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Road and Rail Infrastructure III

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PROBLEMS IN PLANNING OF THE PRIMARY ROAD CORRIDORS IN THE CITIES ON THE EXAMPLE OF THE CITY OF ZAGREB

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Abstract

Primary road corridors are the main city road corridors for acceptance and distribution of traffic. This paper describes methodological approach to define the optimal solution for road corridors that can take the traffic load. Proves the need for upgrading the secondary road network along the primary road corridors based on the analysis of the transport corridor. Discusses calculated transport effects of alternative solutions and compares them with investments for the construction or reconstruction of the corridor. Displays the construction characteristics of road corridor with a series of split level intersection. This paper analyses the basic requirements for road corridor design in the urban area, resulting in modern transportation solution.

Keywords: road corridor, traffic corridor, road design, traffic modelling, traffic planning, evaluation

1 Introduction

Primary road corridors in the cities are the main ones to accept and distribute traffic on which the entire transport system is based. Planning of a primary road corridor is time consuming process whose origins date back to the time of creation of urban areas and making of first urban plans. Over time, in the area of primary road corridor occur changes that cause the need for further evaluation, and traffic and construction.
Investment in transport infrastructure of cities in Croatia very often do not follow demographic expansion which results in traffic problems, considering that traffic volumes exceed the capacity of the system.
Planning of a primary road corridors as well as constant monitoring of events in the space is a basic prerequisite for the protection, preservation and quality of space, and ensuring sustainable urban development and the quality of the built environment. The primary road corridor in Zagreb is formed from the transport network between junctions Jankomir and Ivanja Reka or road Ljubljanska – Zagrebačka – Slavonska Avenue, which was once part of the Highway "Bratstvo i jedinstvo" and is one of the most burdened roads of Zagreb.
This paper describes the problems in planning of primary road corridors on the example of the City of Zagreb through the methodological approach and the selection of the optimal solution based on the analysis of space and integrated transport system. Valuation of transport networks leads to modern transport solution for the City of Zagreb.

2 Methodological approach

In planning of the transport system of cities, of which one component is the primary road corridor, decision must be based on a modern integrated transport model. Modern transport model allows simulation of traffic in the transport system for the base year, as well as forecasting the future state of traffic in the years in which particular scenario is tested. Based on the calculated traffic impacts of scenarios (variants) of the transport system development, the evaluation and decision on the optimal solution is performed. Methodological evaluation procedure is performed through the basic steps as follows:

· analysis of spatial planning and traffic-technical documentation;
· development of transport models;
· development of technical solutions;
· defining scenarios of the road network;
· analysis and evaluation of scenarios.

3 Display of choice of the optimal solution of the primary road corridor of the City of Zagreb

3.1 Spatial planning documentation

The basic spatial planning documents used in creation of the optimal solution and evaluation of the primary road corridor Ljubljanska – Zagrebačka – Slavonska Avenue (the Avenue) is Master Plan of the City of Zagreb (further in the text MP).

In the MP from 1970 (Figure 1) the corridor is categorized as "urban highway". The "urban highway" according to the MP is "expressly linking the eastern and western parts of the city with the city centre and connecting the eastern and western terrestrial highways" and "acceptance and distribution of traffic on the rest of the road network of the city via the connection of major roads that must be of high capacity".

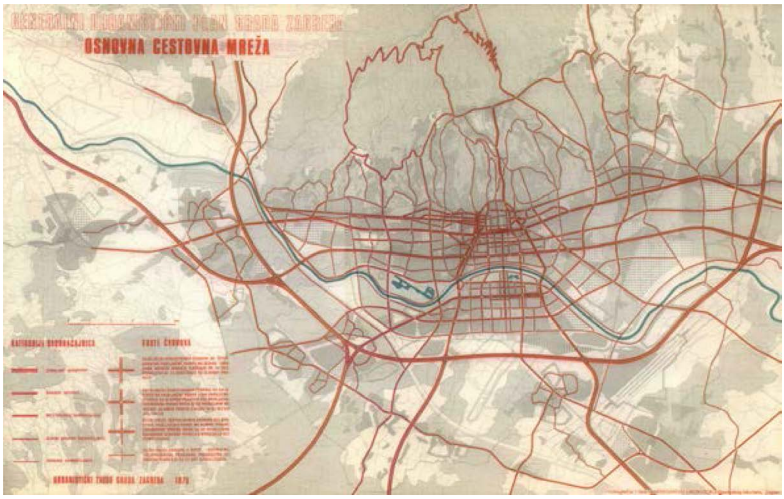

Figure 1 Master Plan of the City of Zagreb 1970 – Basic road network

General construction characteristics of urban highway defined by MP from 1970 were: design speed of 80-90 km/h; lane width 3.50 m; principal corridor width 70 meters on both sides of the axis; dual carriageway with central belt width 4.00 m; the number of transit lanes depen-

