nesbit et al., 2007; Jovanović et al., 2011; Delhomme et al., 2012; Bachoo et al., 2013; Zhang et al., 2015; Bogdan et al., 2016; Wickens et al., 2016).

The DAS factor structure and psychometric properties were widely examined in samples from the United Kingdom (Lajunen et al., 1998), New Zealand (Sullman, 2006), France (Villieux and Delhomme, 2007; Villieux and Delhomme, 2010; Albentosa et al., 2018), Spain (Sullman et al., 2007), Turkey (Yasak and Esiyok, 2009), Malaysia (Sullman et al., 2014), China (Li et al., 2014; Feng et al., 2016) and Romania (Sârbescu, 2016). Nevertheless, certain authors bring to our attention a variety of issues that are psychometric in nature and have to do with utilizing the DAS.

These several studies have raised doubts about the dimensionality of the DAS. A range of factor structures that were acquired in the mentioned research shed light on what the most adequate structure would be for such a scale. Lajunen et al. (1998) have argued in favour of a three-factor solution. Through the elimination of non-anger provoking situations and the factor analysis procedure, the DAS 21-item version was established in the United Kingdom (UK). Specifically, they have argued that driving anger should be partitioned into the dimensions: “progress impeded”, “reckless driving” and “direct hostility”. Subsequently, Sullman (2006) suggested a four-factor model drastically different than what was devised in the research conducted in the USA and the UK (risky driving, progress impeded, discourteous behaviour and hostile gestures). Recently, Feng et al. (2016) revised the original DAS and devised a version of the DAS containing 19 items. In its totality, the scale was comprised of four dimensions. These included traffic obstructions, discourtesy, illegal and slow driving, which showed a significant difference compared to that of the factor structures obtained in the USA (Deffenbacher et al., 1994). The same can be said about the studies conducted in the UK (Lajunen et al., 1998) and New Zealand (Sullman, 2006). In France, Delhomme and Villieux (2007) revealed five main underlying factors of the DAS that share a similarity with those that have been identified in the initial version from the USA. Four of the five factors were fairly consistent with the original DAS (i.e. police presence, illegal driving, traffic obstructions, and hostile gestures), except the discourtesy factor. The fifth factor labeled as “progress impeded” was devised in such a way that the items from the original version of slow driving (five of them) were combined with the discourtesy factors (two items). This factor had similarities with the progress impeded factor reported in Lajunen et al.’s (1998) study. Delhomme and Villieux (2010) then proceeded to test the psychometric properties of the DAS based on these five factors. Researchers have confirmed that the five-dimensional model is valid and reliable. Furthermore, several factor analytic studies have replicated the original six-factor structure by using confirmatory factor analysis (CFA) in moderate-sized samples (Sullman et al., 2007; Sullman et al., 2014; Li et al., 2014; Albentosa et al., 2018). Finally, Sârbescu (2016) investigates the degree to which the scores of the DAS subscale are reliable, by means of utilizing the bifactor model approach. The author has revealed that it is safe to say that the collection of the items needs to be thought of as unidimensional.

The paper at hand aims to assess the factorial structure of the DAS and estimate how reliable these factors are when dealing with Serbian participants.

2. METHODOLOGY

2.1. Participants

The sample consisted of 380 regular Serbian drivers (221 males and 159 females) ranging in age from 19 to 71 (M = 41.22, SD = 11.35). A regular car driver was defined as a person having a car driving license and who has driven at least 1,000 km with a car or a van within the last twelve months. The drivers’ experience ranged from less than a year up to 54 years (M = 19.21.; SD = 10.45), and the mileage in the past twelve months was between 1,000 and 180,000 kilometers (M = 14,024.47; SD = 15,451.92).

2.1.2. Instruments

The Driving Anger Scale (DAS). The DAS is a self-report instrument designed to assess the anger engendered by specific driving-related situations (Deffenbacher et al., 1994). In its long-form, the scale consists of 33 items divided into six scales: hostile gestures, illegal driving, police presence, slow driving, discourtesy, and traffic obstructions. On each item, respondents are asked to rate the amount of anger generated by each situation, using a 5-point Likert scale ranging from ''Not at all'' to ''Very much''.

