Study on reduction of the fuel consumption and the pollution by using traffic management systems in urban areas

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Abstract. The traffic management systems are implemented on a large scale during the last decades in urban areas due to their feature to optimize the traffic capacity, in a simultaneous and real time, not only at the individual junctions but also the entire city level. This is achieved through the short term predictions, using the traffic data bases collected by the specific sensors from the traffic controlled crossroads or from other places into the city street network, data that’s used on-line in order to optimize the traffic lights cycles onto all the controlled crossroads. In this way it is accomplished a optimal capacity for a certain traffic volume over a period of time. Using this method good results are obtained considering the reduction of the fuel consumption and of the pollution level. Another result is the increasing of the average speed of vehicles and the decreasing waiting times on the crossroads, which is beneficial for both cars and public transport. The case study for the Pitesti city highlights these aspects and shows how the urban transport model could be used for quantifying the effects of implementing the traffic management systems. The paperwork summary regarding the public transportation is attached.

1. Introduction
Chemical pollution caused by road traffic is an important problem faced by the administrations of most of today's modern cities. At the same time, the increasing costs of fuel used by motor vehicles as well as the high fuel consumption of motor vehicles traveling in cities due to reduced travel speeds, partial engine operating regimes and traffic jams require measures to be taken to alleviate these problems. Such a measure is the adoption by local administrations of the Integrated Traffic Management Systems.

The present paper refers precisely to such an action, based on the results obtained in the implementation of the traffic survey for the implementation of the Integrated Traffic Management System in Pitesti city, which aims to identify the effects of its achievement on traffic performance. Thus, the specific objectives of the traffic survey are the quantification of the effects of the project implementation: the reduction of the travel time and the reduction of the pollutants caused by the movement of the vehicles.

2. City transport model
In order to develop and calibrate the transport model, it was necessary to define the base year. This is the year 2017 for which the data on the transport system was collected. The collected data refers to the following categories of information:
- the transport areas and the socio-economic data of each area;
- the road and street network including detailed representation of all junctions;
- survey on mobility patterns: household surveys, traffic counts, passenger counting, roadside interviews, travel time surveys;
- the public transport system network, with the stations and characteristics of the public passenger transport service.

The zoning system were defined so that the main daily patterns of inter-urban migration can be correctly captured and modelled.

The model-specific transport area is an important element in representing the mobility demand, as the travels are generated and attracted by the functions specific to each area. Thus, the zoning system is an integrated planning element, while at the same time making the intrinsic link between urban characteristics and mobility.

A requirement for a transport model to be as close as possible to reality is to take into account a large number of areas and the areas to be considered must be correlated with the existing socio-economic data and for the purpose for which it is developed the model.

The starting point in the zoning of the transport model was the delimitation of the polling stations for the organization and conduct of the 2016 elections, being further detailed in relation to their functional, socio-economic and demographic characteristics.

The study area consists of 169 zones, 145 of which cover the city of Pitesti and 24 of its territory of influence. In the case of large commercial or industrial centers, specific areas within the transport model have been considered, due to their specificity, which leads to the attraction of important flows of people and goods.

In the Figure 1 is shown the population density for Pitesti municipality according to the areas of the transport model.

**Figure 1.** Density of the population on the areas established in the Transport Model.
The socio-economic data for each area provides the following information:
- population (by age, occupation, level of income, whether or not the car is owned);
- jobs by type of activity;
- education (educational establishments, students and pupils at their respective educational establishments);
- the level of revenue and availability of a car;
- economic activities (industry, services, commerce, tourism, agriculture).

An analysis of the road network and intersections within the city has been performed to define the road network attributes of the transport model, including:
- the number of bands in circulation;
- speed limit or average speed,
- road / street with single or double sense;
- lanes dedicated to public transport or priority lanes,
- car parking;
- road signs;
- road markings;
- types of intersections and configuration / sewer / signaling times.

The public transport network was defined according to local and external transport services. The public passenger transport system has been defined for each route and includes all public transport stations and terminals. The route timetable is embedded in the transport model as well as the tariff system for each public transport mode.

![Figure 2. Public passenger transport routes within the Pitesti city.](image)

For the recalibration of the urban transport model, the new data from the traffic review activity at 14 main intersections in Pitesti Municipality were taken into account, in addition to traffic data reviewed in 2017 within the Sustainable Urban Mobility Plan of the Pitesti city (40 intersections reviewed during 8 hours per day). With these data, the recalibration of the transport model for the base year 2018 was performed.
3. Results and discussions
At this stage, the implementation of the Integrated Traffic Management System was considered, considering the intersections that are currently being trafficked, as well as the new intersections that are recommended to be traffic lights, with 38 intersections and pedestrian crossings being considered.