ding on the forecasted load, at least three in each direction; all intersections are split-level intersections; distance of intersections minimum 1,000 m (exceptionally 600 m); pedestrian traffic longitudinal and spatially separated from motor traffic, transverse split-levelled; public transportation, is only possible rapid bus, without disturbing the main lanes.
In the current MP corridor is defined as the avenue with the following characteristics: corridor width of at least 40 meters; lane width 3.25 m; "intersection can be split-level intersections if required by traffic needs, and allowed by space capabilities"; "it is necessary to predict the rows of trees."
Analysis of the spatial planning documents, and comparison of historical and present data, shows, except reduction of characteristics of the primary road corridor, a noticeable and significant reduction in the width of the corridor (from 140 m to at least 40 m). Current corridor width of the Avenue according to the latest MP is shown in Figure 2.
As a result of the analysis of the corridor it has been established that east of Heinzelova corridor width is greater than 110 m. Looking westward from Heinzelova corridor width varies between 60 and 80 meters. The Avenue corridor is narrowest between Savska and Šarengradska with width of only 50 m.
The above described analysis shows that there is a lot of pressure on the idea of the primary road corridor in the cities, which results in the "confiscation" of space intended for transportation infrastructure. Ultimately, this result in additional costs and time required for implementation of the optimal solution, given that it is already spatially limited urban environment.

Figure 2 Zagrebačka and Slavonska Avenue corridor (up: Nehajska-Savska; down: Heinzelova-Čavićeva)

3.2 Description of present state

The Avenue was built as dual carriageway road, two lanes per carriageway, separated by a central reserve. Zagrebačka Avenue was reconstructed in year 2006 with upgrade of third lane on the stretch from Savska Opatovina to Selska.
On the whole stretch, length 22 km, 25 intersection was built (approximately every 900 m) of which 15 as signalized intersections in level. Split-level intersections were built mainly at the

intersection with avenues, with the exception of the intersection Ljubljanska Av. – extended Medpotoki, Zagrebačka Av. – Savska Opatovina and Slavonska Av. – Ljudevita Posavskog. Intersections were constructed over the last 30 years and in various forms (Figure 3): motorway loop "clover" with three levels (Držićeva), "trumpet" (Škorpikova and extended Medpotoki), the classic "diamond" (Savska Opatovina, Selska, Savska, HBZ and Posavska), "half-diamond" (Gospićka), "diamond" with the left detachment for the left turn (Heinzelova).
In the analysis of the classic "diamond" intersections design solutions are also not unified: classic four-way intersection (Selska, Savska, Posavskog), expanded four-way intersection (HBZ) and roundabout (Savska Opatovina). Such "mixed" design solutions of intersections as by type, as in the traffic management also represents a big problem for the driver and is one of the factors that influence the formation of traffic jams and reduce the safety of the existing transport system of described corridor.

Figure 3 Split-level intersections on Ljubljanska – Zagrebačka – Slavonska Av

3.3 Description of the planned project

Solution of the primary road corridor of the City of Zagreb is based on the reconstruction of Slavonska, Zagrebačka and Ljubljanska Avenue by reconstruction of the existing signalized intersections into split-level intersections and upgrading the number of required lanes on the main transit carriageways. In the area of coverage, from the Puljska in the west to the street Marijana Čavića in the east, the Avenue makes 16 intersections, 10 of which are split-level intersections and 6 connections, with the existing and planned road network.
The planned intervention in the initial step predicted two basic variants of reconstruction of the Avenue: "do minimum" (Variant 1) and "do maximum" (Variant 2). Based on the traffic analysis and spatial constraints of both variants, traffic segments that define the optimal solution (Variant 3) were selected.

