ANALYSIS OF THE CAPACITY OF INTERSECTIONS ACCORDING TO CONTROL / SIGNALING

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Rezumat. *Modelele cu rol de simulare a traficului rutier au un rol esențial în modelarea fluxurilor reale, permiţând inginerului de trafic posibilitatea de a evalua situaţii complexe ce nu pot fi analizate prin alte mijloace directe. Modelele oferă capacitatea de a evalua strategii de control şi planificare a traficului la anumite ore şi pe anumite artere, fără a folosi resurse costisitoare şi consumatoare de timp necesare pentru implementarea strategiilor alternative din domeniul transporturilor.*

Abstract. *Traffic simulation models play a vital role in traffic flows by allowing the traffic engineer the ability to assess complex traffic situations that cannot be analyzed directly by other direct means. The models provide the capacity to evaluate the traffic control and planning strategies at certain times and on certain arteries without using costly and time-consuming resources to implement alternative strategies in the field of transportation.*

Keywords: PTV VISUM**,** congestion, traffic

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1. Introduction

The transport model is a set of geo-spatial databases and mathematical relationships that aim at the abstract representation of systems and transport demand. In the current study, the VISUM PTV transport planning software package was used. Transport models describe current levels of demand, replicate current movement patterns and define system capacities and thereby provide a detailed representation of a transport system for analysis and forecasting purposes [1], [2], [3].

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2. PTV Visum at a glance

PTV VISUM is an integrated software system, which integrates in a single model all types of, both individual (PrT= Privat Transport) and public (PuT= Public Transport).

The vast majority of the basic data provided by the information about the transport systems together with their planning, can be managed "consistently with VISUM and updated using a network editor. Unlike simple GIS systems, VISUM allows you to capture complex relationships across a single transport system or across multiple transport systems" [12]. Thus, an appropriate transport model can be created. PTV Visum is a "digital replica of mobility, land use and socio-demography for gaining a deeper insight in to the challenges of today and future what-if scenarios, connected data hub for fusion, analytics and embedded GIS, develop strategies for future mobility including shared mobility and MaaS, inform cost-benefit appraisal for new infrastructure, land use development, public transport operations, and shared mobility, perfect platform for generating microsimulation models via seamless linkage with PTV Vissim" [10].

Modeling consists in the theoretical, abstract representation of phenomena and processes that take place in the real environment.

The mathematical tools used in theoretical representation have different degrees of complexity, the most common in applications being equations, systems of equations, stochastic processes, algebraic structures, geometric structures, algorithms, etc. [4], [5], [6].

The phenomena and processes in the real environment subject to modeling are varied, they represent any system whose behavior can be observed (transport, physical system, financial, social, economic).

3. PTV Visum - Network Model

The network model differentiates between:the basic objects of the network, such as nodes, links, which illustrate the structure of the network; network objects that are only used for modeling the public transport network (PuT): general network objects that have no relevance to traffic.

Network Model:

- nodes: usually representations of street intersections;

- connections (arches): with characteristics such as speed, capacity, etc.

- turns: characterizes the permission, respectively the penalty of turns for private transport, respectively points and end areas for public transport;

- areas: origin and destination of the transport request.

