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Strategic Planning of Cycling Infrastructure Towards Sustainable City Mobility - Case Study Osijek, Croatia

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Abstract. Bicycle traffic, together with public transport, is one of the most significant sustainable forms of achieving acceptable levels of citizen mobility and sustainable development of cities. In recent decades many cities around the world have started to promote cycling as a way of urban transport. However, few have been able to integrate cycling as a relevant mode of transport in the urban transport system. The qualitative shift in relation to the existing situation and the achievement of the increase in quality of the transport system and transport infrastructure in the Republic of Croatia was made by adopting the new Strategy for transport development for the period 2017-2030. Eastern Croatia with its relief features has a potential for the realization and implementation of sustainable city mobility plans. Osijek, as regional centre of eastern Croatia, is the city with the most cycling trails in Croatia - up to 40 kilometres. This paper presents an overview of the thematic strategic documents on local level of the city of Osijek in eastern Croatia, with the aim of identifying the existence or non-existence of the principles promoted by SUMP (Sustainable Urban Mobility Plans). In the first step, the strategic documents will be reviewed and set goals will be outlined. These goals will be analysed according to the categories of the SUMP principles, ranging from lack of mentioning, then merely quoting, implementing or prescribing the principle implementation. This will identify the lack and the need for implementation at the strategic level. Further, the genesis of planning bicycle traffic in Osijek will be analysed, in the context of the objectives set for the Relevance of non-car modes of transport in SUMP. In the conclusion, a proposal will be made for the location of strategic goals and measures for improving the cycling infrastructure at the local level.

1. Introduction

A decade ago Europe declared dedication to the cities: “Town and cities are the drivers of the European economy” [1]. The quality of life in the cities became an umbrella scope for all the city policy decisions. Urban sprawl, brownfield inefficiency, congestion, unsafety, unemployment waited to be resolved. Statistical data from the transportation sector on congestion, pollution and safety directed transport policies on national, regional and local levels toward sustainability paradigm. Back in 2011, the White Paper on Transport 2011 [2] announced that the European Commission plans to establish procedures and financial support mechanisms for preparing Urban Mobility Audits, followed by Urban Mobility Plans, and a European Urban Mobility Scoreboard. To date, documents on strategic European level are determined, guidelines are produced and mechanisms for monitoring are set. Within city transportation, restrictive goals were set for the vehicle transport, while non vehicle transport was preparing to become the main theme. Researches on cycling in cities are rooted in several research areas – the ones that study factors for decline of vehicle traffic in the city, the ones that deal with planning, design and promotion



of non-vehicle – pedestrian and cycling traffic, studies that elaborate integrated planning of urban tissue and functions and sustainable forms of traffic in the city and medical researches on how traffic behaviour affects the health of the residents. The reasons and aims are the same: cleaner, safer and healthier communities supported by The Europe 2020 Strategy [3].

In recent decades, many cities have promoted cycling as a mode of urban transport, but few have been able to integrate cycling as a relevant mode of transport in their urban traffic systems. Despite numerous cycling paths, cycling is, in most cases, a leisure activity rather than a daily mode of transport in the urban transport system. It is evident that in order to promote cycling as relevant mode of urban transport a different approach is needed: an integrated transport policy approach that includes cycling planning, but as part of a wider strategy for all types of transport which will make cycling more attractive, transport by personal vehicles less attractive and not feasible, and which will improve public transport and options for pedestrians [4]. Transport policy has been adopted in several European countries, among which the most significant are Germany, Denmark, Netherlands, Switzerland and France. It is carried out in larger cities with the aim of discouraging private use of cars on one hand, and on the other, promoting cycling, walking and public transport as sustainable forms of achieving an acceptable level of citizen mobility and sustainable city development.

