Qualitative traffic indicators analysis and optimization model for traffic operations in urban zone

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Abstract: *The greater interest of people living in urban areas has been accompanied by an increase in demand for motorized movements and other forms of active movements in these areas. As a result, traffic problems have been increased extremely for these road users both in terms of the quality of movement and safety. This research is focused on identifying factors related to the quality of motorized and non-motorized movements in urban areas, a particular case study of the municipality of Fushe Kosova, and the design of a model for traffic optimization in urban areas. The current approach to prioritizing the solution of motorized traffic problems, especially in developing countries, has proved ineffective because, in the absence of addressing other mobility requirements (pedestrian, cyclist mobility), road users have been encouraged more to use this form of transport, leaving no room for other alternatives. The research aims to apply advanced methods for handling and managing traffic problems based on the principle of inclusion and building a model for optimizing traffic operation based on a specific case. The model is built using the programming language "Synchro," which enables the analysis, optimization, and simulation of all forms of transport: motorized traffic, movement of pedestrians and cyclists in the road network planned following these requirements. Obtained results show the advantages of using different forms of transport depending on the selected concept and the priority of certain forms of transport. The summary results and their comparison in terms of quality for different time intervals, including the different conditions of access to urban areas, are presented in tabular forms.*
Keywords*: LOS, DELAY, VEHICLE, MOVEMENTS, SIMULATION*

1. Introduction

Growing size of cities and increasing population mobility has led to a surge in the number of vehicles on roads [1].

Traffic flow in heterogeneous conditions is highly complex and is difficult to predict the flow behavior on urban roads. Driver's comfort, convenience, traffic volume, lane width, grade type, geometric design, travel delay and safety are the major concerns on urban roads which are to be taken care [3]. LOS monitoring and traffic volume which represents quality transport has become indispensable. Traffic congestion and decreasing level of service has become major issues in most of the cities and results its impact on urban economy and its environment [2]. The route a vehicle takes through the network is dictated by a complex interaction between objectives of each vehicle and constraints imposed by the city on the roads. The objective of all vehicles movement with minimize of the time and without delay, it takes to travel from the source to the destination and it may re-route if the traffic conditions on their path deteriorate due to congestion [7]. An integrated city road network will enable faster, more comfortable and safer travel from source to destination [4].

In the concrete case of the research is included a part of urban road network of the F. Kosova. The layout of urban-local roads are in the form of a network, forming rectangular shapes of residential areas roads.

This urban area includes connecting roads "Dardania", "Hajrullah Zymi", "Shefki Kuleta", "Pajazit Islami", "Fehmi Lladrovci", "Tahir Zemaj", "Agron Rrahmani", and "Dedë Gjo Luli". There is no categorization of these roads, but from the function and the layout in blocks a categorization can be created, such as from geometrical dimensions, function of road (approach), and movement (figure.1.).

Geometric parameters of this part of the road, number of lines in available for movements, and approach of traffic in intersections result in not an appropriate LOS (level of service) and consequently, the quality of traffic operations is not acceptable (especially at peak hours). Also in terms of road safety [5], due to the high demands of motorization traffic and other traffic participants for access from the side parts, urban zone its characterized from unappropriated LOS.

The main local roads consist of two lanes, with two-directions of movement. There are sidewalks, which do not fulfill the needs of pedestrian movements, because in certain parts the width of sidewalks are less than the minimum required width. As result a number of car-pedestrian crash have been caused [5]. So the road safety in this urban zone is not in high level. The different mutual needs in local or urban areas and others impacts (vehicles parking needs, fulfilling of business requirements or commercial purposes), do that the urban mobility its unsustainable.

Fig.1. *Urban zone of Fushe Kosova*

Also in functional terms, traffic control intersections applied in some cases do not provide an acceptable level of service.

Road safety problems continue to be a concern for cyclists, without cycling lines and a lack of accommodation infrastructure to encourage people to use bicycles or other forms of active movement.

