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STUDYING THE EFFECTS OF RIGHT TURN IN CONGESTED URBAN INTERSECTIONS USING TRAFFIC SIMULATIONS

Ilir Doçi, Musli Bajraktari
University of Pristina, Faculty of Mechanical Engineering, Prishtina, Republic of Kosova

ABSTRACT

Modern cities have high congested traffic road networks with issues and problems that needs to be solved. Congestions in intersections are created due to high number of vehicles, increased number of pedestrians and improper regulation of traffic signalization. Because of this high congestion, delays, stops, blockades and long queues appear on the signalized intersections which create problems of traffic flow. It has been noticed that issues of right turn is matter of study in order to determine whether the right turn with adjacent lane should be channelized or non-channelized, signalized with traffic lights or regulated with sign for travel of vehicles. This creates the dilemma which choice gives best performance in given conditions. The study will be done based on the survey on one of most congested intersections of Prishtina city, capital of Kosova, during peak hours. Modeling of the street and simulations will be done with traffic simulations software [1] in order to have results that can be studied and implemented in practice. Results will be given for influential traffic parameters [2],[3], and possible solutions will be presented in order to have the best movement scenarios and optimized traffic flow [2].

Keywords: Traffic Intersection, Congestion, Right turn, Signalization, Modelling, Simulations

1. INTERSECTION PROPERTIES

Figure 1. Intersection view

Study will be done based on the surveys and measurement of several traffic parameters taken in one part of the street – a signalized intersection. This Intersection is shown on the Fig.1, in two projection views. It is one of main Intersections of Prishtina, type of cross- intersection with traffic lights and with double and triple lanes in both directions. This Intersection is crosslink between Agim Ramadani Str. In North-South Direction and Eqrem Qabej Str. In East-West direction. Surveys were done in two

times of day (8÷9 AM) and (5÷6 PM), which are considered peak hours of traffic circulation and congestions. Traffic flow reaches up to 1050 vph or veh/hour for some lanes (Fig.3). The Intersection is regulated with traffic lights on three signal phases. All right turns are permitted on green phase of through lanes. The aim of this work is to study effects of right turn in overall network parameters and possibilities of its optimization through study of different cases of right turn types and right turn channelization and comparing them, in order to find the best scenario of right turn for intersection. Another negative parameter that affects the results is high presence of heavy transportation vehicles in this intersection, which goes up to 22% for some lanes, and high number of bus stoppages that goes up to 15 for some lanes. Study will be accomplished by using software for traffic calculations, modeling and simulations called *Trafficware 6.65* [1].

2. INPUT MODELLING PARAMETERS AND RESULTS

In Fig.2 is showed model of intersection created with software. In Fig.3 are shown group lanes, their directions defined with acronyms and their flow in vehicles per hour. In Table 1 are given input parameters of Intersection based on surveys and implemented in software.

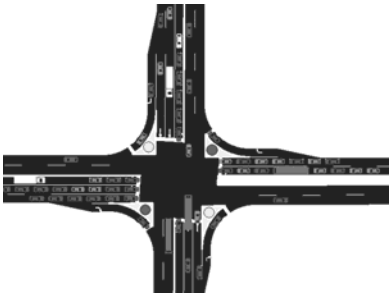

Figure 2. Model of Intersection

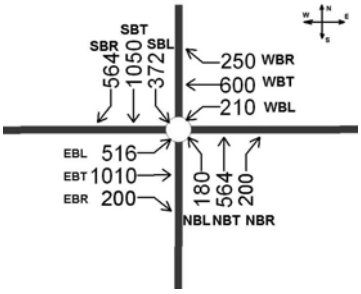

Figure 3. Traffic flow for lane groups (vehicles/hour or vph)

Table.1. Input parameters of intersection

LANE WINDOW	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lanes and Sharing (#RL)												
Ideal Satd. Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (m)	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Grade (%)	–	15	–	–	-15	–	–	-15	–	–	15	–
Area Type	–	CBD	–	–	CBD	–	–	CBD	–	–	CBD	–
Storage Length (m)	70.0	–	16.0	0.0	–	20.0	50.0	–	16.0	50.0	–	30.0
Storage Lanes (#)	1	–	1	–	–	1	1	–	1	1	–	1
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Leading Detector (m)	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2
Trailing Detector (m)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turning Speed (km/h)	30	–	30	30	–	25	24	–	25	24	–	30
Right Turn Channelized	–	–	Signal	–	–	Signal	–	–	Signal	–	–	Signal
Curb Radius (m)	–	–	15.2	–	–	15.2	–	–	15.2	–	–	15.2
Add Lanes (#)	–	–	0	–	–	0	–	–	0	–	–	0

