

## IMPROVEMENT OF URBAN ROAD TRAFFIC IN CRAIOVA CITY BY USING GIS DATA PROCESSING

**Avram Sorin, Curcan Gheorghe, Vladut Alina, Marinescu Ioan**

**Abstract:**

*As Romania became a member of the European Union and bank credits more accessible to numerous citizens, the number of vehicles registered a remarkable increase. However, local development of the road and parking infrastructure did not register the same ascendant tendency, and, consequently, cities, including Craiova, presently confronts with numerous traffic problems.*

*The Geographic Information System allows the interpretation of statistical data referring to the values registered by urban road traffic on different time intervals (daily, seasonally, and multi-annually) through the achievement of thematic layers that may suggestively render the intervals and perimeters where traffic jams frequently occur. It also allows the estimation of the movement speed of the auto vehicles on different road portions and the impact traffic lights or roundabouts have upon the speed distances are covered, which may eventually lead us to a better management of an integrated system of the urban road traffic. By applying the index of the probability of traffic jam occurrence, one may give some recommendations with regard to the necessity of one way roads and/or traffic lights and roundabouts, also integrating the variables offered by alternative means of transport (public transportation, bicycle tracks).*

*According to the analysis achieved in GIS, the sustainability capacity of the road traffic in Craiova city is overtaken in terms of road infrastructure quality and quantity, lack of cycling tracks, insufficiency of parking places, and inadequate offer of public transportation. Besides the initial analysis, the utilization of GIS also allows the coordination and optimization of urban road traffic and of the way the inhabitants of the city and experts in territorial planning perceive it.*

**Key words:** urban road traffic, GIS, means of transport, potential of traffic jam

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### INTRODUCTION

Located on the left of the Jiu River, Craiova city displays a configuration of the urban network that is mainly imposed by local topography and secondly by the rigidity of the former network that do not allow accessible town interventions. Having a population of about 300,000 inhabitants and another 40,000 inhabitants within the rural-urban perimeter, Craiova city faces obvious problems related to traffic jams, lack of parking places, environment quality deficiencies due to pollution.

The channeling of the road traffic, mostly on some main streets developed from East to West (Calea București – Calea Severinului) and from North to South (on the roads towards Tg. Jiu and Bechet), made the planners of the road network have as objectives to take over part of the traffic and direct it towards the city ring roads. For a good period of time, the city northern inner ring represented an alternative for crossing the city from the East to West, namely Dacia Boulevard that took over part of the transit traffic (facing obvious problems related to the asphalt cover, which required frequent maintenance works, to noise pollution, and to PM 10 and PM 2.5 particles) and also helped the dispersion of the traffic generated by the SE industrial platform and Ford factory. Presently, the city is crossed by the European Corridor No. 4 – E 70, which links the capital of the country, Bucharest eastwards and Timișoara westwards. It is made up of three sectors. The first one is Calea București Boulevard, developed between T.F. Lăpuș Passage and

km 0, which has a length of 3.5 km and a width that varies between 7 and 10 m per roadway, two lanes and tram railway per way separated by a median green area. The second sector is N. Titulescu Boulevard located between km 0 and the crossroad Str. Maria Tănase with Calea Severinului. It is a main traffic road with two lanes and tram railway per way separated by a median green area. It has a length of 2.5 km and a width of 7 m per lane. The third sector is Calea Severinului Boulevard, which continues N. Titulescu Boulevard and together form what is known as Calea Severinului; it has two lanes and a tram railway per way. Its length is of 3.98 km and the width 7.5-8 m per lane.

Starting with 2007, when the northern ring road became functional, heavy transit road traffic was mostly deviated from the city, but we consider it quite inefficient as it is not linked with the industrial platforms located in the southern or south-eastern part of the city and there is no inner or external ring road in that area. Of course, the two aforementioned factors (topography and rigidity of the urban network) subsequently had numerous consequences through the presence of the Jiu River and its floodplain, as well as through the poor quality of the road located on the right of the river.