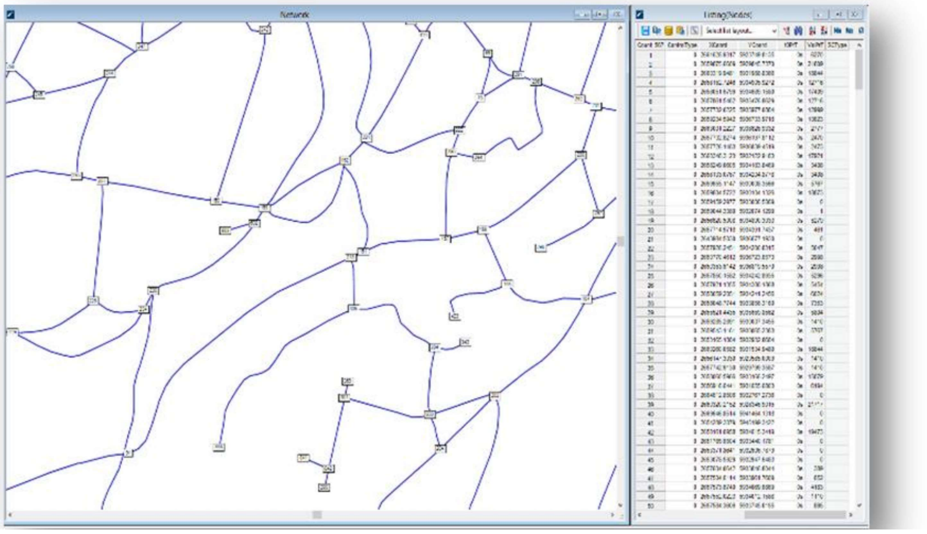

Fig. 1. Network nodes

4. **PTV Visum - Types of Transport Systems**

Visum uses the following traffic types:

1. PrT – demand and simulation of individual transportation.

This includes, for example:• Cars • Trucks • Trailer trains • Special vehicles • Motorcycles • Mopeds • Motor scooters • Bikes • Pedestrian

2. PuT – demand and simulation of public transport.

This includes, for example: •PuT commuter, PuT traveler, PuT business journeys •Means of transport: bus, tram, train, ship, plane, taxi, …

5. Results in PTV Visum

VISUM displays the results in both graphical and tabular form and allows the graphical representation of the results.

In VISUM, different impact models are offered for the analysis and evaluation of transport systems and resources. These are:

1. The user model, which simulates the driving behavior of drivers (PrT case) and public transport passengers (PuT case).It calculates traffic volumes and service indicators, such as travel time and number of transfers (transhipments).

2. Operator model, which determines the operational indicators of the public transport service, such as service mileage, vehicle mileage, number of vehicles or operating costs.

3. An environmental impact model, which provides several ways to determine the environmental impacts of transport.

For example, you can display and analyze: routes, O-D, type connections, traffic flows per each transport systems,isocrones,node flows.

Indicators are calculated as index matrices (index matrices):travel time, number of transfers (transfers), frequency of service & others [7], [8], [9].

6. The procedure of assignment with ICA in PTV Visum

When Assignment with ICA in Visum is the chosen assignment method, it is necessary to model junctions in detail.

Usually, the network includes a significant number of junctions on the main road network that are typically responsible for the overall delays of vehicle journeys. The control type as well as the geometry of these junctions must be modelled in detail so that the Intersection Capacity Analysis (ICA) can be used to determine capacity and delays for these junctions. (In the following, these nodes are referred to as nodes calculated by ICA.)

