

FINDING SOLUTIONS FOR OVERLOADED ROUNDABOUTS

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Abstract

The Study presents the ways in which the solutions are found for the reconstruction of the at-grade roundabout which is loaded with the annual average daily traffic (AADT) of 100,000 vehicles/day. The variants described have the capacity to take over mentioned traffic loads, while the presented traffic model stands as a methodological base for the solution finding. The need for road network extension in the project area surroundings onto which the problems of overloaded roundabout are reflected is hereby being proved. The assessed transport effects of variant solutions are discussed and compared with the investments planned for the reconstruction.

Keywords: traffic modeling, road designing, high capacity roundabouts, assessment and selection of designs.

1 Introduction

The existing circular intersection of Jadranska and Dubrovačka Avenues in Zagreb (the Remetinec roundabout) is the highest loaded at-grade intersection in Croatia with the average daily traffic of about 100,000 vehicles entering the intersection. This roundabout is practically the only access for the traffic coming from the A1 Highway to Zagreb. The morning and afternoon peak loads may be dealt with only with the traffic police assistance.



Figure 1 The existing state of the intersection

The accident statistics indicates the decrease of accidents in the period from 2001 to 2006 with 129 accidents recorded. There were no fatal accidents in that period.

The data on traffic intensity, the spatial and time distribution on the intersection and on the distribution in the part of the network affected by the intersection provides the base of every intersection design.

The Study describes the ways of finding the solutions for the saturated roundabout, as well as the impact of the solutions on the traffic network of the city.

2 The existing state

The intersection of Jadranska and Dubrovačka Avenues in Zagreb (hereinafter the Remetinec roundabout) is of circular form and located at +1 level with the tram traffic passing at ground level. The external radius of the roundabout is 74.0m. Figure 1 presents the existing situation of the roundabout.

The Table 1 presents the results of the traffic count throughout the day per access to the intersection. The hourly traffic variations per access are shown in the Figure 2.

The traffic count per access to the roundabout cannot be used in determining the distribution of the traffic within the roundabout, instead the additional dynamic traffic counts are carried out, e.g. using the video recordings. Traffic distributions for morning and afternoon peak loads are shown in the Figure 3.

Table 1 Results of daily traffic count on the intersection

<i>Daily traffic, counting 24.10.2008.</i>				
Approach	Turn			TOTAL
	right	straight	left	
Jadranska avenija	11	11.060	12.817	23.888
Remetinečka cesta	3.928	7.126	20	11.074
Avenija Dubrovnik	24.647	8.344	1.513	34.504
Jadranski most	12.975	4.575	12.007	29.557
OVERALL				99.023

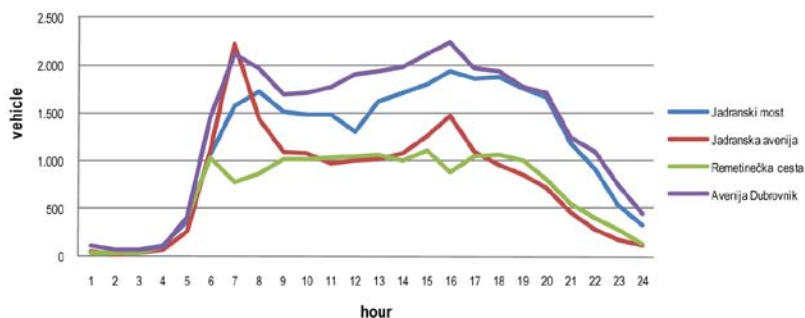


Figure 2 Hourly variations of traffic per access

There were 129 recorded accidents in 2006, 57 of which were collisions of vehicles, 72 accidents were the result of switching lanes, interweaving, ignoring the right of way, skidding off the road, etc.

The accidents per year are shown in the Table 4.

For accident distribution, a firm convergence can be established with the traffic volume as per access, so per individual section of the roundabout.