The cover of the urban road infrastructure of Craiova is represented by 50 percent asphalt, mainly on the roads located in the center and in its immediate proximity and on the recently modernized streets; concrete holds 30 percent and it was used within northern residential areas (Craiovița Nouă, Brazda lui Novac, Rovine and in the south, in the area located on the left of Popoveni road); square stone represents 15 percent of the material covering the urban roads and it is mainly used within the areas influenced by active geomorphologic processes, namely by the deformation of the topographical surface induced by water excess in the Jiu Floodplain or by the slope of the scarps of the terraces; 5 percent of the road surface is covered by ballast, especially in the areas with a poorer development of human activities or in the recently built-up districts.

Of the total length of the urban road network of 261.39 km (2010), 26 km represent the main road structure with boulevards, parts of the European and national roads, generally with two lanes per way; 73.66 km are second category roads as they take over the traffic coming from the main roads and establish the link with the residential perimeters or other functional zones of the city. The third category roads do not exceed 7 to 11 m width having only one lane per way. This category holds 161.13 km of the total road length.

## **DATA AND METHODS**

In order to gather the data referring to the traffic volume and specific time intervals, our team worked for a week (without legal or any other kind of holidays) in each month of 2008. There were 48 traffic survey spots placed along the first category roads (entirely monitored) and on second category roads (partially monitored). The one way roads, the give way or stop signs, the crossroads with traffic lights (total monitoring of 15 crossroads), as well as the roundabouts – recommended by the European directives have also been studied in order to correct the data taken into account. In order to study the travel behaviour within the urban perimeter, there has been taken into account the distribution of the city functional zones, which means the localization of residential spaces – industrial platforms – multi-shopping areas and the locations with administrative-educative functions.

The digitization and geocoding of the road infrastructure was achieved based on topographical plans at a scale of 1:5,000 and the utilization of the orthophotoplans at the same scale. In order to synthesize the data, we have chosen two time intervals representative for an increased traffic volume, namely 8.00 – 9.00 a.m. and 3.00 – 4.00 p.m. because the number of vehicles in motion is the highest during the day, as people usually go from the residential areas towards their working place and vice versa. An example of the quantification of the traffic volume is rendered in Table no. 1 for the crossroads with traffic lights, where the interval of red colour lasts for 99 seconds. This method allows the calculation of the traffic volume for the above-mentioned time intervals. For the first category roads, we used human monitoring, as well as monitoring and road traffic quantification cameras placed in different areas during the selected weeks and time intervals.

After gathering the data referring to the traffic volume and the digitization of the road network, we have loaded the data with attribute value and calculated the traffic blocking potential (Den Boer, Emilia, den Boer, J., Jager, J. 2005), using the formula for optimizing the waste collecting service. However, we have modified the parameters referring to the collecting fractions with a null value, the number of stops along a route being calculated after applying some questionnaires for the individuation of the travelling behaviour, and the number of collecting vehicles with the total number of auto vehicles registered by the fees and taxes directorate of Craiova Municipality.

Table no 1 Data regarding the traffic volume the crossroads with traffic lights

TIME INTERVAL	STREETS			
	Calea Severinului <i>No. of cars / 99 sec</i>	Calea Bucuresti <i>No. of cars / 99 sec</i>	Carol Boulevard <i>No. of cars / 99 sec</i>	Aries <i>No. of cars / 99 sec</i>
07 a.m. – 10 a.m.	27	30	15	22
10 a.m. – 2 p.m.	32	42	29	38
2 p.m. – 6 p.m.	30	40	29	32
6 p.m. – 10 p.m.	33	42	20	27
10 p.m. – 7 a.m.	12	14	9	10

Source: Negreanu S., Avram S., Boengiu S., 2008

$$TrBP = \frac{\sum_{sec\ torj=1, wfi=1}^{m,k} PiTT_{j,i} \times NuCY_{j,i}}{NuIn}$$