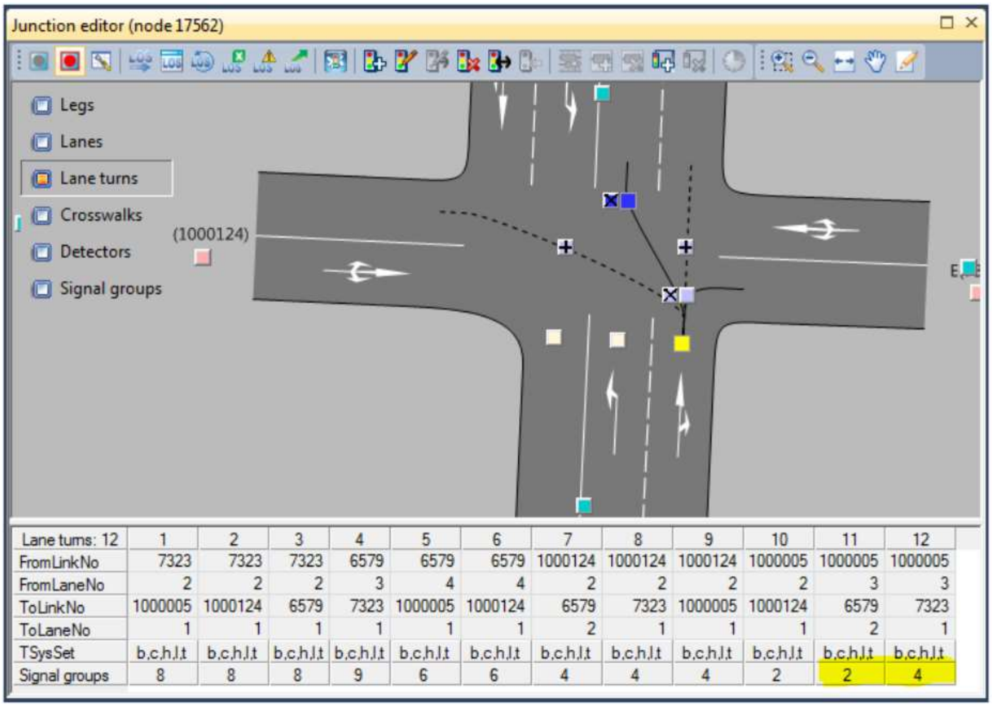

Fig.2. Assignment with ICA

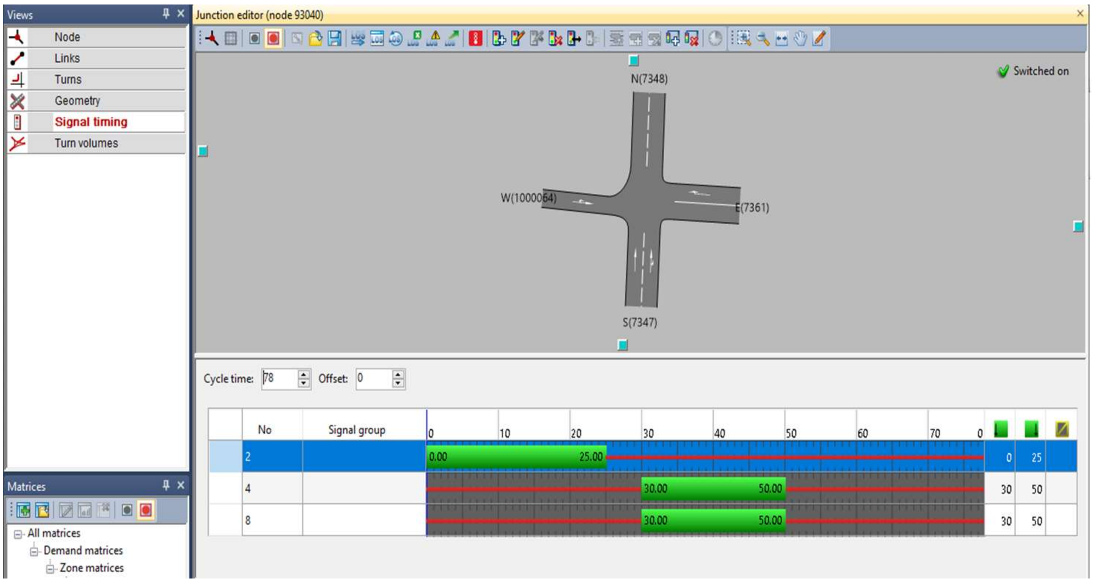

Fig.3. Example of signal timing for signalised junction

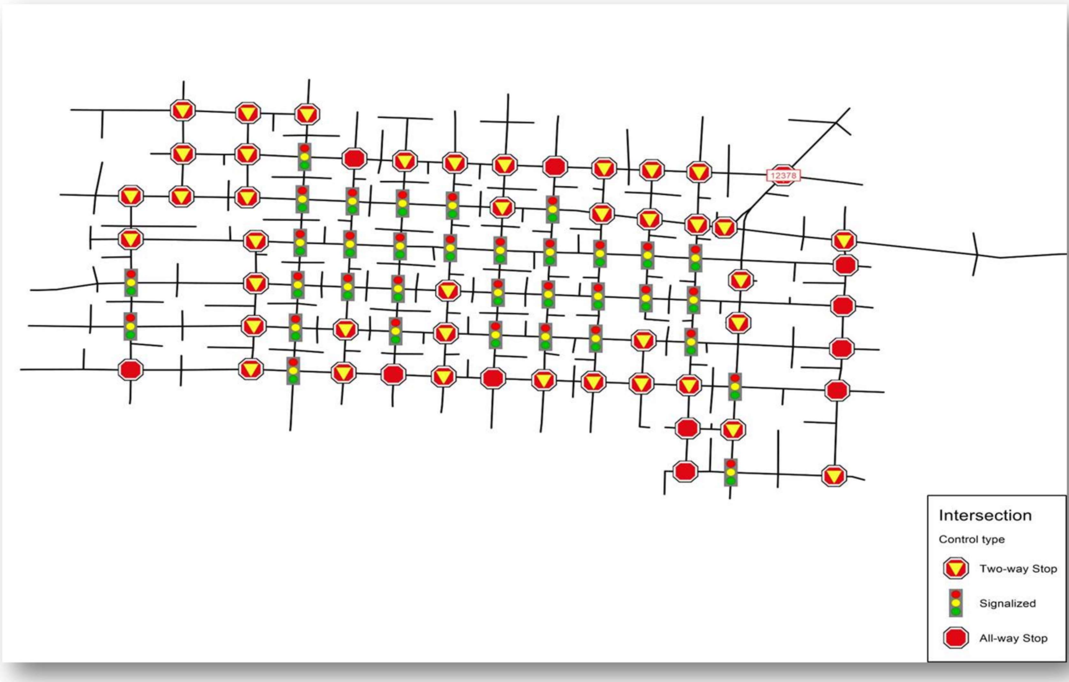

Fig.4. Examples of intersection control type

7. ICA - Standards for nodes capacities

Nodes capacities were calculated according to HCM 2000 standards

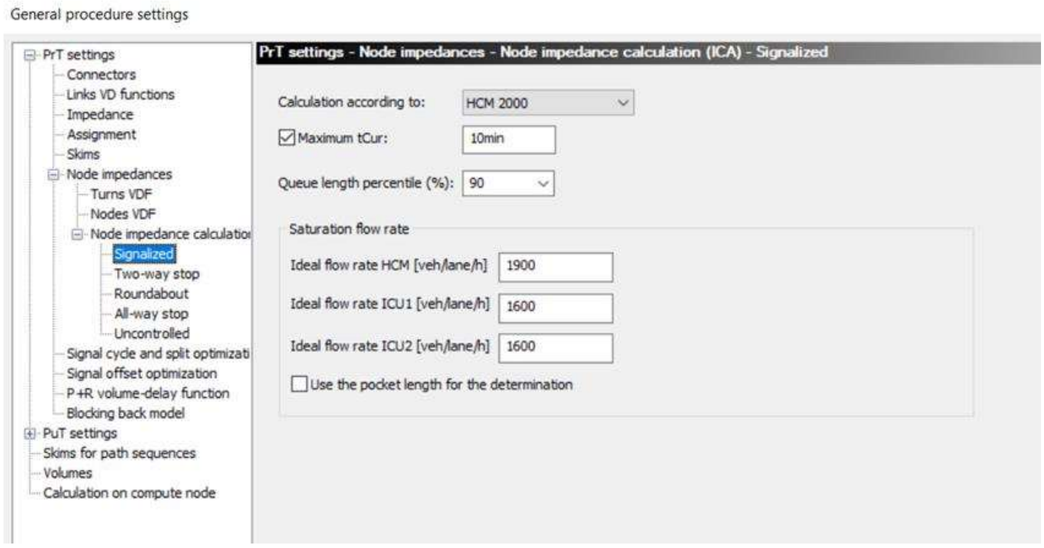

Fig.5. Standards for nodes capacities

8. Level of Service

The service level is a quantitative estimate of the operational conditions of traffic expressed in traffic speed, duration of travel, comfort and safety of traffic. In practice, 6 service levels marked with letters A to F are used [11].

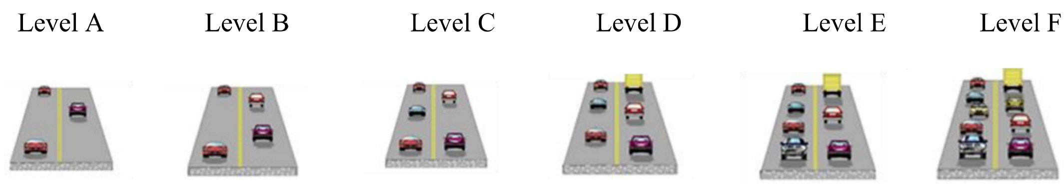

Fig.6. Level of service

Level of service A describes very low delay operation, less than 10 seconds per vehicle. This happens when the progression is extremely favorable and most vehicles arrive on the green phase. Most vehicles do not stop at all. Short cycles can also contribute to a short delay.