VOLUME WINDOW	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Traffic Volume (vph)	516	1010	200	210	600	250	180	564	200	372	1050	564
Conflicting Peds. (#/hr)	12	–	10	0	–	10	0	–	10	0	–	10
Conflicting Bikes (#/hr)	–	–	0	–	–	0	–	–	0	–	–	0
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Heavy Vehicles (%)	22	5	14	4	10	3	12	22	2	4	22	18
Bus Blockages (#/hr)	15	2	10	2	5	2	10	15	1	2	15	15
Adj. Parking Lane?	No	No	No	No	No	No	No	No	No	No	No	No

Options >

Controller Type: Pretimed

Cycle Length: 94.0

Actuated C.L.: 94.0
Natural C.L.: 140.0
Max v/c Ratio: 3.06
Int. Delay: 218.0
Int. LOS: F
ICU: 113.7%
ICU LOS: H

Lock Timings

Offset Settings

TIMING WINDOW	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	PED	HOLD
Lanes and Sharing (#RL)													–	–
Traffic Volume (vph)	516	1010	200	210	600	250	180	564	200	372	1050	564	–	–
Turn Type	Split	–	Perm	Split	–	Perm	Perm	–	Perm	Perm	–	Perm	–	–
Protected Phases	4	4		8	8			2			6		–	–
Permitted Phases			4			8	2		2	6		6	–	–
Detector Phases	4	4	4	8	8	8	2	2	2	6	6	6	–	–
Minimum Initial (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	–	–
Minimum Split (s)	30.0	30.0	30.0	21.0	21.0	21.0	28.0	28.0	28.0	28.0	28.0	28.0	–	–
Total Split (s)	37.0	37.0	37.0	23.0	23.0	23.0	34.0	34.0	34.0	34.0	34.0	34.0	–	–
Yellow Time (s)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	–	–
All-Red Time (s)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	–	–

Based on input parameters, software can calculate output parameters. In order to have general results, software can do simulations using module of software called SimTraffic [1]. Software has calculated that intersection in current condition already works above its capacity limits (113.7%). For our case of interest, in Fig.3, right turns are EBR, WBR, NBR, SBR [1],[3].

2.1. Case 1 – Results from recordings and survey

Case 1 represents actual-real case, based on recordings and surveys done in intersection. All right turns are **permitted** on green phase of through lanes, channelized with islands on intersection. Permitted turn type means right turns go on green ball but yield to pedestrians. Most important results of calculation and simulations are those that affect entire network performance and are shown in Table.2. Results of average speeds per each lane are shown in graph, Fig.4. Based on graph, lanes SBR, WBR, NBR and EBL have lowest average speed (< 5 km/h) which results in low flow, longer queues, longer delays and other negative effects for traffic flow.

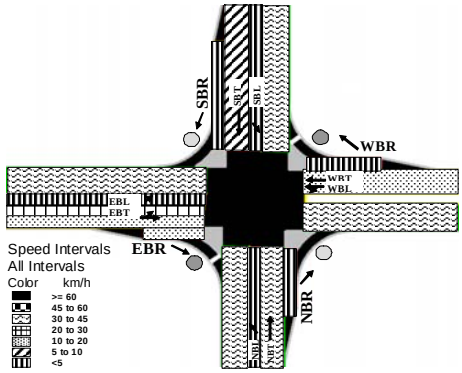

Figure 4. Graph of average speed per lane

Table.2. Results of simulation

Total Delay (hr)	51.3
Delay / Vehicle (s)	255.9
Stop Delay (hr)	38
Total Stops	2050
Stop/Vehicle	2.84
Travel Distance (km)	1876.5
Travel Time (hr)	92.3
Avg Speed (km/h)	21
Fuel Used (l)	428.6
CO Emissions (g)	5038
Vehicles Entered	891
Vehicles Exited	553
Hourly Exit Rate	3318
Denied Entry of veh After	77

2.2. Case 2 – Right turns with permitted and overlap option

We will simulate other cases for study if the right turns were different then one of real right turns in Case 1 and compare them, in order to see which option is the best in order to suggest it for regulation. In this case, type of right turns are Permitted + Overlap. Overlap means right turns go on a compatible left turn phase. Other input parameters remain same. Results on the third column of Table 3 are given as a difference in percentage between Case 1 and Case 2. We can notice that Case 2 is showing better performance, particularly with less total delays, Delays/vehicle, stop delays, hourly exit rate and Denied entry of vehicles after. Fig.5 shows that lanes SBR and NBR have higher average speed than in Case 1, which results in better traffic flow.