2. Methodology

For the purposes of the research, was used the automatic method of demand receiving for motorized traffic through cameras (figure 2), also is used the manual method and counting at characteristic points in the road network segments.

Data processing is realized by algorithm applying, which is preliminarily prepared in programming language "Python" [8]. By applying this algorithm, it is possible to count and categorize the traffic vehicles from video camera record, such as: car, van, minibus, bus, truck etc.

Fig.2. *Traffic volume count from video- camera*

For traffic quality indicators analysis, optimization, and derivation of the results of this research are used HCM mathematical model and software model "Synchro" which uses the same mathematical model (HCM 16 edition).

In the framework of traffic operation quality indicators, are analyzed some of important indicators such as: intersection capacity utilizes, v/s ratio, v/c ratio, progression factor, delay for vehicle, adjusted flow approach delay and approach LOS.
The obtained results then, are tested in the traffic simulation model built through the "Sim Traffic" software.

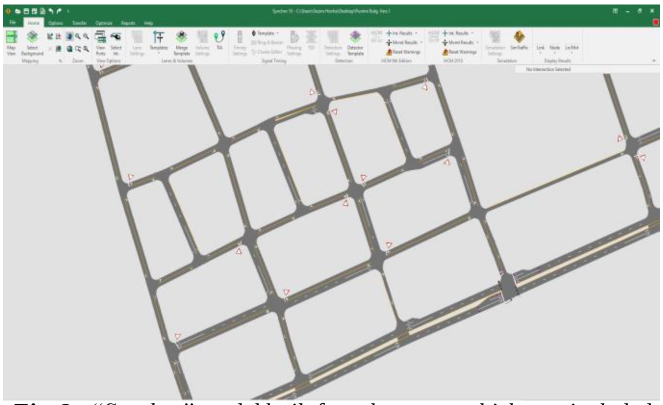


Fig. 3. *"Synchro" model built for urban zone which was included in research*

Within the road network of the urban area, have been selected the intersections with the main problems in the traffic operation, the biggest delays in the traffic and the poor quality of LOS (level of service), (fig. 4.).

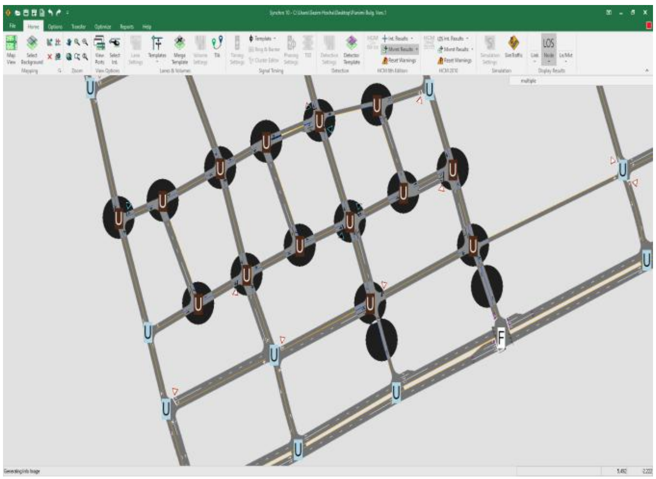


Fig.4. Selected intersections with the main problems in the traffic operation inside urban zone

3. Modeling, analysis, and optimization

By applying HCM mathematical model and Synchro model, has been analyzed: the quality of traffic operation inside the urban zone, especially at intersections, traffic problems, time delays, and general level of service. The left turns at intersections have been identified with greater delays and a very poor level of service. Even though according to the ICU calculation method, the capacities of some intersections have not been exceeded, in general in most intersections according to the HCM model, the level of service is unacceptable (in mainly intersections is F).