Table 1. Level of service.

Characteristic elements	Level of service					
	A	B	C	D	E	F
Conditions to ensure the flow of traffic	Free flow	Stable flow	Stable flow	Flow close to instability	Unstable flow	Forced flow
Service charges	Small 420	Average 750	High 1200	Large with considerable fluctuations 1800	Capacity 2800	Below capacity
Speeds corresponding to the maximum service flows	High	Large but on certain sectors with traffic restrictions	Average speeds with many traffic restrictions	Medium speeds with high fluctuations	Low	Very low
Freedom of maneuver for drivers	Complete	Almost full	Partially restricted traffic	Small limited traffic	Almost zero	Zero
Comfort of travel	Very good	Good	Medium	Sufficient	Insufficient	Traffic congestion

Level of service B describes delays in the range of 10 to 20 seconds per vehicle. This generally occurs in good progression and / or short cycles. They stop more vehicles than in case A producing higher levels of average delay.

Level of service C describes delays in the range of 20.1 to 35 seconds per vehicle. These longer delays may result from poor progression and / or longer cycles. At this level, cycle disturbances may begin to occur. The number of vehicles waiting to stop is significant at this level, although there are still many non-stop crossings.

Level of service D describes operation with delays in the range of 35.1 to 55 seconds. At level D, the influence of congestion becomes much more visible. Longer delays can result from a combination of unfavorable progression, longer cycle times, or longer v / c ratios. Many vehicles stop and the proportion of non-stop vehicles decreases. The failure of individual cycles reaches a level to be taken into account.

Level of service E describes delayed operations in the range of 55.1 to 80.0 seconds. This is considered to be the acceptable delay limit. These high values generally indicate a slow progression, long cycle times, and high saturation values. Individual cycle failures occur frequently.

Level of service F describes delayed operation exceeding 80.0 seconds per vehicle, which is considered unacceptable for most drivers. This condition occurs when supersaturation occurs when incoming flows exceed the capacity of the intersection. Saturation degrees above 1.00 can also occur with many failures of individual cycles. Poor progression and long cycle times can make a major contribution to delays at this level.

9. Level of Service –case study

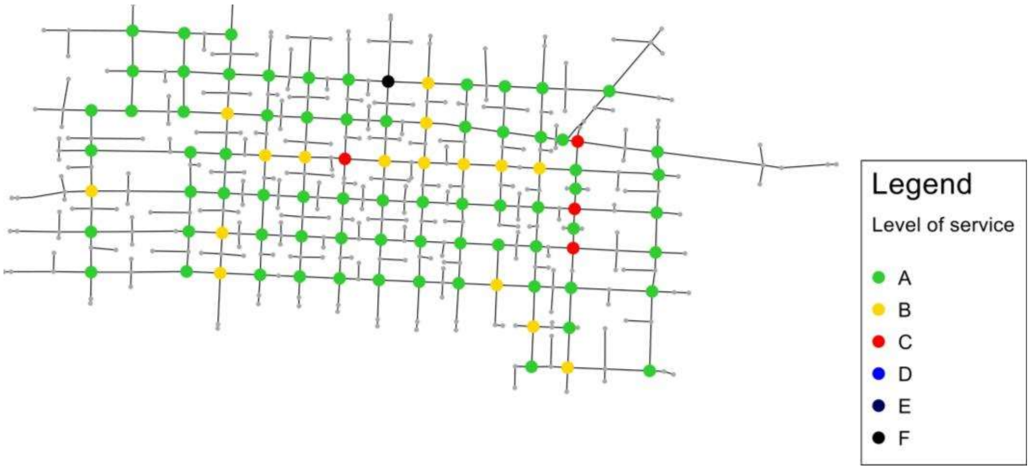

Fig.7. Level of service in a network

Analysis of a current state network analyzed in VISUM with the service level for each intersection.