3.3.1 Description of Variant 1 – "do minimum"

The main characteristic of Variant 1 is the upgrade of main transit carriageways to at least three lanes per direction and reconstruction of the existing signalized intersections into split-level intersections, Črnomerec and Kruge, with three lanes in each direction on main carriageways, construction of a new split-level intersection Šarengradska and construction of underpasses Sveučilišna – Miramarska – HBZ with 2 lanes per direction on the main carriageways. Existing split-level intersections are retained with two lanes per direction on main carriageways (Selska, Savska, Držićeva and Heinzelova).

3.3.2 Description of Variant 2 – "do maximum"

Variant 2, except upgrade of main transit carriageways to at least three lanes per direction, predicts reconstruction of existing signalised intersections into split-level intersections (Črnomerec and Kruge), reconstruction of the existing split-level intersections (Selska, Držićeva and Heinzelova), construction of new split-level intersections (Šarengradska, Sveučilišna and Miramarska) and construction of underpass Sveučilišna – Miramarska – HBZ with three lanes per direction on the main carriageways. In addition to the existing underpass Savska includes construction of a new underpass with three lanes for the northern carriageway of Slavonska Avenue.
Beside the upgrade of the third lane, Variant 2 predicts reconstruction of the intersection Držićeva from the motorway intersection in the classic diamond intersection typical for urban areas as shown in Figure 4.

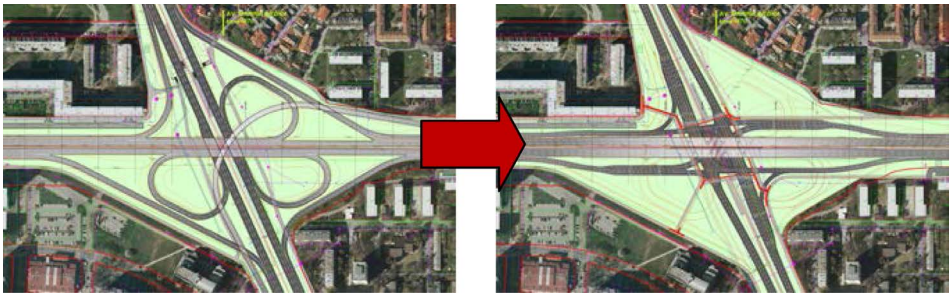

Figure 4 Reconstruction of intersection Držićeva

3.4 Selection of the optimal solution

In the area of research deterministic static simulation of individual traffic flows was made, where a wider area of the model covers an area from Vukomerečka road in the east to Zagrebačka road in the west. The wider scope of the model enables to test the traffic corridor or individual actions (scenarios) of the road corridor Zagrebačka and Slavonska Avenue and interventions in the immediate environment. This approach allows combining scenarios and finding an optimal solution in the metropolitan area.

3.4.1 Traffic analysis of existing corridor

Traffic analysis of the existing situation proves that the congestion on the Avenue in research area is mostly affected by signalized intersections Marohnićeva, Kruge and Čavićeva whose capacity is lower than other split-level network segments. In the segment of Slavonska Avenue between Držićeva and Heinzlova congestion is caused by the inability to distribute traffic to the north due to delays in Heinzlova Street towards intersection with the Vukovarsta street. Congestion can occur on ramps on Slavonska Avenue (Figure 5).

The planned increase of traffic volumes by 25% in year 2033 compared to the year 2013, with increased capacity of the Avenue, must be distributed through existing and planned split-level intersections.

Figure 5 Saturation of the network in year 2033 (Scenario 2033_V1-0)

3.4.2 Scenario analysis

Traffic analysis of future transport system predicted 8 scenarios. Basic characteristics of the scenarios are inclusion of both variants of the design solution for primary road corridor Slavonska and Zagrebačka Avenue (Variant 1 and Variant 2) in conjunction with actions in the network directly along the Avenue. This analysis leads to the conclusion that the functioning of the Avenue in the area of research to year 2033 is possible with reconstruction of existing signalized intersections into split-level intersections and construction of 2x3 lanes on the main carriageways, which would balance the traffic offer on transit east-west corridor.