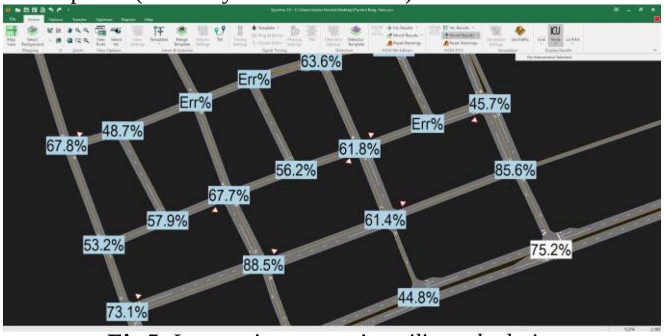


Fig.5. *Intersections capacity utilize calculation*

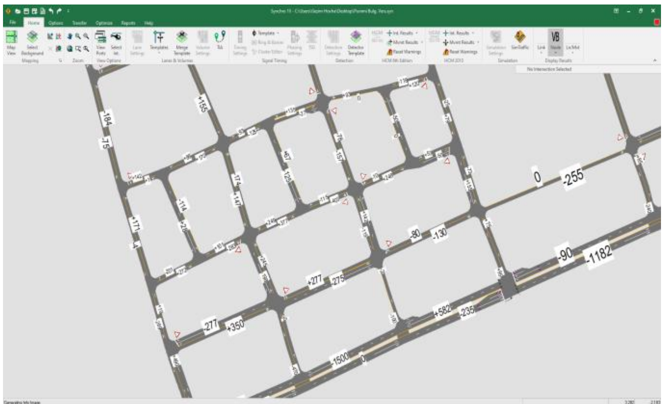
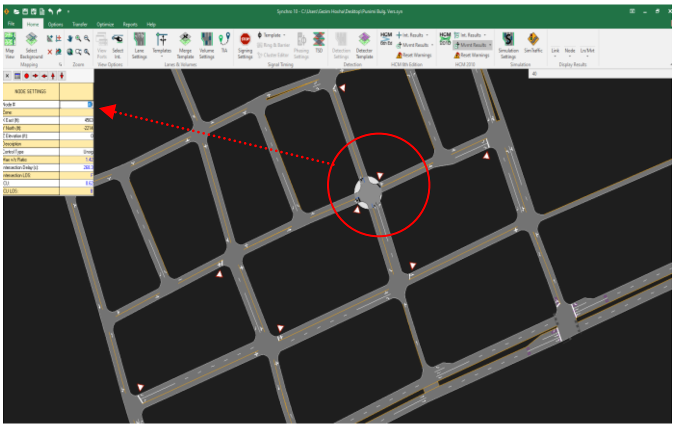


Fig.6. *Intersections volume/balancing*

The results about movements quality at the intersections with the biggest problems in the traffic operation (especially for left turns), are shown in the incorporated tables inside figure 7 as well as in table 1.