- TrBP* - traffic blocking potential (h/inh./year)
- j* - city sector
- m* - number of city sectors
- wfi* - separately collected waste fraction (*wf*), e.g. packaging waste, bio-waste etc.
- k* - number of fractions collected separately
- PiTT<sub>j,i</sub>* - the average pick-up time per trip (per sector *j* and waste fraction *i*) in hours (h)
- NuCY<sub>j,i</sub>* - the number of collection vehicle trips per year (per sector *j* and the waste fraction *i*) (no)
- NuIn* - number of inhabitants of the city (inh.)

The travelling behaviour inside the urban perimeter was estimated on the base of the traffic volume and questionnaires applied to drivers, directly by means of multiannual evaluation achieved by the statistical bureau of the municipality and by intersecting the statistical data referring to the people’s present dwelling place, their working place, as well as through demographic analysis (age, sex, religious structure).

Using the values gathered in 2005, it results that the values corresponding to the East-West axis, for the time interval 3 p.m.-4 p.m. are as it follows (Fig. 1): 1,156 cars along the first segment (entrance); on the next segment, at the contact with the inner ring road of the city the volume reaches 1,297 cars, but it decreases in the next interval and remains constant, around 1,000 cars, crossing the aforementioned sector. The highest values is registered on the segment corresponding to the crossroads with Stefan cel Mare – Calea Unirii Streets (North-South axis), namely 2,155 auto vehicles. The values for the last segment of the axis seem quite strange as they are registered in the districts with the highest demographic density in the city.

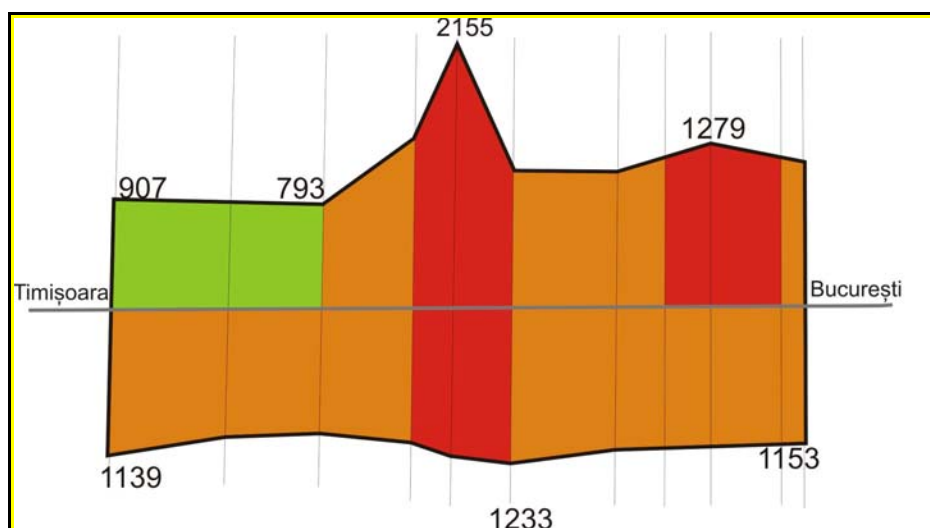


Fig.1 Nomogram of road traffic on the axis East-West of Craiova city

For 2010, the traffic values along the aforementioned axis increase and become more and more significant, being directly correlated with the economic development. Even if the city registered a demographical decrease, the number of the inhabitants dwelling in the settlements located within the urban-rural fringe got higher and higher. Thus, the values registered in this year are: at the city entrance, the traffic value reaches 1,352 vehicles – it increased with about 200 cars when it takes over the traffic coming from the inner ring of the city (Decebal Boulevard); along the next interval, it decreases to about 1,200 vehicles that cross this segment in an hour, then exponentially increasing at the crossroads with the North-South axis to 2,521 cars; then, the traffic volume registers a decrease to 907 vehicles as this axis crosses certain residential districts, and at its exit, we counted 1,061 vehicles/hour.