Transport policy includes measures that can be divided into three categories: *infrastructure measures* that discourage car usage and improve alternatives, including bicycle paths with bicycle parking around the city, *economic measures* such as the introduction of vehicle parking fees or other charges and *legal and organizational measures* which give possibility for bicycle transport by trains, trams or buses. Whether biking becomes a part of a formal or an informal traffic planning process depends on each country individually. The EU proposes the implementation of sustainable urban mobility plans, but they are not binding in its application. By adaptation of strategic documents, national governments can play an important role in promoting the development and integration of bicycle traffic. Increasing number of European countries is developing and implementing national cycling strategies. In them, as well as in the action plans, activities and precise goals are set for development of cycling at the national level.

The Republic of Croatia has not yet adopted a national cycling strategy, although a qualitative shift, when compared to current state, and increase in the quality of the transport system and infrastructure was made, by adopting the new Traffic Development Strategy for the period 2017-2030 [5]. According to the Strategy, there is a great potential for changing travel habits in favor of bicycles, public transport, e-mobility and other forms of transport, thereby significantly reducing greenhouse gas emissions and facilitating the use of multimodal transport systems.

For functional regions, Strategy prescribes a measure under the title review and update of local and regional master plans that follow the principles of Sustainable Urban Mobility Plan - SUMP. In December 2016, a Master Plan of Traffic Development of the City of Osijek and the Osijek-Baranja County was developed, which includes a part of the functional region of Eastern Croatia [6]. One of the goals of the Master Plan was to achieve an integrated approach to traffic planning at all levels - national, (functional) regional, local, all based on common methodology and establishing a clear sequence of planning, starting with the Transport Development Strategy [5].

2. Towards integrated strategies for urban and transportation planning

Several researches tried to correlate urban physical planning with traffic planning and behaviour. Compact development was the urban planning concept that was depicted as correlated with driving, but reports have shown conflicting results [7], [8], [9], [10]. Stevens [10] used meta regression analysis on 46 studies that dealt with D-variables, as coined by Ewing and Cervero [7], in order to have more clear overview on assumed links. D variables are namely: density, diversity, design, destination accessibility and distance to transit. Results showed that compact development reduces driving but to a limited extent and that several strategies should be applied to meet the goal of reducing driving in the city. Handy et al. [11] and Saelenas [12] tried to correlate traffic behavior with urban asset on the neighbourhood level. Results confirmed relation of neighbourhood environment to walking and cycling while authors highlight the need for moving the scope from land use, density, connectivity to design project range of

elements, such as presence and quality of sidewalks, pedestrian signals, parking cost, location, and availability and presence of bicycle lanes and paths and other street range elements.

The indications for necessity to provide common approach in transport and spatial planning are obvious so the policy aims that promise improvements should be found in comprehensive strategic documents on the local level. The new approach is well represented in the concept of Sustainable Urban Mobility Plans [13]. The concept of SUMP seeks for “a collaborative planning culture across different policy areas and sectors and between different governance levels within the “functioning city” [13].

While the scientific findings as well as European documents determine the common directions that the urban development and mobility have to follow, implementation in European cities presents „urban mobility gap between leading cycling cities and the rest of them. Not only on city level, but the data aggregated on the pan-European region level show differences between Western European and Central and Eastern European cities [14]. Wolek [14] presented wide differences in spatial structure as well as in transport infrastructure that can be found if comparing the cities from these regions. Evidences on state of the art of sustainable urban mobility plans [15] confirm non coherent development of SUMP while finding Croatia at the very beginning of the process [16], [17].

Sustainable Urban Mobility Plan should be built on existing planning practices and policies relevant to local planning process is a guideline for the first phase of developing SUMP [13]. Based on that statement, this paper aims to provide an overview of local strategic documents of the City of Osijek, settled in the eastern part of Croatia in order to identify overlaps and gaps with SUMP objectives. Adaptation of integrated set of objectives from SUMP and from Urban Mobility Package according to György et al. [17] will be provided and selected documents will be analysed.