Table 2. Results of Intersection Capacity Analysis (selection)

Number	Name	Control Type	Avg Delay	Avg LOS	Max Delay
10202	Main_SE12th	TWSC	2,30	A	34,93
10203	Main_10th	Signalized	31,00	C	50,76
12329	Baseline_1st	Signalized	7,63	A	12,64
12330	Oak_1st	Signalized	11,88	B	16,99
12331	Baseline_Dennis	Signalized	10,81	B	20,45
12332	Oak_Dennis	Signalized	9,35	A	28,03
12333	Baseline_5th	Signalized	6,31	A	15,25
12334	Oak_5th	Signalized	5,51	A	17,05
12335	Oak_4th	TWSC	0,33	A	37,27
12336	Baseline_6th	Signalized	5,45	A	16,55
12337	Baseline_9th	Signalized	6,85	A	19,75
12338	Baseline_10th	Signalized	23,68	C	35,32
12339	Baseline_SE12th	AWSC	7,81	A	8,05
12340	Oak_10th	Signalized	27,37	C	78,01
12341	Oak_9th	Signalized	3,82	A	12,94
12342	Oak_6th	Signalized	4,61	A	13,42
12343	Baseline_4th	TWSC	0,33	A	51,64
12344	Maple_10th	Signalized	10,02	B	36,35
12345	Maple_9th	AWSC	7,90	A	7,93
12349	Jackson_1st	TWSC	0,65	A	23,21

Level of Service comparison

Comparison for LOS after changing the control/green times for the intersections with with critical level of service.

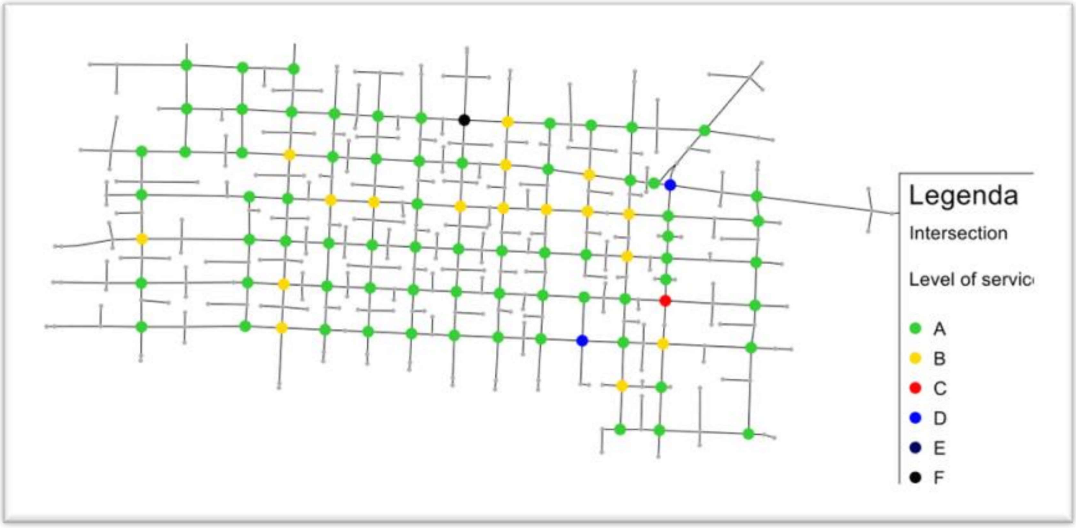

Fig. 8. Level of service in a network (after)