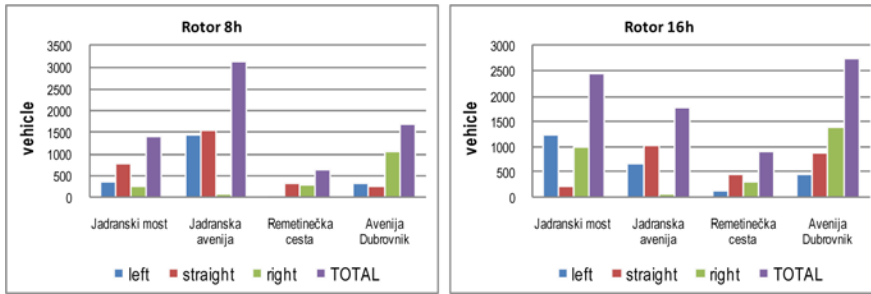


Figure 3 Traffic distribution per access

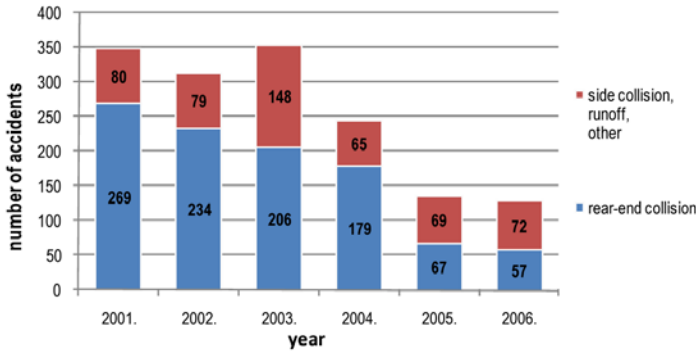


Figure 4 Traffic accident distribution per year

3 Solution finding methods

The procedure for the selection of the solution was carried out through six work phases as follows:

- Phase 1. – Based on the traffic count and video recordings of the traffic, the values of traffic per access and in the roundabout should be established. Enter the current data in the journey matrix calibration.
- Phase 2. – Examine the assumption that the problem of the existing at-grade intersection can be solved by interventions, or by the construction of the network segments in the roundabout surroundings. It is supposed that the new network might reduce the traffic of the roundabout and create the conditions for the roundabout to function in its present form (or with minimum changes).
- Phase 3. – The dominant traffic flows with respect to volume should be dislocated in terms of elevation, and as less traffic as possible should be let into the intersection at ground level.
- Phase 4. – Elaborate a construction design corresponding in terms of capacity to the traffic volumes and test it “in point sources” not intervening into the traffic network of the City of Zagreb.
- Phase 5. – Find out which actions (interventions) into the city network would be efficient in the positive sense, if used in combination with the construction design, and define minimum interventions, which along with the new construction design of the roundabout would meet with the forecast traffic volumes.
- Phase 6. - Perform assessment and ranking of the designs calculating the traffic savings and net present values.

In order to carry out the work phases above, 17 scenarios were elaborated which helped in finding the solution. The subject scenarios are presented in the Table 2.

Table 2 Scenario Overview

Nr.	Scenario	Variant of roundabout		Aktion		Traffic godina	Proof of step
		Nr.	Description	Nr.	Description		
1	0800	0	Existing status	0	Network 2008.	2008	a
2	0900			0	Networki 2008.	2009	a
3	1010			2	Bridge Jarun-EAST - without south parting	2018	b
4	1020			1	Vrapčanska, Priobalna, Vatikanska	2018	b
5	1200	2	Tunnel WEST - EAST	0	No upgrades network	2018	d
6	1300	3	Viaduct WEST-NORD + tunnel NORD-EAST (triangl)	0	No upgrades network	2018	d
7	1801	2	Tunnel WEST - EAST	1	Vrapčanska, Priobalna, Vatikanska	2018	e
8	1802			2	South parting	2018	e
9	1803			3	Šarengradska	2018	e
10	1804			4	Draškovičeva - SR Njemačke	2018	e
11	1809			5	Bridge Jarun-EAST - without south parting	2018	e
12	1805	3	Viaduct WEST-NORD + tunnel NORD-EAST (triangl)	1	Vrapčanska, Priobalna, Vatikanska	2018	e
13	1806			2	South parting	2018	e
14	1807			3	Šarengradska	2018	e
15	1808			4	Draškovičeva - SR Njemačke	2018	e
16	1810			5	Bridge Jarun-EAST - without south parting	2018	e
17	1800			0	Existing status	0	Network 2008.