Background information regarding the participants' socio-demographics (e.g., age, gender, place of residence), driving characteristics (e.g., driving experience, mileage in the past 12 months), and general driving history (e.g., accident and violation involvement) was obtained.

2.1.3. Procedure

All procedures were in accordance with the revised Helsinki Declaration (2013) and all the participants gave consent before completing the questionnaires. The participants filled in the DAS in accordance with a procedure that has been approved by the Ethics Committee. The survey had no time limit. Filling in the questionnaires took 5 min on average.

We implemented a cross-sectional Internet-based survey to collect the data for this study. All the survey data was collected and organized via the JotForm online survey software and questionnaire tool. The participants were recruited into the research using social media and email invitations. Internet data collection methods have been evaluated in many studies and found to be generally equivalent to a paper-and-pencil method (Davidov and Depner, 2011; Weigold et al., 2013).

3. RESULTS

We conducted CFAs of the data on the DAS with IBM® SPSS® Amos™ 22 (Arbuckle, 2013), comparing five competing models identified in the prior studies (see Table 1). These models included a three-factor model proposed by Lajunen et al. (1998), (Model 1); a four-factor model put forward by Sullman (2006), (Model 2); a five-factor model of Villieux and Delhomme (2007; 2010), (Model 3); the original six-factor model identified by Deffenbacher et al. (1994) and confirmed by Sullman et al. (2007; 2014), Yasak and Esiyok (2009), Li et al. (2014), and Albentosa et al. (2018), (Model 4); and a bifactor model proposed by Sârbescu (2016), (Model 5).

The CFA fit indices reflect to what extent the hypothesized factor structure is explained by the covariances between the items, which refers to the model fit. The fit of these models was evaluated by using several model fit indices available in the literature. Apart from the χ^2-test, which is known to be overly sensitive when the sample size is large, we adopted the widely accepted cut-off criteria in the scientific community. The guidelines for interpreting RMSEA (Root Mean Square Error of Approximation) are as follows: RMSEA < 0.05 indicates a good model fit; 0.05 < RMSEA < 0.08 indicates a reasonable model fit; and RMSEA > 0.10 indicates a poor model fit (Steiger, 1990; Browne and Cudeck, 1993; Hair et al., 1998). The χ^2/df ratio needs to be between 2 to 5 to indicate an adequate model fit (Marsh and Hocevar, 1985). The values of Comparative Fit Index (CFI), Goodness of Fit Index (GFI), and Tucker-Lewis Index (TLI) greater than 0.90 and 0.95 are typically taken to reflect an acceptable and excellent fit to the data, respectively (Bentler and

Bonett, 1980; Hu and Bentler, 1999). The maximum likelihood estimation method was used, because of its good applicability to a wide range of analytical conditions (Hu, Bentler, & Kano, 1992).

Table 1. Factor models with components and associated items

Model	Factor structure	Factor: DAS items
Model 1.	Three–factor (Lajunen et al., 1998)	Progress Impeded: 1, 3, 4, 8, 9, 10, 17, 20, 28
		Reckless Driving: 2, 5, 6, 7, 12, 13, 14, 15, 25
		Direct Hostility: 21, 24, 27
Model 2	Four-factor (Sullman, 2006)	Risky Driving: 2, 5, 6, 7, 13, 15, 22, 25, 26, 30
		Progress Impeded: 11, 16, 18, 19, 23, 29, 31, 32, 33
		Discourtesy: 1, 3, 4, 8, 9, 10, 12, 14, 17, 20, 28
		Hostile Gestures: 21, 24, 27
Model 3	Five-factor (Villieux and Delhomme, 2007; 2010)	Progress Impeded: 1, 3, 9, 10, 18, 20, 28
		Illegal Driving: 2, 6, 13, 25
		Hostile Gestures: 21, 24, 27
		Police Presence: 11, 16, 23, 29
		Traffic Obstructions: 26, 30, 31, 32
Model 4	Six-factor (Deffenbacher et al., 1994; Sullman et al., 2007; Yasak and Esiyok, 2009; Sullman et al., 2014; Li et al., 2014; Albentosa et al., 2018)	Hostile Gestures: 21, 24, 27
		Illegal Driving: 2, 6, 13, 25
		Police Presence: 11, 16, 23, 29
		Slow Driving: 1, 3, 4, 9, 10, 18
		Discourtesy: 5, 7, 8, 12, 14, 15, 17, 20, 28
		Traffic Obstructions: 19, 22, 26, 30, 31, 32, 33
Model 5	Bifactor (Sârbescu, 2016)	Hostile Gestures: 21, 24, 27
		Police Presence: 11, 16, 23, 29
		Slow Driving: 1, 3, 4, 9, 10, 18
		Discourtesy: 5, 7, 8, 12, 14, 15, 17, 20, 28
		Traffic Obstructions: 19, 22, 26, 30, 31, 32, 33
		Illegal Driving: 2, 6, 13, 25

