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Quantification of Benefits for Interactive Traffic Management

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Abstract

Currently, the growth of the cities presents some critical factors that affect the daily urban mobility, such as: the car density with respect to the surface of the city; the urban structure that prevents radical viability transformation; the tourism flow (although usually concentrated in specific periods of the year); the daily commuters' flows from the suburb to downtown and vice versa, and so forth. Thus there is an environmental and societal need to deliver a next generation transport management in order to widely manage the information about why, how, when and where people plan to travel and goods need to get transported and utilise it such that traffic predictions and routing options offered by the Traffic Management Centres (TMC) and Mobility Service Providers (MSP) respectively, can be optimised through real time cooperation in order to meet the objectives of sustainability (reduced energy use and lower CO2 emissions), cost efficiency and reduced congestion.

The Traffic Management 2.0 (TM2.0) platform, that builds on these ideas the concept of "interactive traffic management", aims to provide the environment for its actual deployment by addressing business models, deployment steps, public-private cooperation concepts, organisational architecture and data exchange principles.

Nevertheless, for achieving success it is fundamental to involve all categories of stakeholders in the process. In order to raise a major interest of Public Authorities, this work aims in defining a methodology for the Quantification of Benefits of TM2.0 and to further apply this to a specific case study (Thessaloniki).

Keywords:

TM2.0, Interactive Traffic Management, Connected Vehicle

1. Introduction

Due to the growth of the urban areas and connected mobility issues, cities begin to outline clear targets across the three pillars of sustainability (environment, quality of life and welfare) (1). There are some initiatives as the Covenant of Mayors, an agreement signed by 3.721 cities for augmenting the energy efficiency and the exploitation of renewable energy sources to address the objective of the 20% CO2 reduction within 2020. In the same line the European Commission has delivered the SET-Plan that establishes an energy technology policy for Europe and other initiatives affect transports, environment and social aspects.

Thus, there is an environmental and societal need to deliver a next generation transport management in order to widely manage the information about why, how, when and where people plan to travel and goods need to get transported to travel and utilise it such that traffic predictions and routing options offered by the TMCs and MSPs respectively, can be optimised through real time cooperation in order to meet the objectives of sustainability (reduced energy use and lower CO2 emissions), cost efficiency and reduced congestion.

The concept of TM2.0 (2), object of this paper, builds upon the deployment of connected vehicles and travellers in order to achieve convergence of mobility services and traffic management, combining actions of the individual travellers with the collective mobility objectives. This way, TM2.0 connects the innovative developments in the vehicle and on the road while improving the value to the legacy systems and, at the same time, creating new business opportunities.

The TM2.0 ERTICO Platform was originated in 2011 by TomTom and SWARCO Mizar; now regroups more than 20 members from all ITS sectors focussing on new solutions for advanced active traffic management. It aims to agree on common interfaces to facilitate the exchange of data and information from the road vehicles and the TMC, and back, improving the total value chain for consistent management and traffic services as well as avoiding conflicting guidance information on the road and in the vehicles (3).

The overall objective of TM2.0 is to provide a discussion forum around the topic of interactive traffic management for all relevant stakeholders, in the entire Traffic Management Procedure value chain.

In order to increase the interest and involvement of Public Authorities, there was a need to identify the benefits generated by the TM2.0 deployment. This paper aims to describe the methodology for the Quantification of Benefits for TM2.0 and its application in the city of Thessaloniki.

2. Benefits of TM2.0

Based on the main concept of TM2.0 platform, which is the exchange of data and information between MSP and TMC there are three major categories of benefits that can be identified:

1. Economic Benefits:

The exchange, between MSP and TMC, of data derived from installed equipment can ultimately lead to a reduction in equipment needed for monitoring the transport infrastructure especially from the side of TMC. This is related to the public investment costs for purchase, maintenance and use of the on-site equipment.

2. Benefits for MSP and the users of their services

   The provision to the MSP of the management plans that a TMC is about to implement in the near future (in return for the provision of real time data from the side of MSP to the TMC) based on the real time traffic conditions in an area can enable the MSP to create and provide more accurate and up-to-date services to their users. The MSP will be able to meet the needs of their users in an optimal way based on the fact that the MSP is not only aware of the real time conditions of the network but the management plans that are going to be implemented in the near future.

3. Benefits for all the drivers

   Since the TMC will be aware of the real time situation of the road network not only through data gathered by their static sensors but also through Floating Car Data (FCD) of the various fleets of MSP, there should be a better selection (and maybe definition) of the Traffic Management Plans and related measures. In this sense there should be a better coverage of the road network and the respective Traffic Management Plans would lead to an optimized management of the road network and therefore to a better traffic assignment and to minimisation of delays for the users.