The Figure 5 shows the interventions in the road network in combination with individual scenarios.

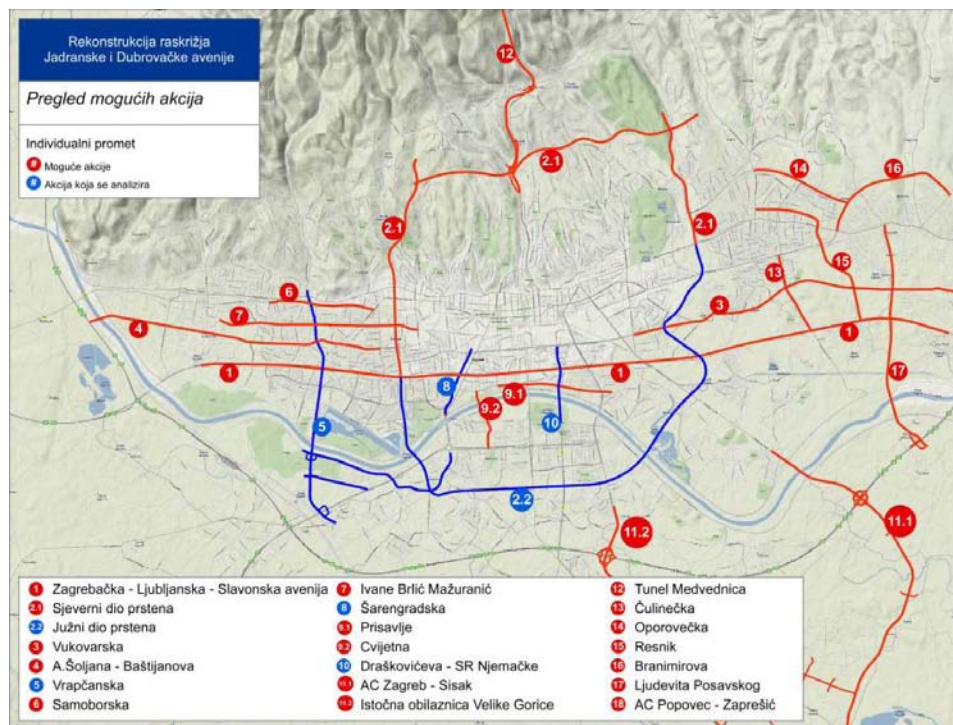


Figure 5 Road Network Actions

4 Solution finding

Pursuant to the aforesaid phases presented within the solution finding procedure (1st Phase) for the purposes of elaboration of the detailed traffic model in the design surroundings, the journey matrices have been calibrated on the basis of the current data. The calibration was conducted by means of the TFlowFuzzy module in the software which was used for elaboration of the traffic model [1].

By network traffic allotment for the individual scenarios (2nd Phase), it was concluded that the network constructed in the neighborhood cannot take over sufficient traffic, so that the roundabout could serve the traffic coming onto it without further reconstruction. Scenarios 1010 and 1020 (construction of bridges next to Jarun district) “release” over 50,000 vehicles/day onto the roundabout, which again exceeds the signal-controlled roundabout capacity. Figure 6. presents roundabout loads per individual scenario.

The basic presumption during the elaboration of the 3rd Phase (construction design proposal) was that the roundabout capacity $rv=74m$ amounts to 50,000 vehicles per day orientationally of the signal-controlled roundabout (FGSV 242, FGSV Verlag, Koeln 2006.). Such a condition shall be complied with all the variants.