Two of the optimized results obtained for the base year 2018 by simulating the system implementation are shown in Figures 3 and 4.

The forecast for the 2030-time horizon was carried out based on the future developing trends on land use, future car ownership and future committed developments of the transport system.

The 2030 vehicle fleet composition has been considered the same as in the base year, in order to estimate as accurate as possible the effect of the implementation of the traffic management system. If other exogenous inputs would be considered in the scenario, then the effects would be based on the combined actions of each measure and it would be difficult afterwards to extract the effects of one specific measure.

![Figure 3. Vehicle traffic / hour at morning peak hour.](image1)

![Figure 4. Volume / capacity ratio and service level at intersections at the morning peak hour.](image2)
From the analysis of the results obtained at the level of travel time for all O-D (origin – destination) relations it is found that, in the case of the implementation of the Integrated Traffic Management System for Pitesti city, the total travel time and the route of the vehicles, in the scenario with and without the implementation of the system, for the level base year 2018 and for the projected year 2030, are as shown in Table 1.

**Table 1. Results obtained by simulations.**

|                      | Base year 2018 | Forecast for 2030 |
|----------------------|---------------|-------------------|
| **Morning peak hour**|               |                   |
| Current situation /  |               |                   |
| with no Integrated   |               |                   |
| Traffic Management   | 10650         | 16062             |
| System, 2018, morning| 198743        | 240799            |
| Situation with       |               |                   |
| Integrated Traffic   |               |                   |
| Management System,   | 10563         | 15619             |
| 2018, morning        | 198790        | 240878            |
| Time gain, morning   | 87            | 443               |
| **Afternoon peak hour**|            |                   |
| Current situation /  |               |                   |
| with no Integrated   |               |                   |
| Traffic Management   | 11599         | 17244             |
| System, 2018, afterno| 232944        | 271523            |
| Situation with       |               |                   |
| Integrated Traffic   | 11054         | 16463             |
| Management System,   | 233020        | 270916            |
| 2018, afternoon      | 545           |                   |
| Time gain, afternoon | 545           |                   |
| **Time gain in the morning and afternoon, in daily veh-hour** | **632** | **1.225** |

It is noted that the main benefit, which is to reduce the travel time, is for both peak hours estimated at 632 daily veh-hours in 2018 and 1,225 daily veh-hours in 2030.
Simulation of pollutant chemical emissions by vehicles was carried out in the situation of the two scenarios: with and without the implementation of the Integrated Traffic Management System (ITMS). Table 2 presents the impact of the implementation of the Integrated Traffic Management System on the pollutant emissions in 2030, in tons per year.

Table 2. The results obtained for the reduction of pollutant emissions of cars in urban traffic.

|                      | NOx     | FC     | CO2    | SO2    | VOC   |
|----------------------|---------|--------|--------|--------|-------|
| **Morning peak hour, 2030** |         |        |        |        |       |
| Without ITMS implementation | 212.544 | 11136.330 | 35450.766 | 0.891  | 1.463 |
| With ITMS            | 214.175 | 11045.075 | 35160.271 | 0.884  | 1.486 |
| **Reduction of pollutant emissions** | **-1.631** | **91.255** | **290.495** | **0.007** | **-0.022** |
| **Afternoon peak hour, 2030** |         |        |        |        |       |
| Without ITMS implementation | 221.826 | 12622.197 | 40180.792 | 1.010  | 1.702 |
| With ITMS            | 222.582 | 11659.958 | 37117.653 | 0.933  | 1.712 |
| **Reduction of pollutant emissions** | **-0.755** | **962.239** | **3063.139** | **0.077** | **-0.011** |
| **TOTAL morning and afternoon** | **-2.386** | **1053.494** | **3353.633** | **0.084** | **-0.033** |

From the above, the positive impact on emission reductions, especially for GHG (CO$_2$), for which an emission reduction of 3,353 tonnes per year is estimated, is observed.

4. Conclusions
The following main results of the implementation of the Traffic Management System on the total travel time and emissions of GHG can be outlined:

➢ For time horizon 2030 the total time spent if traffic by private car is decreasing with 3.68% in terms of vehicle-hours, while the total travelled distance remains almost the same, thus overall leading to less emissions from private car;

➢ Emissions of GHG are decreasing with 4.43% in year 2030.

   Beside the above, the reliability of public transport it is also increasing due to the optimisation of traffic control.

As a general conclusion, the implementation of the Integrated Traffic Management System within the Pitesti city will have beneficial effects in the medium and long term, contributing to development of a sustainable urban transport system and of a clean and attractive urban environment

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