Table 2 summarizes the goodness-of-fit indices for the five models. Based on the goodness-of-fit indices, the five-factor and bifactor solutions offered the best fit to the data relative to the other models. However, in absolute terms, neither of these models offered an acceptable representation of the data.

Table 2. Model goodness-of-fit indices.

Model	χ^2	df	χ^2/df	CFI	GFI	TLI	RMSEA	RMSEA 90% CI
M1	888.50***	186	4.78	0.794	0.807	0.767	0.100	0.093 – 0.106
M2	2047.18***	489	4.19	0.708	0.733	0.685	0.092	0.088 – 0.096
M3	588.96***	199	2.96	0.869	0.871	0.848	0.072	0.065 – 0.079
M4	1443.34***	480	3.01	0.820	0.798	0.802	0.073	0.068 – 0.077
M5	1033.56***	447	2.31	0.886	0.836	0.865	0.061	0.056 – 0.066

Note: ***$p < 0.001$

4. DISCUSSION AND CONCLUSIONS

In the present study we compared the measurement models of the DAS proposed in the previous empirical research and revealed that the factor structure of the DAS developed in these studies does not seem to be entirely applicable to our Serbian sample.

The original DAS is a widely used instrument for measuring levels of driving anger and its factor structure has been investigated in various samples and across cultures. To the best of our knowledge, this is the first study using the original DAS in the Serbian driving context. Therefore, we compared five competing models (three-factor, four-factor, five-factor, six-factor, and bifactor) found in previous literature, and discovered that the bifactor model was the most supported, followed by the five-factor model. However, neither of them indicated a reasonable fit with the data. A lack of fit to the data and differences among these factor structures were also found in previous studies (Sullman et al., 2007; Sullman et al., 2014; Sârbescu, 2016; Albentosa et al., 2018). These inconsistencies may arise from cultural and methodological divergence. For example, studies used different approaches to locating the underlying dimensions of a data set. Deffenbacher et al. (1994) analyzed their data using cluster analysis, while the other studies used principal component analysis (Sullman, 2006; Yasak and Esiyok, 2009; Feng et al., 2016) or factor analysis (Lajunen et al., 1998; Villieux and Delhomme, 2007).

The study limitations should be highlighted. Firstly, the problem of giving socio-desirable responses, the context influence, and the problem recalling can lead to measurement errors due to applied self-reported measurement technique. However, in the present research respondents were convinced in anonymity and confidentiality of their responses, which should reduce social desirability and the problem of impression. Moreover, the previous research have shown that self-reported aberrant behaviors are not susceptible to social desirability. In addition, Blanchard et al. (2010) have revealed consistency between self-reported and objective exposure measures in sample of older drivers. Nevertheless, the results of the present research complement to the present practice, and suggest that adapted DAS represents useful instrument in terms of understanding the driving anger phenomenon.

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THE SPATIAL DISTRIBUTION OF ROAD ACCIDENTS AND THEIR CONSEQUENCES IN THE AREA OF AP VOJVODINA

Key Words

Road safety; Road accidents; Spatial distribution

Abstract

Determining the spatial distribution of road accidents is an important aspect of working in traffic safety. The paper presents an analysis of the spatial distribution of road accidents and their consequences in the area of AP Vojvodina.