3. Methodology

In order to quantify the aforementioned benefits a methodological framework has been developed. The main focus of this study is to identify a detailed methodology that can be applicable for any case where a TM2.0 scheme is implemented. Therefore a general framework is proposed below which is tested through a case study in order to be evaluated and validated.

The proposed methodology for the assessment of the impacts (i.e. traffic and environmental) of interactive traffic management encompasses the use of microscopic traffic simulation. Interactive traffic management presumes the utilization of real-time traffic information (i.e. floating car data etc.) from traffic management operators for the optimization of the network performance. Thus, a dynamic (i.e. traffic assignment will be performed iteratively at specific time intervals based on the prevailing traffic conditions during the simulation time-line) microsimulation model has been developed for the evaluation of the effects of different traffic regulation schemes. For example, updated traffic signal plans could be set based on the estimation of the actual traffic conditions that the traffic management operator will have conducted through the utilization of real-time traffic information. Or, other traffic management measures (i.e. reversed lanes, lane closures, forced turns etc.) could be also deployed. Due to the dynamic nature of the microsimulation model the improved network state that will have emanated from the imposed traffic measures can be estimated, since new vehicles are going to be

assigned to new routes based on the new traffic operations.
The microscopic traffic simulation is expected to effectively quantify the second and third category of benefits while for the first there is no need for simulation or modelling tools. In this case, the quantification could be done through economic assessment methods such as cost-benefit analysis and multi-criteria analysis. However these methods are out of the scope of this study and therefore the first category of benefits will be not be included in the followings.

4. Dynamic traffic microsimulation modelling

Microscopic traffic simulators imitate the longitudinal and lateral movement of individual vehicles as they occur in real-life. Their ability to dictate these movements is based on a set of sub-models which replicate driver's car-following, lane changing and gap acceptance behavior. Thus, the simulators estimate each vehicle's position, speed and acceleration for every simulation step.

Traffic conditions in a simulated environment are continuously and accurately monitored. Therefore, it is feasible to utilize past traffic states for the estimation of future traffic assignments in specific time intervals. The developed microsimulation model in Aimsun (4) is going to be dynamic in nature (5), thus capable of adjusting the traffic operations according to traffic patterns that have stemmed from the implementation of traffic management measures. For example, the estimation of optimal traffic signal plans or the closure of road sections is going to alter the operation of the network, potentially modifying the attractiveness of the available routes in the network. The microsimulation model is going to capture the changes that will be imposed by the new traffic signal operation or management scheme and subsequently assign traffic accordingly in order to optimize the network performance. It is expected thus, that the new network state is going to be predicted by the model according the implemented management plan.

Moreover, the estimated trajectories of the vehicles are utilized for the estimation of fuel consumption and emissions by the corresponding models that are integrated with the microscopic traffic simulation models. Thus, the environmental benefits of TM2.0 are also going to be assessed. A microscopic emission model has been integrated with Aimsun (6). The importance of using microscopic emission models for the assessment of the environmental impacts of traffic management and control policies has been stresses explicitly, since this is a complex issue that requires detailed analysis of not only their impact on average speed but also on other aspects of vehicle operation such as acceleration and deceleration (7).

5. Case Study description

<u>Thessaloniki, GREECE</u>
Thessaloniki is the second largest city in Greece behind the capital, Athens. It has a population of

about 1 million citizens and acts as the social, financial and commercial centre not only for Northern Greece but for the greater Balkan region as well. There are three TMC for the road network of the metropolitan area of Thessaloniki. All of them are hosted by the Region of Central Macedonia and they differ from each other based on the area of their operation (one for the peripheral highway of the city, one for the traffic lights management of the whole urban area and one for the management of the traffic within the central business district of the city).

With respect to traffic data collection there are various systems operating in the road network. There are static loop detectors that count traffic volumes throughout the road network of the city. Moreover, there is a network of more than 40 Bluetooth detectors tracking trips along the main routes of the city. Finally FCD from a fleet of 1200 taxis are available to provide real time traffic status of the road network. The loop detectors are operated by the Region of Central Macedonia while the Bluetooth detectors network collection data and the FCD are available for the Hellenic Institute of Transport of the Centre for Research and Technology Hellas (CERTH-HIT) to utilize them for providing Advanced Traveller Information Services through its suites of platforms and services.