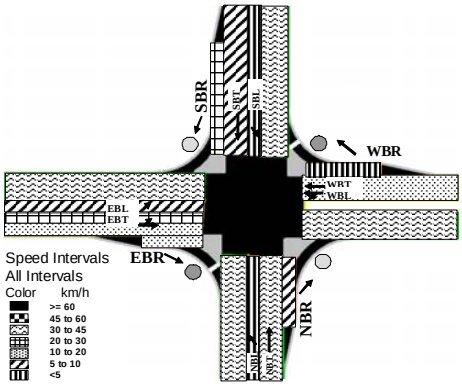

Figure 5. Graph of average speed per lane

Table.3. Results of simulation for Case 2

	Case 1	Case 2	Difference (%)
Total Delay (hr)	51.3	48.1	-6.65%
Delay / Vehicle (s)	255.9	230	-11.26%
Stop Delay (hr)	38	35.1	-8.26%
Total Stops	2050	1987	-3.17%
Stop/Vehicle	2.84	2.64	-7.58%
Travel Distance (km)	1876.5	1923.5	2.44%
Travel Time (hr)	92.3	90	-2.56%
Avg Speed (km/h)	21	22	4.55%
Fuel Used (l)	428.6	436.5	1.81%
CO Emissions (g)	5038	5089	1.00%
Vehicles Entered	891	918	2.94%
Vehicles Exited	553	588	5.95%
Hourly Exit Rate	3318	3528	5.95%
Denied Entry of veh After	77	50	-54.00%

2.3. Case 3 – Right turns have no traffic lights, but yields to the traffic with yield sign

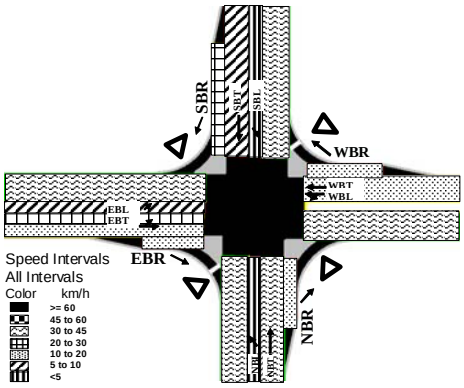

Figure 6. Simulation view for Case 3

Table 4. Results of simulation for Case 3

	Case 1	Case 3	Difference (%)
Total Delay (hr)	51.3	47.1	-8.92%
Delay / Vehicle (s)	255.9	223.8	-14.34%
Stop Delay (hr)	38	33.9	-12.09%
Total Stops	2050	1966	-4.27%
Stop/ Vehicle	2.84	2.59	-9.65%
Travel Distance (km)	1876.5	1941.8	3.36%
Travel Time (hr)	92.3	89.4	-3.24%
Avg Speed (km/h)	21	22	4.55%
Fuel Used (*l*)	428.6	431	0.56%
CO Emissions (g)	5038	5134	1.87%
Vehicles Entered	891	918	2.94%
Vehicles Exited	553	599	7.68%
Hourly Exit Rate	3318	3594	7.68%
Denied Entry After	77	50	-54.00%

This case has given highest difference in results and best performance in all parameters, particularly in delays, stops and denied entry, which gives a conclusion as a better choice than the actual first case. In Fig.6, all right turns have higher average speed than Case 1, which results in better traffic flow.

2.4. Case 4 – Right turns are not channelized and all are permitted type

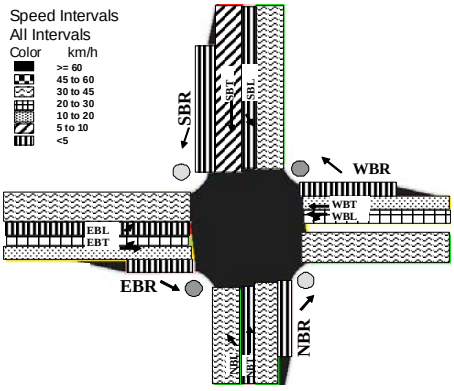

Figure7. Simulation view for Case 4

Table 5. Results of simulation for Case 4

	Case 1	Case 4	Difference (%)
Total Delay (hr)	51.3	50.8	-0.98%
Delay / Vehicle (s)	255.9	250.2	-2.28%
Stop Delay (hr)	38	37.3	-1.88%
Total Stops	2050	2107	2.71%
Stop/Vehicle	2.84	2.88	1.39%
Travel Distance (km)	1876.5	1884.6	0.43%
Travel Time (hr)	92.3	91.9	-0.44%
Avg Speed (km/h)	21	21	0.00%
Fuel Used (l)	428.6	434.4	1.34%
CO Emissions (g)	5038	5024	-0.28%
Vehicles Entered	891	898	0.78%
Vehicles Exited	553	565	2.12%
Hourly Exit Rate	3318	3390	2.12%
Denied Entry After	77	71	-8.45%

From the results on Table 5, this case has little difference with first case in almost all parameters. In Fig.7, only change is for EBR turn, which has lower speed. We can conclude that right turns can be built with or without channelization. It is more a choice based on constructive or terrain options.

3. CONCLUSIONS

Using simulation software can be very useful to study problems of traffic networks. We can conclude that right turns without traffic lights but only with traffic signs -Case 3, show better performance for most important traffic parameters. This can be useful in planning traffic intersections in urban areas.

4. REFERENCES

[1] Trafficware Simtraffic 6 help & user guide, 2005.
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[3] Highway Capacity Manual 2000, TRB, National Academy of Sciences, 2000.