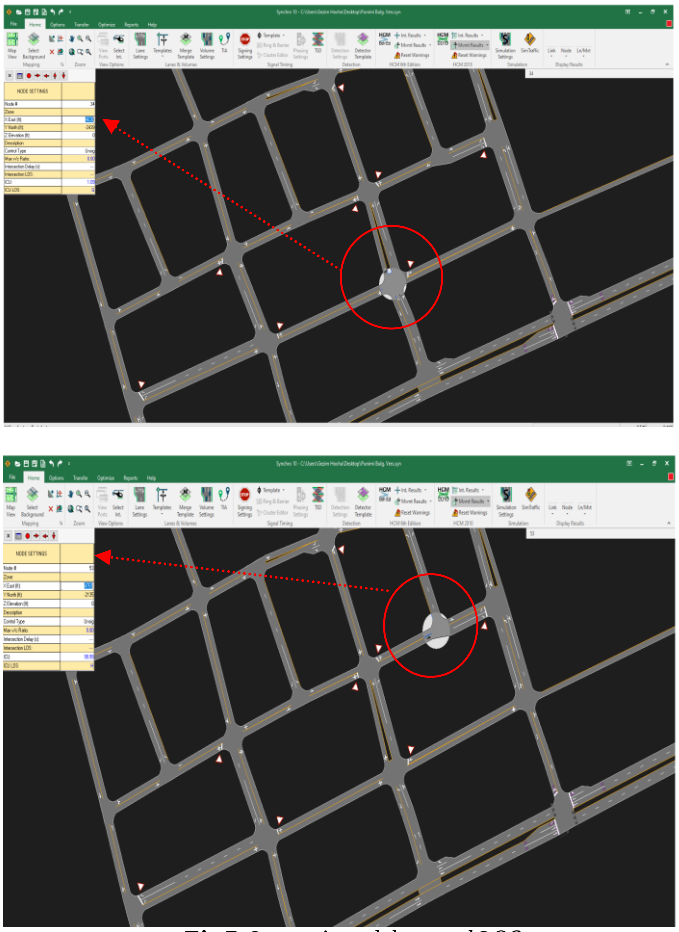


Fig.7. Interections delays and LOS

Results obtained for one intersection inside road network of urban zone analyzed, are shown in table.1.

***Table.1** HCM unsignalized intersection capacity analysis*

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	105	140	145	100	99	110	98	0	0	283	0
Future Volume (Veh/h)	0	105	140	145	100	99	110	98	0	0	283	0
Sign Control		Free			Free			Yield			Yield	
Grade		0%			0%			0%			0%	
Peak Hour 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
Hourly flow rate (vph)	0	105	140	145	100	99	110	98	0	0	283	0
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)												
pX, platoon unblocked												
vC, conflicting volume	199			245			756	664	175	664	684	150
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	199			245			756	664	175	664	684	150
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			89			0	71	100	100	14	100
cM capacity (veh/h)	1373			1321			83	339	868	268	330	897

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	245	344	208	283
Volume Left	0	145	110	0
Volume Right	140	99	0	0
cSH	1700	1321	129	330
Volume to Capacity	0.14	0.11	1.61	0.86
Queue Length 95th (ft)	0	9	1156	299
Control Delay (s)	0.0	4.0	1204.5	69.9
Lane LOS		A	F	F
Approach Delay (s)	0.0	4.0	1204.5	69.9
Approach LOS			F	F

After traffic situation analysis through the above models and assessing of loads condition and traffic flow in the road network of Fushe Kosova, and also considering the high demand for active non-motorized traffic, it is proposed traffic flow reorganize in some "Dardania" neighborhood roads. This reorganize include transforming two-directions street into one-direction street.

So some of the roads within the urban area have been transform into one-way streets in order to eliminate left turns in conflict with other morotized movements at intersections.

Referring to roads width inside the road network of "Dardania", through the transformation into a one-way road, it is possible to accommodate non-motorized movements such as pedestrians and bicycles, and also one part of these roads can be used for car longitudinal parking.

Through the reorganization of motorized traffic, respectively transformation of some roads into neighborhood "Dardania" in roads with one-way traffic and giving priority to certain directions (following the principle of eliminating as many left turns as possible at intersections), are improved some traffic parameters such as: indicators of traffic quality (LOS, intersections delay etc.), intersections capacity, providing acomoditation of active movements and, in general, is improved urban mobility inside this zone.

Based on the above recommendations for measures application, through which it is possible to eliminate some left turns at some critical points in intersections, through the "Synchro" model has been realized the optimization of traffic parameters and have been obtained results which are shown in figure 9 and table 2.