CERTH-HIT has also developed a detailed and extensive traffic model for the urban area of Thessaloniki in order to use it for the various services that provides to end users but most importantly for research purposes. The whole road network of the metropolitan area has been developed in a macroscopic simulation model. In the framework of the above mentioned methodology, the road network of the central business district of the city of Thessaloniki has been simulated and tested in order to try to identify the various impacts of implementing a TM2.0 scheme in an area. More specifically, real time traffic condition of the road network is going to be simulated and scenarios pertaining to traffic management plans will be implemented.

The road network of the central business district area of the city of Thessaloniki has been developed in detail in the microscopic simulation model. The model development has been implemented with the Aimsun microscopic traffic simulator. The simulated network is comprised of 401 sections and 290 junctions; its total length is 42-km and it is depicted in Figure 1. Among the 290 junctions, 62 are controlled by signals. Forty public transport lines have been also simulated along with their corresponding time plans.

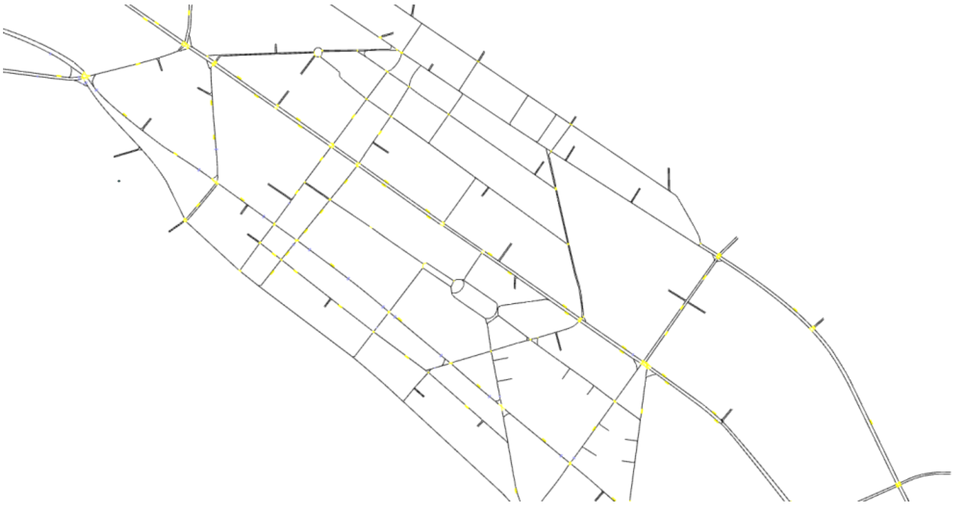


Figure 1 – Road network of Thessaloniki's central business district simulated in Aimsun.

Demand has been obtained through the aforementioned macroscopic traffic assignment model developed in VISUM for the wider area of Thessaloniki (8). Field traffic flow data collected from traffic sensors located throughout the road network of Thessaloniki from an one-hour morning peak period (i.e. 09:00-10:00am) of a typical weekday (i.e. Wednesday 15th October 2014) have been input to the macroscopic model, which executed the traffic assignment and produced the necessary demand info for the "loading" of the microscopic model. Traffic composition information has been also obtained through a previous study (9). According to this study the fleet in this portion of Thessaloniki's road network is comprised 90% by private vehicles, 5% by taxis, 4% by trucks and 1% by buses.

The network has been simulated for two different operating conditions. The "Baseline" case represents the normal operating conditions of the road network of the CBD of the city of Thessaloniki. On the contrary the "Workzone" case pertains to the implementation of section closures around one of the subway's existing construction sites. These closures are imposed 15 minutes after the onset of the simulation and their duration is 30 minutes. The operating conditions for both cases are depicted in Figure 2. Traffic assignment has been performed in three different ways for both cases. Initially statically (i.e. traffic assignment implemented once in the beginning of the simulation), then dynamically (i.e. traffic allocated to routes every 15 minutes based on the prevailing traffic conditions), and finally dynamically with the option of enrouting enabled (i.e. vehicles that had been assigned a route prior to their entrance into the network could reroute after entering based on the existing traffic conditions). Regarding the third traffic assignment option all passenger cars were assumed to be equipped and capable of enrouting at the onset of the traffic restrictions. The dynamic traffic assignment simulations resemble the real-life interaction between a TMC and MSPs, since traffic restrictions can be communicated to the drivers who can select their routes accordingly in advance or reroute on time if they are currently on the network. A comparison with the static traffic assignment option which corresponds to no interactions between TMCs and MSPs can demonstrate the benefits of interactive traffic management. Finally, six scenarios have been simulated.