Presently, the improvement of urban traffic has to take into account all its possible effects, both in terms of benefits and negative elements. If positive elements mainly refer to the economic ones, which are both public and personal, of each individual, the negative ones regard environment quality. Thus, the first impact road traffic exert upon environment refers to noise. In order to analyse this variable and to elaborate the map rendering the noise generated by road traffic (Fig. 2), there have been used the following data series:

- road traffic data;
- railway traffic data;
- meteorological data;
- data about the type of roof and external surface coverage of the city buildings;
- demographical distribution of the population;
- data regarding the distribution of industrial areas.

The noise generated by road traffic was calculated according to the French national method of calculation ‘NMPB Routes-96 (SETRA-CERTU-LCPC-CSTB)’, mentioned in the Government Decision dated May 5, 1995 referring to noise produced by traffic on road infrastructure, the Official Gazette dated May 10, 1995, Article 6, and in the French standard ‘XPS 31-133’. For the values that should be used, these documents make reference to the ‘Guide for the noise produced by terrestrial transportation, annex noise level forecast, CETUR 1980’.

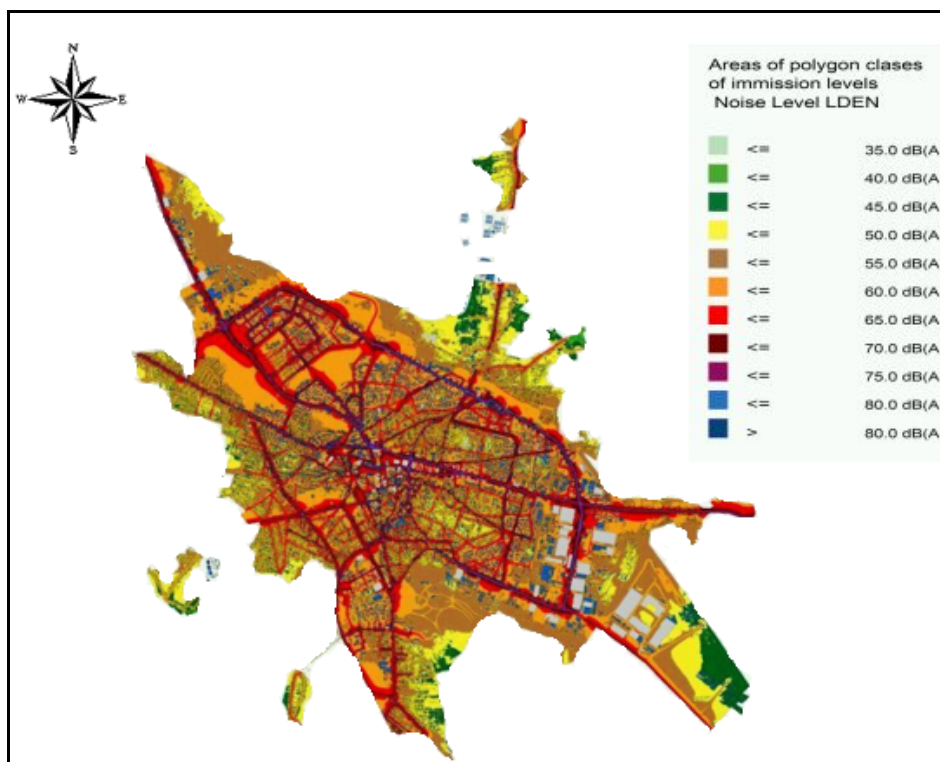


Fig. 2 Road traffic noise map of Craiova city (Source: Craiova Mayoralty)

## RESULTS AND DISCUSIONS

The thematic maps were achieved with the help of data processing system in GIS, which supposes the overlapping of different cartographic products resulted from the interpretation of the graphic/spatial support with the data with attribute value (Fig. 3) – maps rendering the road infrastructure, spatial distribution of the inhabitants on residential districts (Fig. 4), the features of the lithological and pedological background, and the one way roads or the

roads where road traffic is forbidden. This overlapping allows the location of the problematic spots of the traffic system and the search of possible solutions.