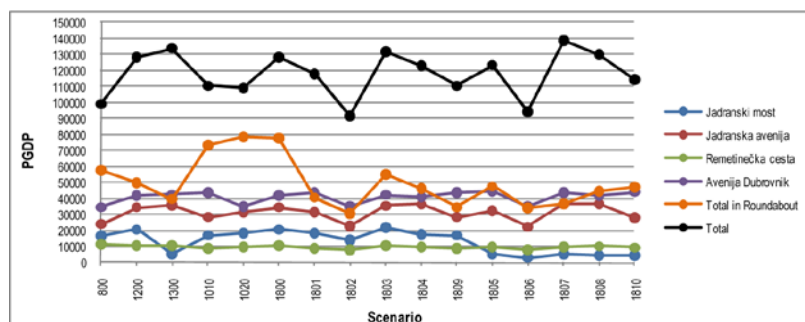


Figure 6 Roundabout loads per individual scenario

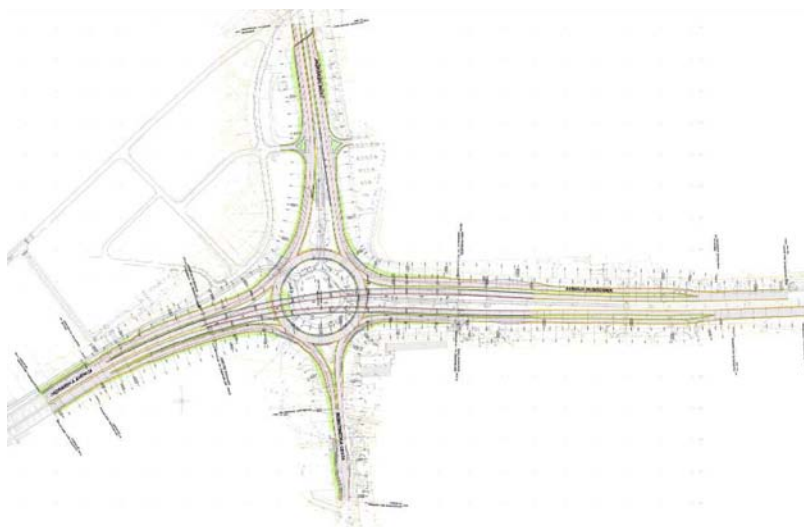


Figure 7 Proposal of the Remetinec roundabout design – 1st Variant



Figure 8 Proposal of the Remetinec roundabout design – 2nd Variant

Construction design was elaborated for four variants, as follows:

- 1st Variant – west-east traffic flows run on viaducts at +2 level (Figure 7),
- 2nd Variant – west-east traffic flows run through the tunnels at -1 level (Figure 8),
- 3rd Variant – west-north traffic flows run on a viaduct at +2 level, while the north-east traffic flow runs through the tunnel at -1 level (Figure 9),
- 4th Variant – north-east traffic flow runs through the tunnel at -1 level (Figure 10).



Figure 9 Proposal of the Remetinec roundabout – 3rd Variant

In all the variants, the right turns are led outside the roundabout in separate traffic lanes. The testing of the impact on the surrounding network which would be appropriate in terms of capacity (4th Phase) has shown that the current problem of the roundabout low-capacity shall be transferred to the surrounding area towards the north onto the Jadranski most Bridge. The Figure 11 shows the good “point source” design as per the scenario 1300 through the city network saturation.