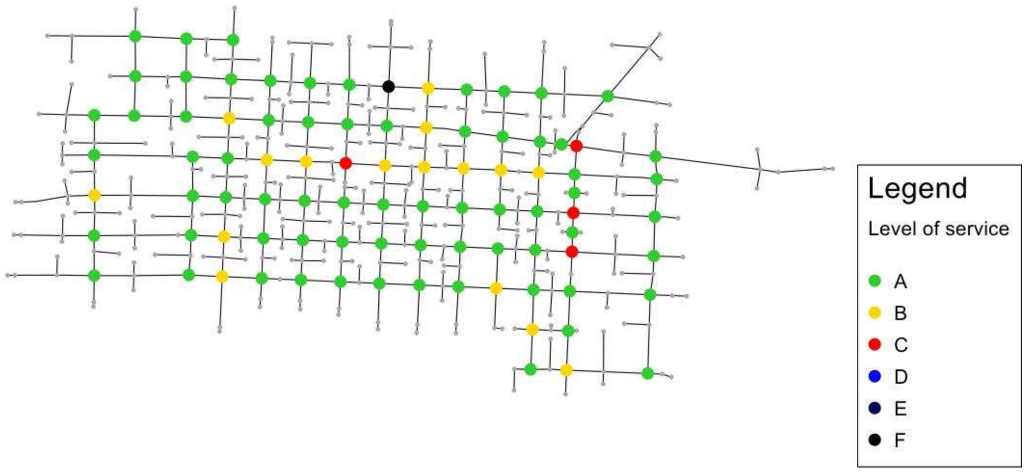

Fig .9. Level of service in a network (before)

Table 3. ICA Results Comparison

Number	Control Type	Avg Delay	Avg LOS	Max Delay	Max LOS	Control Type	Avg Delay
10202	TWSC	2,30	A	34,93	D	TWSC	1,27
10203	Signalized	31,00	C	50,76	D	Signalized	35,41
12329	Signalized	7,63	A	12,64	B	Signalized	7,10
12330	Signalized	11,88	B	16,99	B	Signalized	12,06
12331	Signalized	10,81	B	20,45	C	Signalized	10,14
12332	Signalized	9,35	A	28,03	C	Signalized	7,29
12333	Signalized	6,31	A	15,25	B	Signalized	5,67
12334	Signalized	5,51	A	17,05	B	Signalized	4,85
12335	TWSC	0,33	A	37,27	E	TWSC	0,12
12336	Signalized	5,45	A	16,55	B	Signalized	5,21
12337	Signalized	6,85	A	19,75	B	Signalized	11,24
12338	Signalized	23,68	C	35,32	D	TWSC	5,47
12339	AWSC	7,81	A	8,05	A	AWSC	7,25
12340	Signalized	27,37	C	78,01	E	Signalized	25,19
12341	Signalized	3,82	A	12,94	B	Signalized	4,78
12342	Signalized	4,61	A	13,42	B	Signalized	4,27
12343	TWSC	0,33	A	51,64	F	TWSC	0,79
12344	Signalized	10,02	B	36,35	D	Signalized	9,74
12345	AWSC	7,90	A	7,93	A	AWSC	8,23
12349	TWSC	0,65	A	23,21	C	TWSC	0,67
12350	TWSC	2,43	A	13,18	B	TWSC	2,45
12374	Signalized	1,51	A	24,39	C	Signalized	1,50
12375	TWSC	3,80	A	11,80	B	TWSC	3,66
12376	TWSC	81,72	F	254,56	F	TWSC	59,30
12377	AWSC	10,99	B	12,59	B	AWSC	13,47
12378	TWSC	2,29	A	102,01	F	TWSC	1,84
12380	Signalized	11,00	B	11,66	B	Signalized	11,30
12381	TWSC	3,84	A	32,78	D	TWSC	3,08
12382	TWSC	6,65	A	15,60	C	TWSC	5,86
12383	Signalized	2,13	A	24,63	C	Signalized	2,00

It is observed the change of the type of control from the signalized intersection to the intersection with stop in two directions.

Conclusions

The traffic modeling software is based on a detailed description of the studied elements (intersections, groups of intersections) performing the analysis from the point of view of their capacity and to face the traffic.

The problem of traffic congestion in large urban areas is quite critical, and the use of these software in traffic management, traffic organization and development of transport strategies plays a particularly important role in reducing road congestion.

For a more detailed analysis, Vissim is also used to study in more detail microsimulation and to reflect reality: aggression of drivers, number of lanes, a better optimization of green times etc.

Notations and/or **Abbreviations**

PrT - Privat Transport
PuT - Public Transport
GIS - Geographic Information System
O-D - Origin – Destination
ICA - Intersection Capacity Analysis
LOS - Level of Service

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