1. INTRODUCTION

The problem of safety in road traffic represents a major challenge at a global level. More than 1.35 million people are killed on the world’s roads each year, with low and middle-income countries bearing a disproportionate burden (WHO, 2018). In the development process of European and national road safety programs, it is necessary to work in order to prevent fatalities and injuries on the road. Therefore, decision makers should adapt the traffic system to the requirements and vulnerability of its users. The analysis of the spatial distribution of accidents on the road network provides a unique approach to the observation and road safety monitoring. Monitoring the spatial distribution of accidents is very important for the efficient planning and implementation of appropriate activities so as to reduce the number of accidents (Okabe et al., 2006; Pljakić et al., 2018; Plug et al., 2011).

The paper presents the spatial distribution of road accidents and their consequences in the area of AP Vojvodina.

2. DATASET

This study observes accidents in a then-year period (2008–2017) which included the total number of accidents.

The data regarding the accidents were taken from a database which is authorized by the Road Traffic Safety Agency (RTSA) organized in accordance with the Common Accident Data Set (CADaS) protocol developed by the European Commission. The RTSA database is based on GIS, so that all accidents have coordinates (x,y) of the locations that are precise enough to establish the direction of traveling on major roads.

3. RESULTS

3.1. Road accidents and casualties data

During the analyzed period (2008-2017), it was recorded total 102,887 traffic accidents, of which the total number of fatal accidents was 1,743 (1.7 %). Of the total number of casualties (61,135), 1,953 (3.2 %) were killed and 11,066 (18.1 %) seriously injured. (Table 1.).

Table 1. Road accidents and casualties, AP Vojvodina, 2008-2017.

Accidents		Casualties	
Total	102.887	Total	61.135
with material damage only	60.472	injured	59.182
with casualties	42.415	slight injured	48.116
with injuries	40.672	seriously injured	11.066
with fatalities	1.743	fatalities	1.953

3.2. Spatial distribution per municipalities

Spatial distribution of the casualties by age groups was made according to the municipalities in the territory of AP Vojvodina. By many parameters, municipalities differ significantly, which also affects the number of casualties in their area. The following municipalities can be identified according to the potential for reducing the number of casualties (Figure 2.):

- Novi Sad, as the municipality with the highest potential for reducing casualties. In the municipality of Novi Sad, there were 15,312 casualties recorded, which represents about 25.0 % of all registered casualties in the area of AP Vojvodina.
- Zrenjanin, Subotica and Pancevo, as municipalities with significant potential for reducing casualties. In these municipalities nearly 20.0 % of all registered casualties in the territory of AP Vojvodina.

- Ruma, Sombor, Sremska Mitrovica, Backa Palanka, Indjija, Stara Pazova, Kikinda and Vrbas with low potential for reducing the number of casualties. In these municipalities, about 25.0% of all casualties in the area of AP Vojvodina.
- Other municipalities with very low potential to reduce casualties. In these municipalities, up to 30.0 % of all casualties in the territory of AP Vojvodina.