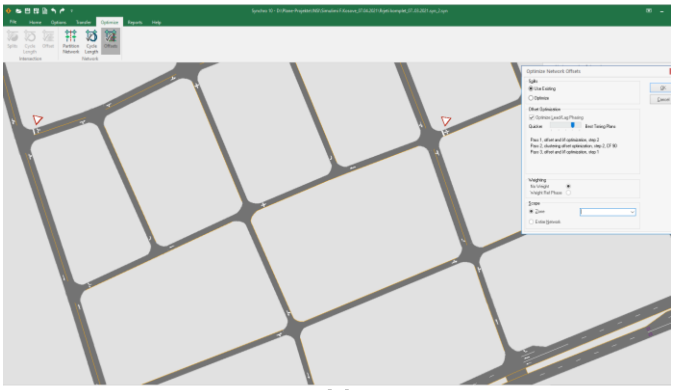
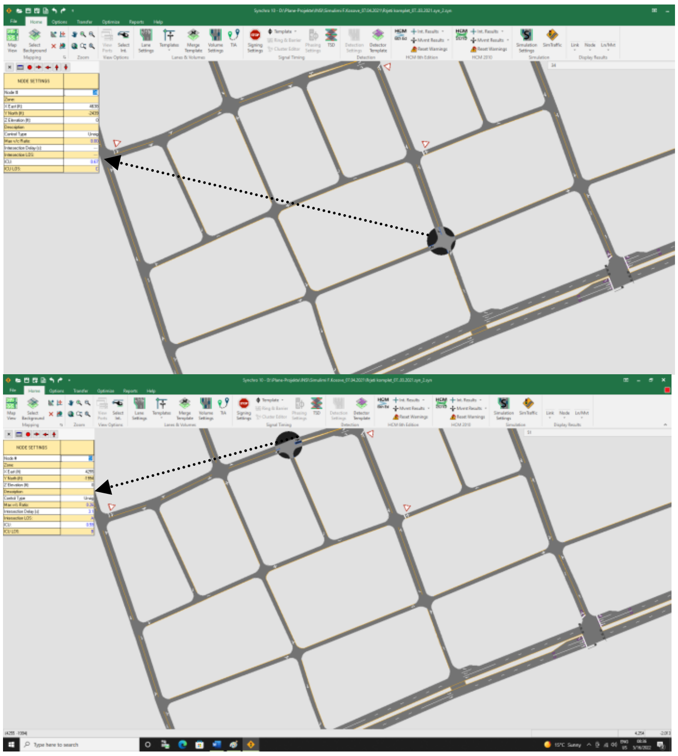


Fig.8. Model optomization



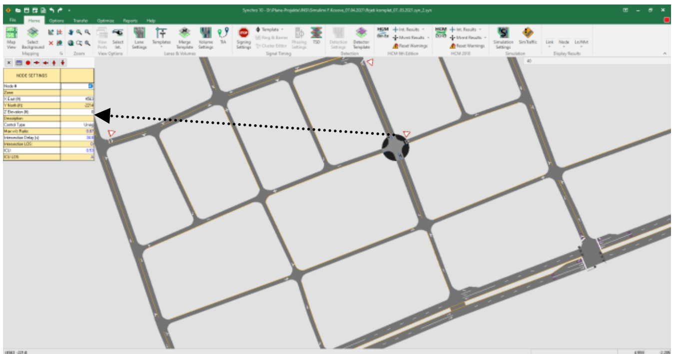


Fig.9. *Interections delays and LOS after traffic parameteres optimization*

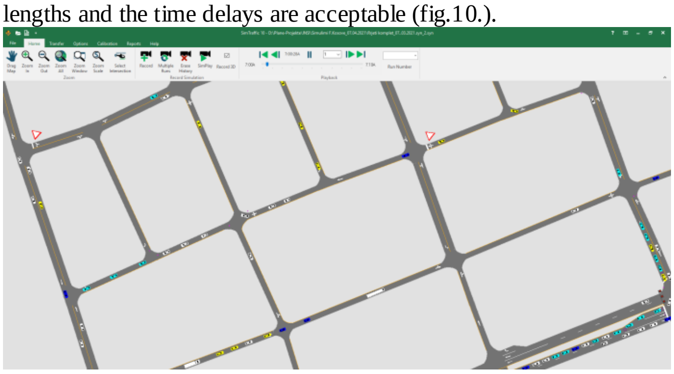
After the optimization model was applied through the traffic reorganization inside the road network in urban area, for the same intersection for which the results of movements quality corresponded to the level of service F, they have passed to the service levels E and B (result for one intersection, table 2).