3. Methods

In the first step of the analysis, set of local sectoral strategy documents create a data base for analysis. Not focusing only on sectoral urban or transportation thematic documents, we also included strategies from social and economy area. According to Bruhova Foltynova and Jordova [18] supportive policy environment for implementation of sustainable transport measures include statement that “long-term goals should be carefully planned and precisely defined (using quantifiable goals) and indicators of their achievement are monitored”. Based on that, we analysed strategic document by searching SUMP objectives among objectives of thematic documents. The protocol was set in following steps:

- searching for sustainability objective keywords in document objectives
- identifying presence of supportive activities and measures
- identifying sustainability objective keywords in the whole document
- identifying monitoring measures and indicators
- defined stakeholders and responsibilities as well as time frame for achieving established objectives.

Based on the range of positive confirmation, the objectives are identified as: *not present*, *announced*, *embedded in document* and *strongly embedded in document*. The general sustainability objectives are defined as a mix of social equity, environmental quality and viable economy aspects presenting “container concept” [19]. Many of these aspects can be found among benefits of SUMP [13] that are: (1) quality of life, (2) economic benefits, (3) better health and environment, (4) improving access, (5) effective use of limited resources, (6) winning public support, (7) preparing better plans, (8) fulfilling legal obligations, (9) using synergies and (10) new mobility culture.

In the second step, we analysed bicycle transport in the City of Osijek according to data presented in Master plan for transportation development of the City of Osijek and Osijek Baranja County, focusing on actual situation and future proposals.

3.1 Case study – the city of Osijek

The city of Osijek is the fourth largest city in Croatia, with an area of about 171 km². Osijek is located along the right bank of the Drava River whose flow defined the shape and development of the city. Namely, Osijek is positioned longitudinally along the Drava River and got a characteristic elongated

shape which also defined development of the city traffic. Consequently, most of the city's main traffic routes are positioned longitudinally, along the larger residential areas and the transversal connections are intermittent by town squares and public rail route that runs through the city [20]. Osijek has once proudly worn the name of the greenest cities in Croatia, today it can be proud of one of the largest mileage of bike paths. Building started in 1990s with only few paths and it grew to more than 40 km of trails in the city today. According to estimates there are around 60 to 70 thousand bicycles in the city of Osijek [6].

The first generation of urban plans in Croatia were conducted and adopted in the period from 2000 until 2006. The first Urban plan of the City of Osijek, designed and adopted in 2006, set the city cycling network rather ambitiously. The city border if presented in the plain geometry forms the rectangular 14x4 km while the cycling network fits in average mesh dimension of cycling block of 750x750 m (figure 1). Figure 1 shows the changes of consecutive spatial plans in the time sequence of every 2 to 3 years as they were changed starting from the year 2006 to the last changes in 2017. Following plans adapted the network slightly, mostly densifying network around transportation nodes (bus and train station) and along the secondary axis of the city (south-north). In accordance with the longitudinal development of the city, bike paths stretch mostly in east-west direction and are connected by a shorter cross-connecting paths (figure 2). Although the City of Osijek is on the route of Euro Velo 6, no distinction of primary and secondary bike paths is proposed by spatial plans. Furthermore, there is no distinction of off road and on road bicycle paths and functional criterion is not applied. No standards for bicycle parking areas are established or nodes for multimodal way of transport.