Figure 10 Proposal of the Remetinec roundabout – 4th Variant

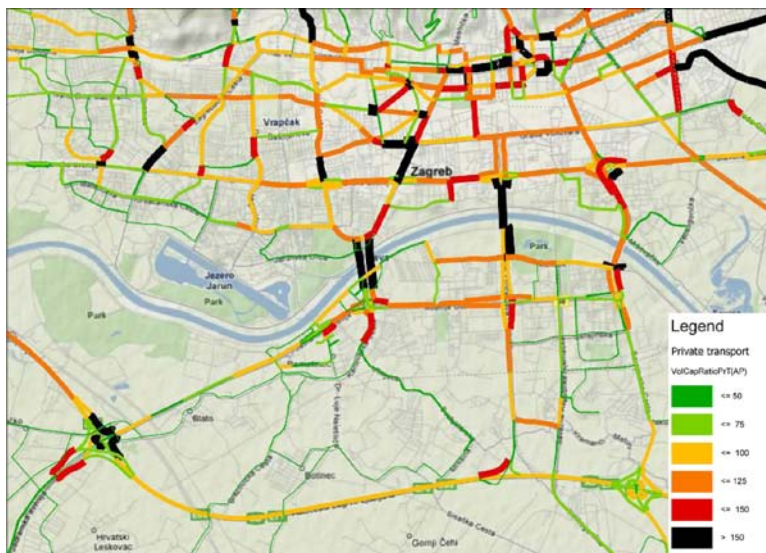


Figure 11 Saturation of the city network as per the scenario 1300

Based on the evidence on dislocation of the traffic problem from the roundabout to the surrounding area, the minimum required intervention into the city network was undertaken (5th Phase) in order to reduce the traffic volumes accessing and entering the roundabout to the roundabout maximum capacity, without suffocating the surroundings.

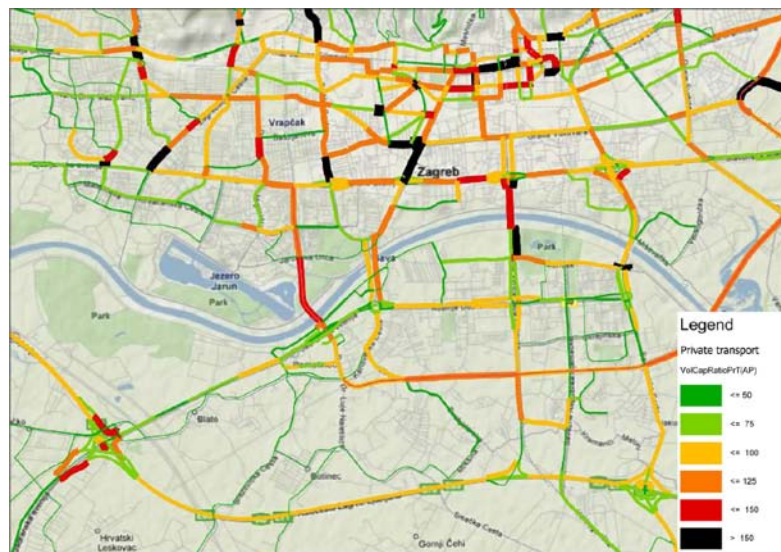


Figure 12 Saturation of the city network as per the scenario 1802.

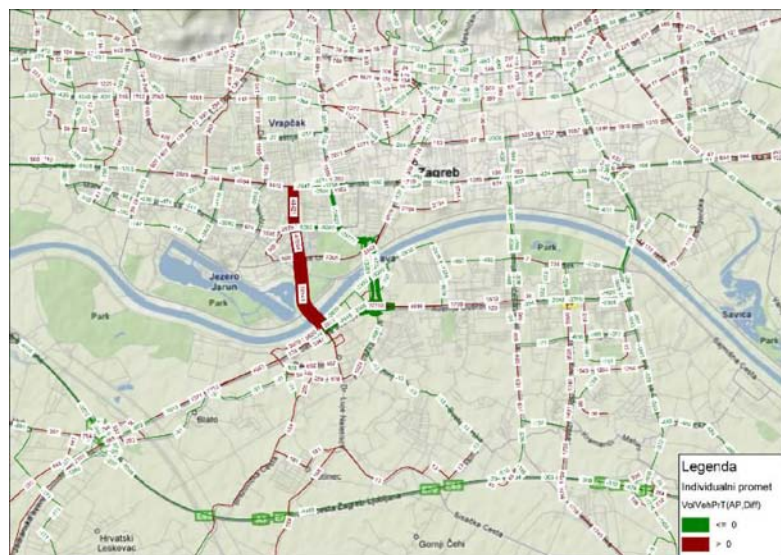


Figure 13 Difference in traffic with the Jarun Bridge –east (scenario 1809) and without the bridge (scenario 1800).

The major traffic savings during the conducted analysis of a series of scenarios from the scenario 1801 to 1810 includes the southern part of the city ring including the Jarun Bridge – east scenario 1802 (See Figure 12).