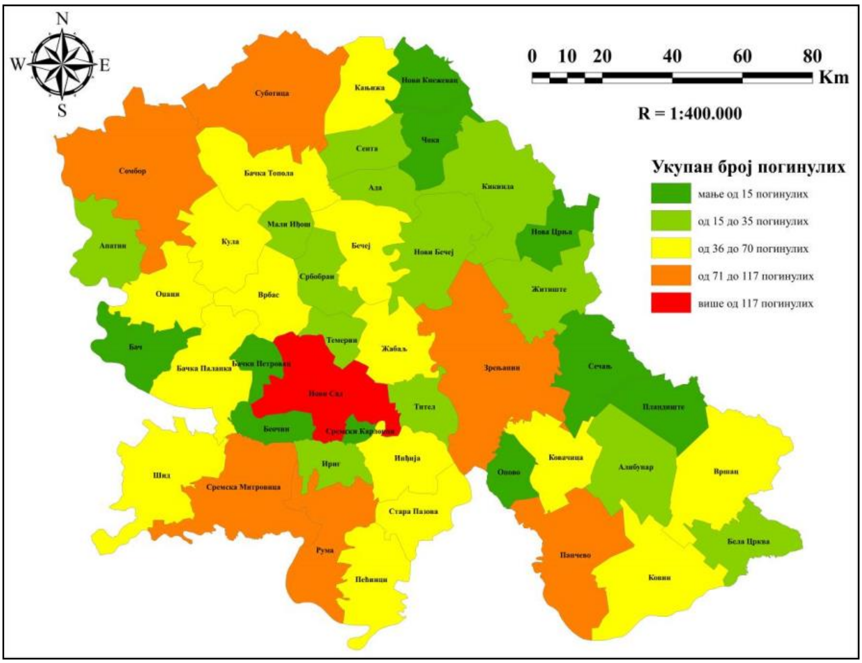

Figure 1. Frequency of total number of fatalities per municipalities, AP Vojvodina, 2008-2017.

The following municipalities can be identified according to the potential for reducing the number of injured drivers (Figure 3.):

- Novi Sad, as the municipality with the greatest potential for reducing the number of injured drivers. In the municipality of Novi Sad, 8,004 casualties drivers were recorded, which is about 22.0 % of all registered casualties drivers in the area of AP Vojvodina.
- Zrenjanin, Subotica, Sombor and Pancevo, as municipalities with significant potential for reducing the number of casualties drivers. In these municipalities, about 24.0 % of all registered casualties drivers in the area of AP Vojvodina.

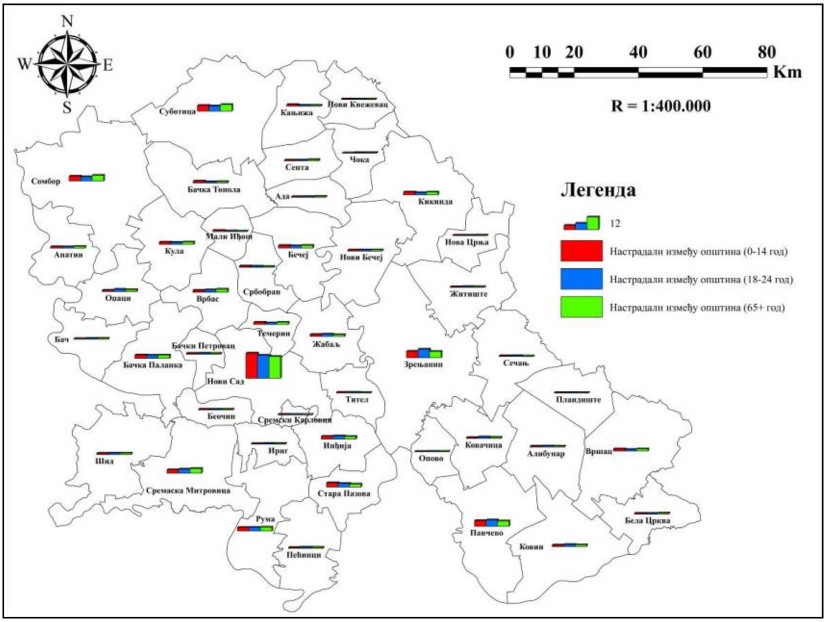

Figure 2. Frequency of casualties by age groups per municipalities, AP Vojvodina, 2008-2017.