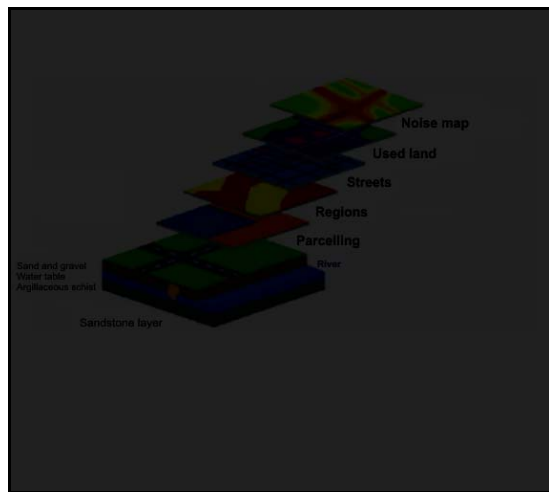


Fig. 3 Overlapping of thematic layers in GIS (source Enviro Consult)

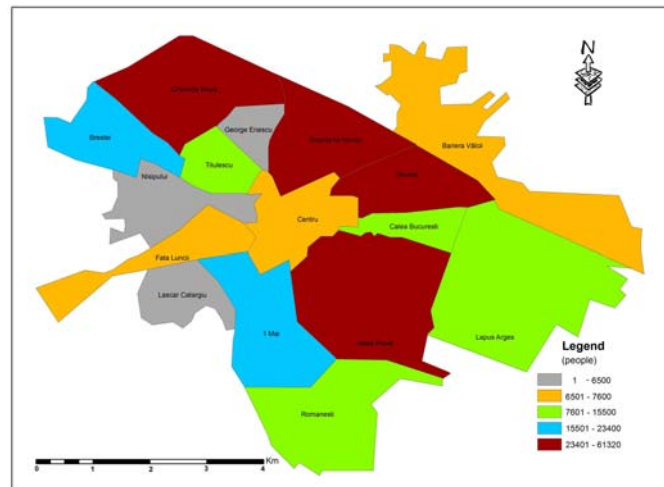


Fig. 4 Demographic density of Craiova city

The digitization of the urban road network and the introduction of the traffic values in a database for ArcGis 9.3 soft allow an analysis for finding the best route available for waste transportation by coordinating the vehicles equipped with a GPS navigation system (Fig. 5). This would eventually lead to the reduction of the traffic blocking index, as well as of the fuel consumption with direct impact on environment quality.