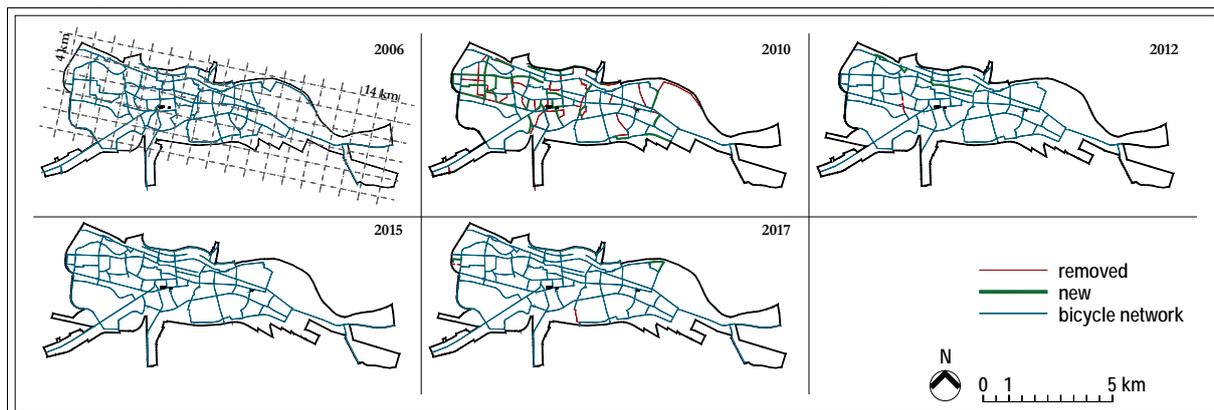


Figure 1. Changes of planned cycling network from 2006 to 2017

Type of bicycle infrastructure used in the city of Osijek are bike paths, while cycling tracks that are part of mixed traffic roads are not used. Streets that have bike paths, usually have planting strip that divide lanes for motorized vehicles from pavement for bicycles and pedestrians. There is only few off road bike paths, built in 1990s, because level of development was lower then, so there was more available space for this separated bike paths.



Figure 2. City map of Osijek with the existing network of bicycle paths [6]

Asphalt, a most comfortable pavement type for bike traffic, is also the most common surface used. Though, concrete pavers, aesthetically preferable solution, is also used on some bike paths.

Bike paths are mainly built on only one side of the street, thus needing to accommodate two-way cyclist traffic. They have an average width of 2 m. However, there are some examples of insufficient path widths, with widths less than 0,8 m. In such cases, safety of bicycles as well as pedestrians is being endangered. These solutions occur on very busy streets and were created in the last 2-3 years, because construction of bike paths was needed to interconnect some parts of bike network, but other interventions were too costly [20].

4. Results

4.1 SUMP objectives in strategic documents of the city of Osijek

Seven strategic documents were identified as being local and were included in the analysis (table 1).

Table 1. Selected local strategies for Osijek

Sector	Title	Year	Time frame
Spatial planning (strategic)	Spatial plan of the Municipality of Osijek [21]	2016	no
Urban planning (strategic and land use)	Urban plan of the City of Osijek [22]	2017*	no
Transportation	Master plan for transportation development of the City of Osijek and Osijek Baranja County [6]	2016	no
Culture	Strategy for culture development of the City of Osijek [23]	2014	2014-2020
Economy	Strategy for development of the City of Osijek – from industrial to intelligent city [24]	2015	2014-2020
Integrated	Strategy for development of urban agglomeration of Osijek [25]	2016	no
Administration	Statute of the City of Osijek [26]	2018*	no

*last adopted version of the document

Table 2. Overview of sustainability goals in selected strategies

Strategic local document \ Sustainability goals based on SUMP	Spatial plan of the Municipality of Osijek [21]	Urban plan of the City of Osijek [22]	Master plan for transportation development of the City of Osijek and the Osijek Baranja	Strategy for culture development of the City of Osijek [23]	Strategy for development of the City of Osijek – from industrial to intelligent city [24]	Strategy for development of urban agglomeration of Osijek [25]	Statute of the City of Osijek [26]
Improving quality of life	●	●	●	●	●	●	●
Creating economic benefits	●	●	●	●	○	●	●
Improving access	●	●	●	○	●	●	●
Effective use of limited resources	●	●	●	●	●	●	●
Winning public support	○	○	●	●	●	○	●
Preparing better plans	●	○	●	○	○	●	●
Fulfilling legal obligations effectively	●	●	●	○	○	●	●
Using synergies, increasing relevance	●	●	●	●	●	●	●
Towards a new mobility culture	○	○	●	○	○	●	○
Policy / sector integration	●	●	●	●	○	●	●
Territorial integration within the city and within the conurban area	●	○	●	●	○	●	●
Modal integration and uniform face of transport	●	●	●	○	○	●	○
Participation, citizen and stakeholder engagement	○	○	●	●	●	●	●

not present ○ announced ● embedded in document ● strongly embedded in document ●

The strategic plan and local implementation plan of the City of Osijek, in its goals are aligned in the vertical plan integration. Review of goals showed that plans focuses have been set for objectives related to the built structure, the efficiency of the urban area, but the strategy does not provide indicators, responsible entities or time frame for implementation. There is a noticeable lack of emphasis in transport sector targets towards non-vehicle transport (table 2). Citizen participation is ensured for the adoption of documents of spatial plans under the law, but participation and public involvement in decision-making are not documented or required by the document.