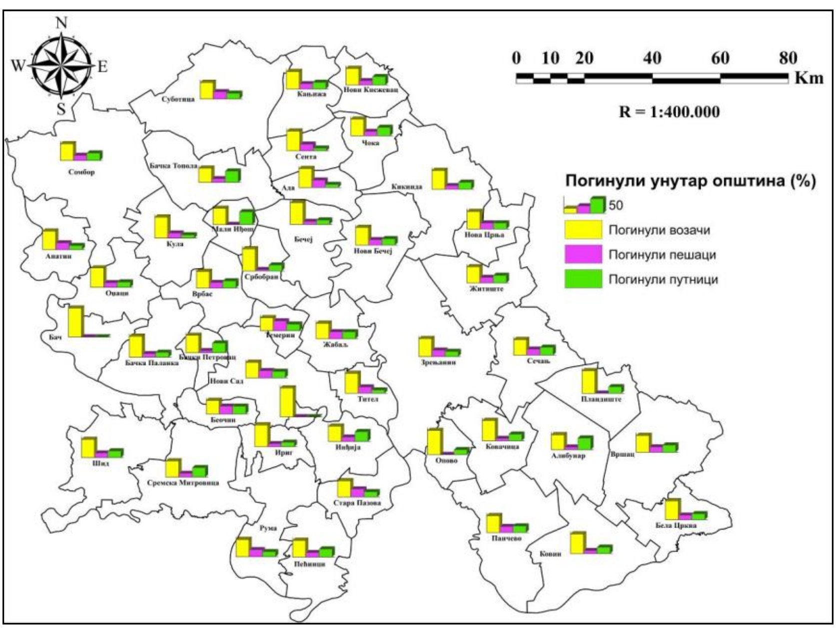

Figure 3. Percentage distribution of fatality drivers, pedestrians and passengers within the municipality, AP Vojvodina, 2008-2017.

- Ruma, Sremska Mitrovica, Backa Palanka, Indjija, Stara Pazova, Becej, Kikinda and Vrbas with low potential for reducing the number of casualties drivers. In these municipalities, about 23.0% of all casualties drivers in the area of AP Vojvodina.
- Other municipalities with very little potential for reducing the number of casualties drivers. In these municipalities, about 30.0% of all casualties drivers in the area of AP Vojvodina.

3.3. Spatial distribution on the road network

In the area of AP Vojvodina, there are 298 sections of roads on the state road network outside urban areas. The sections are specific in their characteristics: the length, intensity and structure of traffic, technical and operational characteristics of the road, the roadside elements, etc. Depending on the mentioned factors, the spatial distribution of traffic accidents and their consequences also differs.

Traffic safety analysis was performed based on the potential for safety improvement (PSI) (Figure 4.).

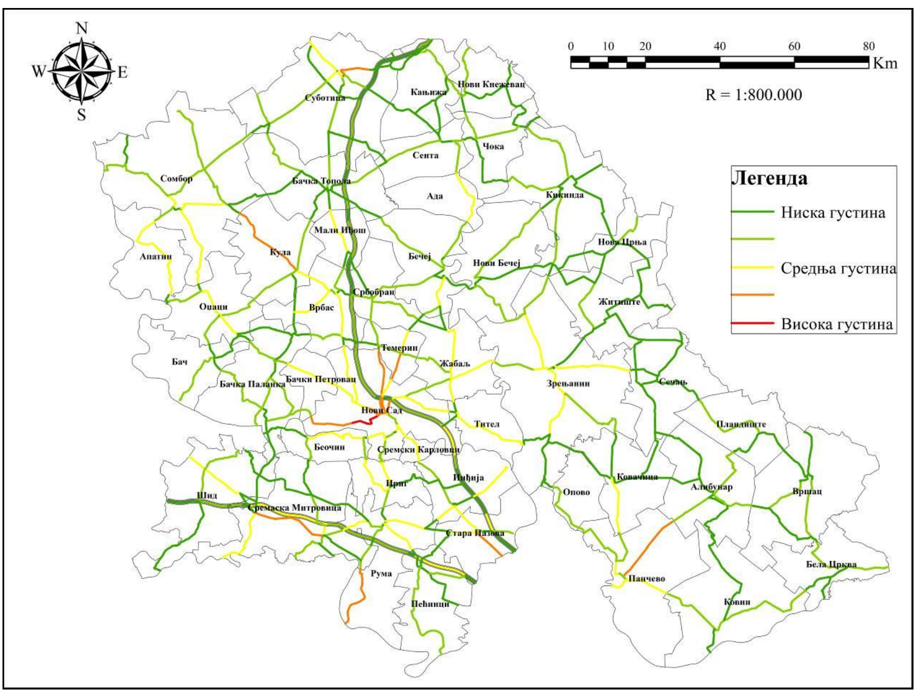

Figure 4. Density of road accidents on state roads, AP Vojvodina, 2008-2017.