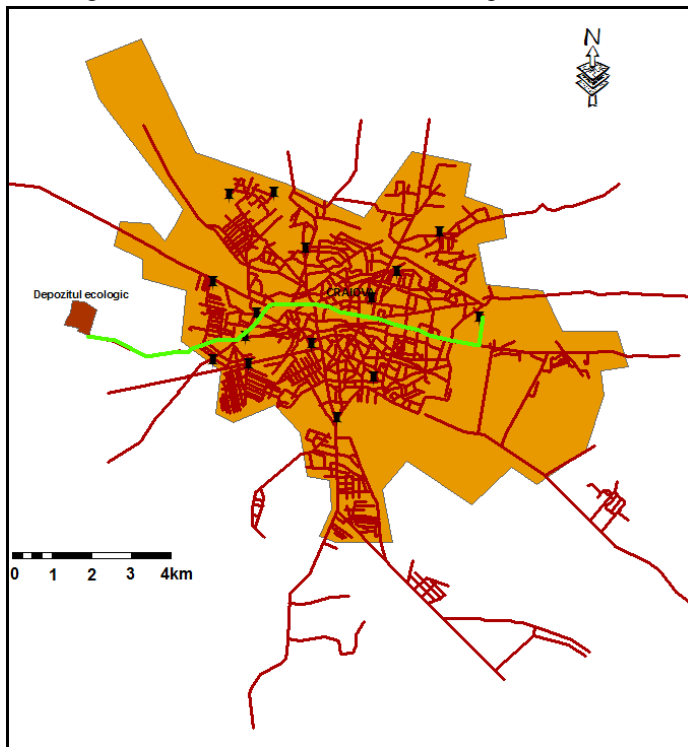


Fig. 5 Optimization of waste transportation (the green line indicating the optimum route) (Source Negreanu S., Avram S., Boengiu S., 2008)

The traffic blocking potential calculated according to the above mentioned formula displays high values corresponding to the traffic peak hours (Table no. 2), starting with 7.00 a.m. till 6 p.m., namely 0.018 or even 0.019, which is a quite increased value. Local authorities cannot handle this situation, the travelling behaviour of the inhabitants being induced by the need of travelling on directions that are not covered by common means of transport or where they are insufficient or badly equipped for winter and summer, which means an increased discomfort for the travellers. This index calculated for each main road allows a better coordination of the urban road system and the temporization of the traffic lights, as well as a better penetration of the vehicles along these roads.

The quantification of the traffic volume allowed us to get aware of the number of vehicles along different roads, which enabled us to notice and study the reality of the traffic blocking potential. Thus, one may notice that the number of vehicles reaches a value of 80 per kilometer along Calea București, Calea Severinului, between 8.00 a.m. and 9 a.m. and between 3 p.m. and 4 p.m. in the proximity of the centre. However, the same value characterizes the roads coming into direct contact with the two aforementioned boulevards, near the centre, which is a direct result of the bad management of the crossroads, either with traffic lights or not. High values, oscillating between 30 and 80 vehicles per kilometer are registered all along the way towards Bucharest, as well as along the northern inner ring road of the city. It clearly results that, presently, the major roads cannot take over the traffic volume at the peak hours.

Table no 2

Table no 2 The traffic blocking index in Lăpuș Argeș district

TIME INTERVAL	TRAFFIC BLOCKING POTENTIAL
	Lapus Arges district
7 a.m. – 10 a.m.	0.018
10 a.m. – 2 p.m.	0.019
2 p.m. – 6 p.m.	0.017
6 p.m. – 10 p.m.	0.011
10 p.m. – 7 a.m.	0.009

(Source: Negreanu S., Avram S., Boengiu S., 2008)

The forecast for 2015 is rendered by the nomogram of the main roads for Craiova city and it indicates a traffic volume of 400 vehicles in the centre of the city for the peak hours. Thus, the inadvertences between private and common transportation systems and the lack of parking places will practically block the city. Starting with 2000 until 2015, we expect the number of vehicles to reach the value 800 for the segment represented by Calea București Road, in the immediate proximity of the centre, where there is also an acute lack of parking places. As for the entrance from Bucharest, the increase is of 400 vehicles, while for the exist towards Timișoara, we forecast a value of 300 units, which means that, at least partially, the increase of the traffic volume for this axis is induced by the external input and this problem can be easily solved if the southern ring road of the city would be built.

The travel behaviour determined in the present study took into account the variables of the urban transport system (Aud T., 2010) (private cars, public transport, bicycling, walking), travel features (modal split, travel length, travel frequency) and land use characteristic to the city surface (true density and location). The result of correlation is rendered by the traffic volume on different time intervals and then interpreted by means of the vehicles number per kilometer of road infrastructure. Thus, the Road traffic map (Fig. 6) renders the intensely crossed roads and the traffic volumes characteristic to the peak intervals. Thus, the highest values correspond to segment located between the city entrance (Calea București) and the crossroads from the city centre; relatively high values can be noticed also along the road that intersects Calea București and takes over the traffic coming from the south of the city. Generally, high traffic values are also registered in the eastern part of the city, as here, beside the vehicles coming from Bucharest, there are also numerous cars that arrive or leave the industrial platforms. Starting from km 0, the traffic volume gradually diminishes westwards.