In Master plan of transportation development, no measures or indicators for two-way flow of information are envisaged. Citizen and stakeholders are included in measures not as active actors, but within activities at the low level of participation - information. One of the objectives announce the goal of fulfilling legal obligations effectively and documents to be followed are listed, but measures did not include such a level of details. This is assumed to be fulfilled in the individual projects through the spatial planning process and conducting of building permits. The document is comprehensive and as stated in the preface it follows key European strategic documents from the transportation area. All other aspects of sustainability objectives are supported by measures and indicators with proposed time-frame although without identified key actors for conducting those measures.

Culture strategy for Osijek is time framed for the period 2014 -2020. It is highly inclusive – for other sectors, wider territory, stakeholders, with highlighted ethnic inclusiveness. All activities are proposed for Osijek and peri-urban area although without exact measures, actors, actions time frame or indicators. It can be depicted that tourism is recognized to be cooperative sector within several objectives so it fits

SUMP objectives on effective use of limited resources and using synergies. The economic Strategy with ambitious title “from industrial to intelligent city” offers only level of statements and proposals. No measures or indicators were elaborated so the highest level that could be identified was announcement.

The Strategy for urban agglomeration of the functional area of Osijek is the most comprehensive document revised within this overview. Although it does not cover all the key themes, it is the only document that identifies actors, stakeholders and responsible institutes for fulfilment of the objective, measure or indicator providing as well as financial framework. With special attention it proposes new low emission ways of transportation – e buses, e bicycles and e cars as well as park and ride and guidelines for development of multimodal ways of transport. With this document the biggest territory is covered and the most detailed plan is proposed. It is evident that administrative city strategy fulfils requirements for providing legal, territorial integration and democratic activities within the city. The mechanisms for providing democratic actions are listed and procedures are elaborated in detail.

4.2. Results of bicycle traffic analysis conducted in Mater plan

Based on the analysis made in the Master Plan [6], the main problem of cycling in Osijek is the insufficient and unconnected network of cycling paths. The problem is especially visible in the western part of the city (Retfala and Višnjevac), which almost does not have any bike paths. The specifics of bicycle traffic in the city of Osijek are:

- At 30% of bike crossings over the roadway advantage is given to cyclists by means vertical signalization, the „STOP“ sign for cars, which is not respected
- Confusing colour of concrete pavers (red and grey in some streets for cyclists and in other same colours are for pedestrians)
- Pedestrian zones used as cycling zones (Ante Starčević square – trams)
- There is no special light for cyclists on the traffic lights.

The disadvantages of bike paths in the city of Osijek are:

- Lack of integration in the wider area - unconnected bike paths (often altering between the road and the bike path)
- poor and inadequate infrastructure,
- high curbs at bike path road crossings which pose a particular problem for children's and sports bicycles (figure 3a)
- occupying the bike paths with parked cars, trams, street lights traffic lights ... (figure 3b),
- uncomfortable bike paths paved by concrete pavers and inadequately maintained (figure 3c),
- only pedestrian crossings marked at certain sections of pedestrian-cycling routes intersecting roads
- unsynchronized/inconsistent horizontal and vertical signalisation
- insufficient horizontal traffic signalization (creates an additional problem with pedestrians on longer streets)
- lack of integration with other forms of transport



a) b) c)
Figure 3. Different disadvantages of bicycle infrastructure network in Osijek

5. Discussion and conclusion

The main objective of the European Union's transport policy is to reduce the impact of the transport system on the environment. It is therefore important to encourage the use of public transport, modes of transport with zero emission rate, use of alternative fuels and the modernization of the public transport fleet in order to increase energy efficiency and use environmentally friendly vehicles. Establishing documents at the local level that would enable multidirectional efforts to ensure sustainable urban mobility for all set goals is not realistic to expect, but with strong support of at least three sectoral activities, sustainable implementation can be expected. Sectoral strategies can be more closely related to the integration of transport, but if they support the integration of multiple sectors and the integration of the wider and narrower urban areas with a mature document, sufficient support for a comprehensive strategic image of the urban area can be envisaged.