In the area of AP Vojvodina, there are 168 intersections on the state road network outside urban areas. Intersections are specific in their characteristics: type, method of regulation, intensity and structure of traffic, technical and operational characteristics of the road, the roadside elements, etc. Depending on the mentioned factors, the spatial distribution of traffic accidents and their consequences also differs.

In the analyzed period (2015-2017), a total of 320 road accidents were recorded at 106 intersections (Figure 5.). Traffic safety analysis was performed based on the EPDO method. With this method, all traffic accidents are reduced to traffic accidents with material damage and the total risk for each individual intersection is calculated on this basis.

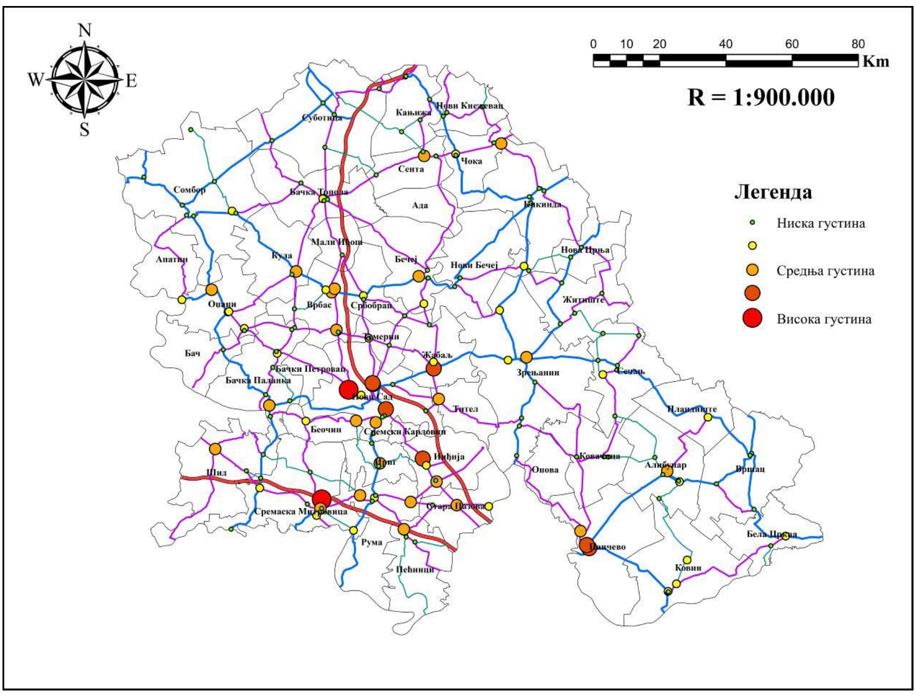

Figure 5. Density of road accidents at intersections, AP Vojvodina, 2008-2017.

4. CONCLUSIONS

Spatial analysis of road accidents is of great importance for understanding the conditions of an accident in order to plan preventive activities in a particular location.

The analysis of road accidents and their consequences in the period from 2008 to 2017 in the area of AP Vojvodina indicates the following conclusions:

- On average, around 7,000 traffic accidents occur annually;
- Between 2008 and 2017, there were 61,135 casualties recorded, 59,182 injured, of which 48,116 were slight injured and 11,066 were seriously injured, and 1,953 were killed;
- Spatial analysis of road accidents indicates that 38,598 accidents were recorded in the territory of Novi Sad municipality, which accounts for almost 40.0% of all recorded traffic accidents in the AP Vojvodina. Nearly 25.0% of traffic accidents occur in the municipalities of Subotica, Zrenjanin, Pancevo, Sombor and Sremska Mitrovica. In the municipalities of Ruma, Becej, Kikinda, Kula, Temerin, Backa Palanka, Indjija, Stara Pazova, Vrbas and Vrsac, about 20.0% of traffic accidents occur and in other municipalities about 15.0% of all recorded traffic accidents occur in the AP Vojvodina;

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