The dysfunctional zones that come out from GIS analysis reveal a series of problems that may be synthesized in the following negative aspects about the urban road system of Craiova city:

- traffic lights insufficiently adapted to the necessities of the traffic
- reduced traffic take-over capacity
- reduced safety at the crossing through the crossroads
- unequal distribution of the fluxes of vehicle
- reduced car speed
- too much waiting time at the giving way and stop signs
- intense traffic generating jams
- multiple relations at the crossroads without traffic lights
- lack of the southern external ring
- insufficient lane surface along the important roads, namely the first and second category roads

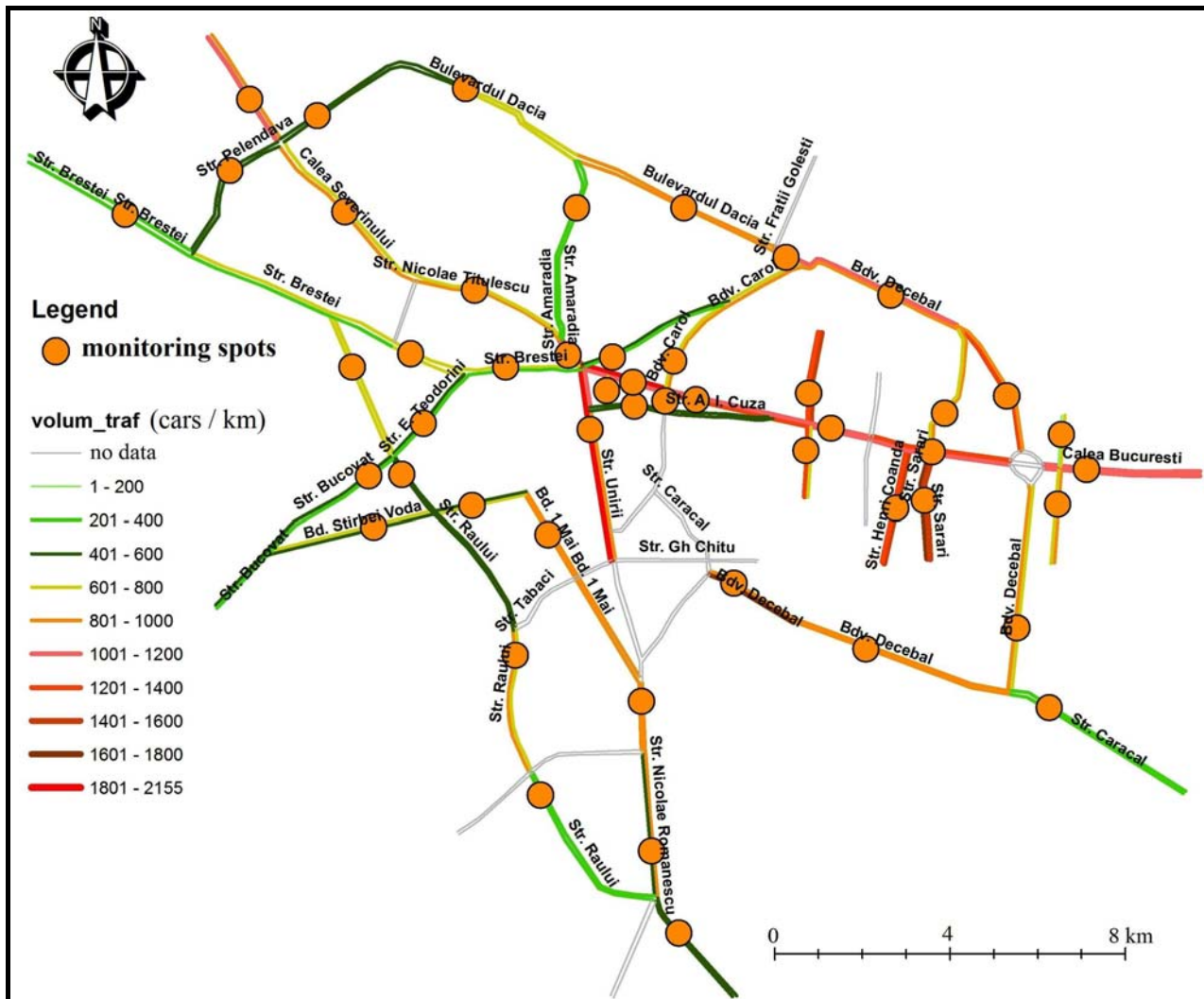


Fig.6 Traffic volume representative for the city between 3 p.m. and 4 p.m.

## CONCLUSIONS

Generally, GIS data processing should not be considered only a method used in urban planning, as it is not sufficient to build wider roads or to decongest the crossroads etc., but it has to be taken into account as an instrument able to modify the administrative politics regarding land-use for the relocation of the urban poles (shops, industrial platforms, administrative centres) in the areas with low road traffic values on the base of cost/benefit analysis.

The dysfunctions of the urban road traffic signaled in the integrated plan for urban development refer to the following aspects:

- Lack of coherence of the first and second category road system that do not allow a judicious organization of the traffic. This aspect appears especially in the central part of the city, where its crossing on a North-South direction is extremely difficult as it follows a sinuous route with certain third category sectors with two lanes, maximum 8-9 m wide;
- The presence of certain geometrical elements of the streets that display improper dimensions that significantly reduce traffic speed between two sections;
- The presence of unfitted crossroads without traffic lights, which make traffic even more difficult;
- The lack of parking places necessary for all urban activities. Thus, if in the new residential districts the number of parking places partially satisfies the population's needs, in the central part of the municipality and in the older districts they are clearly insufficient, citizens parking on the kerb of the pavement. This parking mode certainly leads to an important reduction of the traffic capacity if we take into account the reduced transversal profiles of the streets;