The construction of the Jarun bridge – east (scenario 1809) presents itself as the minimum required action in the network in the Remetinec roundabout point source design surroundings.

The effects of the Jarun bridge – east construction without the southern ring are presented in the Figure 13. The difference in traffic with the Jarun bridge – east (scenario 1809) and without the bridge is shown above.

5 Evaluation

The Variant 1 was omitted from the evaluation due to its unacceptable elevation, since it is located on the same level as the third level of the neighboring collective housing buildings. The Variant 4 was omitted from the evaluation as it introduces 45,455 vehicles/day into the roundabout which presents 90.9% of the roundabout capacity. The Variant 4 is a shortened version of the Variant 3, and it exceeds the Variant 2 in costs (see Table 3). The Table 3 presents total costs of the construction of individual variant designs.

Table 4 presents the traffic volumes in the roundabout per variant based on the traffic counts. Evaluation and ranking was executed for the Variants 2 and 3 through savings and net current value as presented in the Table 5.

Variant 2 is the proposed design which in combination with the southern ring, or the Jarun bridge – east is the highest ranked as per the net current value, savings and the cost benefit factor (B/C).

Table 3 Total costs of the construction of individual variants

Nr.	Variant	Investment (Kn)	Investment (€)	% to proposed variant (V2)	Ranking
1	Varijan 1 Viaduct WEST-EAST	182.826.826	24.874.398	106,56%	3
2	Variant 2 Tunnel WEST-EAST	171.572.452	23.343.191	100,00%	1
3	Variant 3 (TRIANGL) VIADCUT WEST-NORD Tunnel NORD-EAST	277.305.047	37.728.578	161,63%	4
4	Variant 4 Tunnel NORD-EAST	179.152.367	24.374.472	104,42%	2

Table 4 Traffic volumes in the roundabout per variant

Approach	Variant 1	Variant 2	Variant 3	Variant 4
Jadranska avenija	12.817	12.817	11.060	23.877
Remetinečka cesta	7.146	7.146	7.146	7.146
Avenija Dubrovnik	1.513	1.513	9.857	9.857
Jadranski most	16.582	16.582	4.575	4.575
TOTAL	38.058	38.058	32.638	45.455

Table 5 Scenario evaluation through savings and net current value

Nr	Scenario	Variant of the roundabout		Aktion		Benefit - EWS (mil € / year.)	NSV	B/C	Ranking of scenario
		Nr.	Description	Nr	Description				
1	1801	2	Tunnel WEST-EAST (18.811.339 €)	1	Vrapčanska, Priobalna, Vatikanska	10,74	86,05	5,446	5
2	1802			2	South part ring	13,57	113,37	6,710	1
3	1803			3	Šarengadska	4,09	21,16	2,113	10
4	1804			4	Draškovičeva - SR Njemačke	4,59	26,06	2,368	9
5	1809			2	Bridge Jarun-EAST - without south part ring	11,64	95,17	5,991	4
6	1805	3	Viaduct WEST-NORD + tunnel NORD-EAST (triangl) (30.620.430 €)	1	Vrapčanska, Priobalna, Vatikanska	10,41	71,00	3,275	6
7	1806			2	South part ring	12,47	90,73	3,861	3
8	1807			3	Šarengadska	6,51	33,01	2,070	7
9	1808			4	Draškovičeva - SR Njemačke	4,67	14,99	1,485	8
10	1810			2	Bridge Jarun-EAST - without south part ring	12,60	92,76	4,000	2

6 Conclusion

Solving the problem of intersection overloading in the city or suburban traffic network cannot be focused in point sources only on the intersection, as that way the problem which is solved only locally, is being directed to the surrounding part of the network.

In order to locate the problem boundaries and to find the solution a precise traffic model is required in the surroundings of the point source design as a sub-model to the model of the entire city area.

The integral part of the traffic model is the estimation of transport effects which are also the basic parameter in design evaluation.

The net current value criteria estimated by the traditional analysis of discounted cash term is a simple and a reliable indicator of range and the selection of more complex technical designs.

Reference

[1] VISUM 10.0, PTV AG, Karlsruhe, 2007.