In order to achieve the reduction of the use of passenger car shares in favour of the public transport, the Master Plan has set the goal of improving the infrastructure of public transport, for which an increase in modal split in favour of public transport as well as pedestrians and cyclists is needed. The results to be achieved within this objective are the increased capacity and use of urban public transport and the promotion of the modal shift, and increase in the use of the transport type with the zero level of CO₂ emissions.

One of the measures within the objective includes the construction and arrangement of bicycle trails linking households with public transport stops, stations and intermodal terminals. A network of interconnected and functional bike paths with stations and public transport facilities in the area of Osijek and the county should be established. The construction of a bike path network will enable increased and further development of bicycle traffic, which will result in a reduction in traffic loads, reduction of harmful emissions, noise, etc. Also, cycling traffic is a good integration into the public transport system. This measure seeks to increase the safety of the transport system, reduce the environmental impact (carbon dioxide reduction), increase economic and energy efficiency of the system, increase citizen mobility and reduce traffic jams (combined with other measures). Proposed measures for the construction and arrangement of cycling paths belong to the group of short-term measures, whose realization is to be realized in the period 2017-2020.

With the promotion of urban mobility, it is important to raise public awareness of the benefits of using public transport as well as changing their habits. This goal is considered to be one of the cornerstones of successful implementation of the strategy, and it is expected, along with improvement of urban public transport, a 30% increase in the use of sustainable modes of transport (walking and cycling) at distances shorter than 5 km. Organisation of promotional campaigns on the benefits of public transport will include the creation and organization of citizens education, especially vulnerable groups, about the efficient and safe use of public transport.

Contemporary trends in sustainable urban mobility will certainly have an effect on the significant increase in bicycle traffic as one of the most important alternative forms of transportation in cities and it is necessary to appropriately address it. Increase in the use of bicycles as an equivalent to other means

of urban transport, will dictate significant interventions in terms of adjustment of transport infrastructure to expected increase in bicycle traffic.

SUMP offers methodological support to provide a strong plan for sustainable urban transport. Along Guidelines, best practices are valuable source for choosing appropriate measures and mechanisms in individual environments. In Republic of Croatia a pioneer process of searching for the way to apply SUMP on local level has begun. The city of Osijek, through its own strategic documents, strives to align its strategic goals with European visions and contemporary paradigms. The development of sustainable urban transport in the city has already been supported by a number of sectoral strategies. Improvement can be found in updating of existing strategies up to level of detail where the indicator is known, a desirable level of indicator values, time and actors responsible in particular activity. On the other hand, improvements can be made by upgrading the content in accordance with the SUMP objective – *Winning public support, Using synergies, increasing relevance* and *Policy/sector integration* and looking at the transportation more closely – *Towards a new mobility culture* and *Modal integration and uniform face of transport*.

It should be expected that measures given in the Mater plan [6] will result in better quality of cyclist infrastructure, that is integrated in public transport of the city of Osijek. From a construction point of view, a contribution will be given by the new Ordinance on cycling infrastructure [27]. The Ordinance prescribes the basic principles of planning and design elements, construction and maintenance of cycling infrastructure, and its importance goes beyond the scope of construction design. Until the Ordinance [27], cycling in the Republic of Croatia was legally defined with just a few articles in the Roads Act [28] and the Traffic Safety Act [29]. This incomplete and poor legislation has resulted in great inconsistency in the previous practice of designing and construction of cycling infrastructure in Croatia and also in the city of Osijek.

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