- The insufficient maintenance works of the road cover;
- The presence of certain lanes for heavy traffic, which are also extremely busy, within the residential areas;

- The presence of certain crossroads of the streets with the railway at the same level, which lead to major interruptions of the traffic;
- The presence of certain large crossroads where traffic jams frequently occur;
- The lack of a central inner ring road able to take over the external traffic and efficiently distribute it at the level of the central area;
- The lack of a ring road for transit traffic in the southern part of the municipality, this function being presently hold by the street following the main sewer of the city; due to its dimension (second category) it cannot take over the flux, which means numerous traffic jams and a severe pollution of the residential area;
- Another issue is represented by the considerable age of the water and gas supply system, which leads to frequent interventions that deteriorate the road cover. Problems are hard to solve and road traffic is drastically perturbed by these activities.

In this context, the analysis of the phenomenon by means of data interpretation in GIS system is significant as it integrates the data rendering the spatial distribution of the urban traffic with the qualitative and quantitative data, which are important for the modification of the traffic parameters in order to individualize the urban travel behaviour, as well as the causes triggering the present situation.

The integrated management of the urban road traffic supposes the integration of all spatial-geographical and statistical information for a better coordination and capitalization of the city road infrastructure potential. The integration of all the described parameters enables us to identify the problem areas that require rapid solutions for diminishing the traffic blocking potential and allows us to better control the traffic volumes by coordinating the crossroads with traffic lights and by deviating public transport routes from the so-called hot spots. The benefits are even greater as on the background of sustainable development, the elements of urban traffic are essential for the quality of the inhabitants' living environment, and here we mention, the analysis of noise values, discharged polluting substances, and particles in suspension (PM10 and PM 2.5).

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