Figure 6 Saturation of proposed network in year 2033

To solve the problem of distribution it is necessary to activate the planned network connected the Avenue; Šarengradska road from the Jadranski bridge to Vukovarska Avenue, Street Prisavlje from Marohnićeva to Marina Držića Avenue, Sveučilišna Street from Vukovarska Avenue to Street Prisavlje, Miramarska Street from Vukovarska Avenue to Slavonska Avenue, Street Kruge from Prisavlje Street to Slavonska Avenue. In the eastern part of the city must be activated the eastern part of the planned Zagreb ring road or section Vatikanska – Koledov-

čina. Saturation of the network in year 2033 for optimal solution of the Avenue and planned network is shown on Figure 6.
Table 1 shows the traffic effects for optimal solution of the primary traffic corridor in the City of Zagreb which predicts the reconstruction of the Avenue and activation of the planned network related to the Avenue. It turns out that the savings in the transport system in the year 2013 are 220 million € / year. With the increase of traffic in year 2033 effects will be 292 million € / year. The above indicators are evidence of the need for investment in primary road corridor in the City of Zagreb and the development of the network in the immediate vicinity.

Table 1 Traffic effects of the primary traffic corridor in the City of Zagreb

	year 2013				year 2033			
	Base case	Scenario case	Cost diference	Share %	Base case	Scenario case	Cost diference	Share %
Cost components								
Running cost	4,988	5,132	0,144		4,988	5,132	0,144	
Total	***4,988***	***5,132***	***0,144***		***4,988***	***5,132***	***0,144***	
Benefit components								
Operating cost	410,144	342,937	67,207	30,530	523,418	440,409	83,009	28,449
Travel times	458,823	357,525	101,298	46,017	649,756	505,050	144,706	49,594
Accidental events	220,201	178,346	41,854	19,013	278,952	227,730	51,222	17,555
Pollutant volume	1,325	1,090	0,235	0,107	1,745	1,439	0,305	0,105
C02 volume	52,760	43,221	9,539	4,333	70,100	57,562	12,538	4,297
Total	***1.143,253***	***923,118***	***220,134***	100,000	***1.523,971***	***1.232,191***	***291,780***	100,000

* All values in Million €/year

3.5 Description of the optimal solution of the primary road corridor in the City of Zagreb

The optimal solution of the primary road corridor Zagrebačka and Slavonska Avenue represents Variant 3 (Figure 7) which predicts reconstruction of signalized intersections Črnomerec and Kruge into split-level intersection with three lanes per direction on the main transit carriageway, construction of underpasses Sveučilišna – Miramarska – HBZ with 3 lanes per direction on the main carriageway and reconstruction of existing split-level intersection Heinzelova in classic diamond intersection typical for urban areas.

Figure 7 Slavonska Avenue

Geometrical characteristics of the corridor are based on the design speed; 80 km/h on the main transit carriageways and 50 km/h for the service roadways and intersection ramps. The main carriageway of Zagrebačka and Slavonska Avenue contains a minimum of three lanes per direction. On the ramps of split-level intersections number of lanes depends on the forecasted traffic volume, a minimum of two lanes. The cost of construction of Variant 3 is estimated at an amount of 73,4 million €. The project can be realized in three phase. Review of priorities and their costs is given in Table 2.

Table 2 Review of priorities and the cost of reconstruction of the Avenue

Phase	Sector	Start	End	Lenght	Cost
I.	Savska - Kruge	2+000	4+650	2.650	49,30 mio.€
II.	Držićeva - Čavićeva	4+650	7+300	2.650	7,00 mio.€
III.	Črnomerec - Savska	-0+320	2+000	2.320	17,10 mio.€
	Total			**7.620**	**73,40 mio.€**

4 Conclusion

Integrated planning and management of spatial and transport factors allows creation of optimal solutions for the transport system of the city as a whole, which contributes to sustainable development and to improve the efficiency of spatial and transport planning. Revision of existing and planning of new road corridors in the transport system must be evaluated through a modern integrated transport model. The traffic model is the basic "tool" in planning procedure, under which it is possible to calculate the traffic impacts of the proposed idea. This paper describes a practical example showing that corridors planned in spatial plans require further evaluation, and traffic and technical. The result of evaluation often requires an amendment to the spatial planning documentation which is causing an increase in cost and time for implementation of the project.

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