Table.2 *HCM unsignalized intersection capacity analysis after traffic parameters optimaziton*

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SB
Lane Configurations												
Traffic Volume (veh/h)	0	250	50	0	0	0	0	75	110	250	0	28
Future Volume (Veh/h)	0	250	50	0	0	0	0	75	110	250	0	28
Sign Control		Free			Free			Yield			Yield	
Grade		0%			0%			0%			0%	
Peak Hour Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0
Hourly flow rate (vph)	0	250	50	0	0	0	0	75	110	250	0	28
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)					274							
pX, platoon unblocked												
vC, conflicting volume	0			300			533	250	250	398	300	[illegible]
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	0			300			533	250	250	398	300	[illegible]
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.
p0 queue free %	100			100			100	89	86	43	100	7
cM capacity (veh/h)	1623			1261			338	653	789	442	612	108

Direction, Lane #	EB 1	EB 2	NB 1	SB 1
Volume Total	250	50	185	533
Volume Left	0	0	0	250
Volume Right	0	50	110	283
cSH	1700	1700	727	644
Volume to Capacity	0.15	0.03	0.25	0.83
Queue Length 95th (ft)	0	0	25	296
Control Delay (s)	0.0	0.0	11.6	35.3
Lane LOS			B	E
Approach Delay (s)	0.0		11.6	35.3
Approach LOS			B	E

From the model testing through the simulation, it is also concluded that at the intersections entrance can not be seen vehicle rows lengths and the time delays are acceptable (fig.10.).



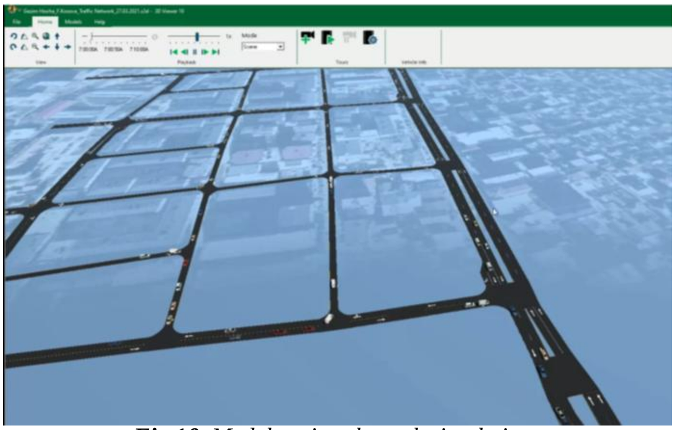


Fig.10. *Model testing through simulation*

Based on the obtained results related to traffic quality indicators, by traffic parameters optimizing and traffic reorganizing inside the area, transforming several two-way streets into one-way streets, eliminating left turns as much as possible, and dhe giving priority to certain directions at intersections: the improvement of the quality of traffic operation within this area has been achieved and, has increased possibility to accommodate non-motorized movements such as pedestrians and bicycles and, also for one part of these roads are increased possibilities for car longitudinal parking.

In line with these results, for responsible entities that manage with traffic problems in that area have been recommended to implement these measures in order to better manage traffic problems and increase the quality of urban life.

3. Conclusion

Referring to research results, we can conclude that through traffic parameters optimization and traffic reorganization of the inside urban zone, without the need for major infrastructural interventions, it is possible to improve the quality of motorized traffic and other movements within urban areas.

In concrete study case, by optimization model applaying, through the traffic reorganization inside the road network in the urban area, for the same intersection for which the results of movements quality corresponded to the level of service F, they have passed to the service levels E and B.

Based on the obtained results related to traffic quality indicators, by traffic parameters optimizing and traffic reorganizing inside the urban area, transforming several two-way streets into one-way streets, eliminating left turns as much as possible, and dhe giving priority to certain directions at intersections: the improvement of the quality of traffic operation within this area has been achieved and, has increased possibility to accommodate non-motorized movements such as pedestrians and bicycles and, also for one part of these roads are increased possibilities for car longitudinal parking.

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