Due to the stochastic nature of AIMSUN multiple runs of each simulated scenario are necessary, so that the simulation output is statistically significant. Therefore, five simulations of the baseline scenario were initially run, each with a different random seed generated by AIMSUN's internal random number generator, and statistics (i.e. standard deviation and mean value) regarding the average network speed were collected for this sample of runs. The significance level was selected to be 95%, the tolerable error equal to 0.5km/h, and given the standard deviation of the average network speed of the initial sample, the required number of runs was determined to be five.

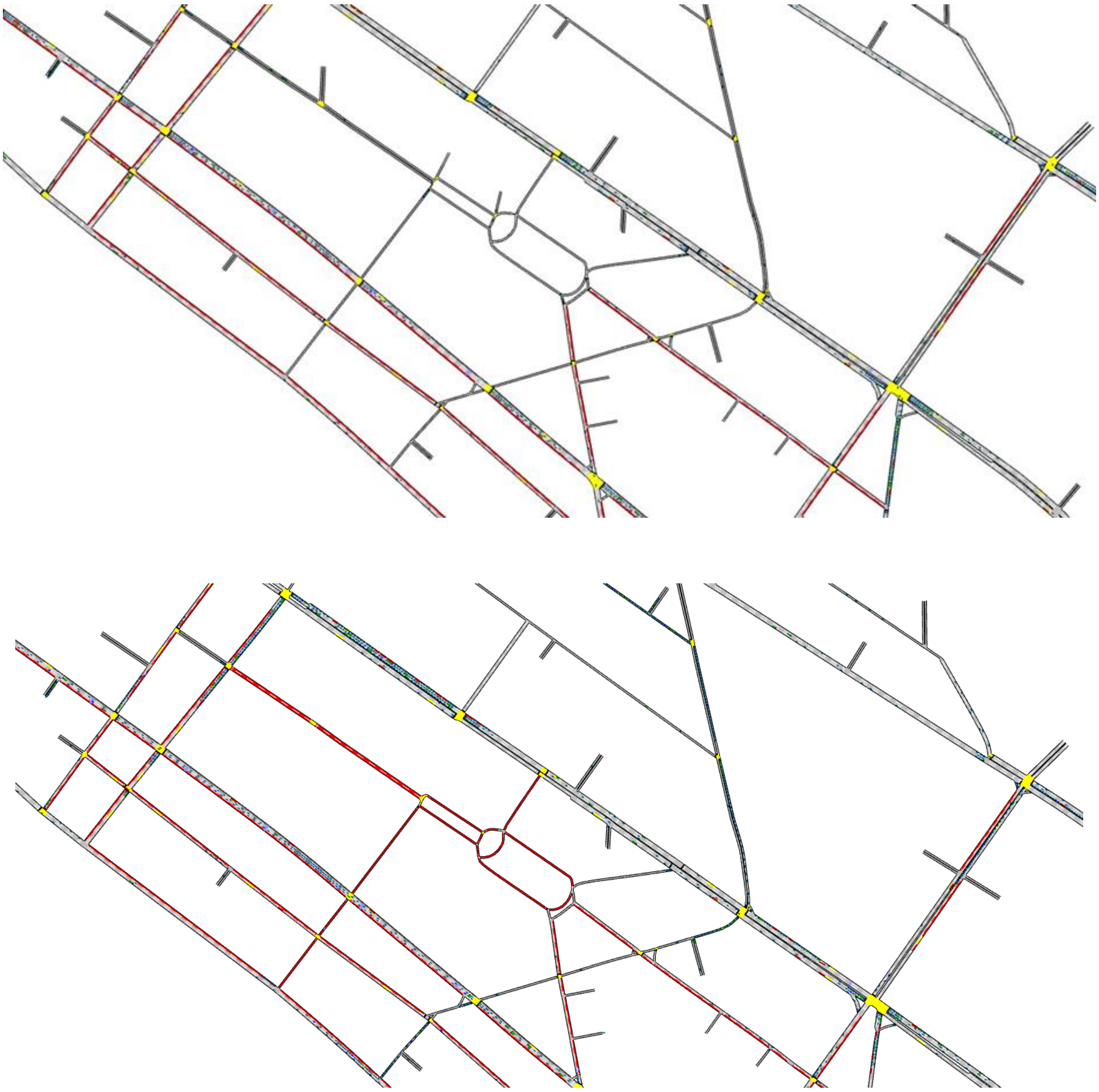
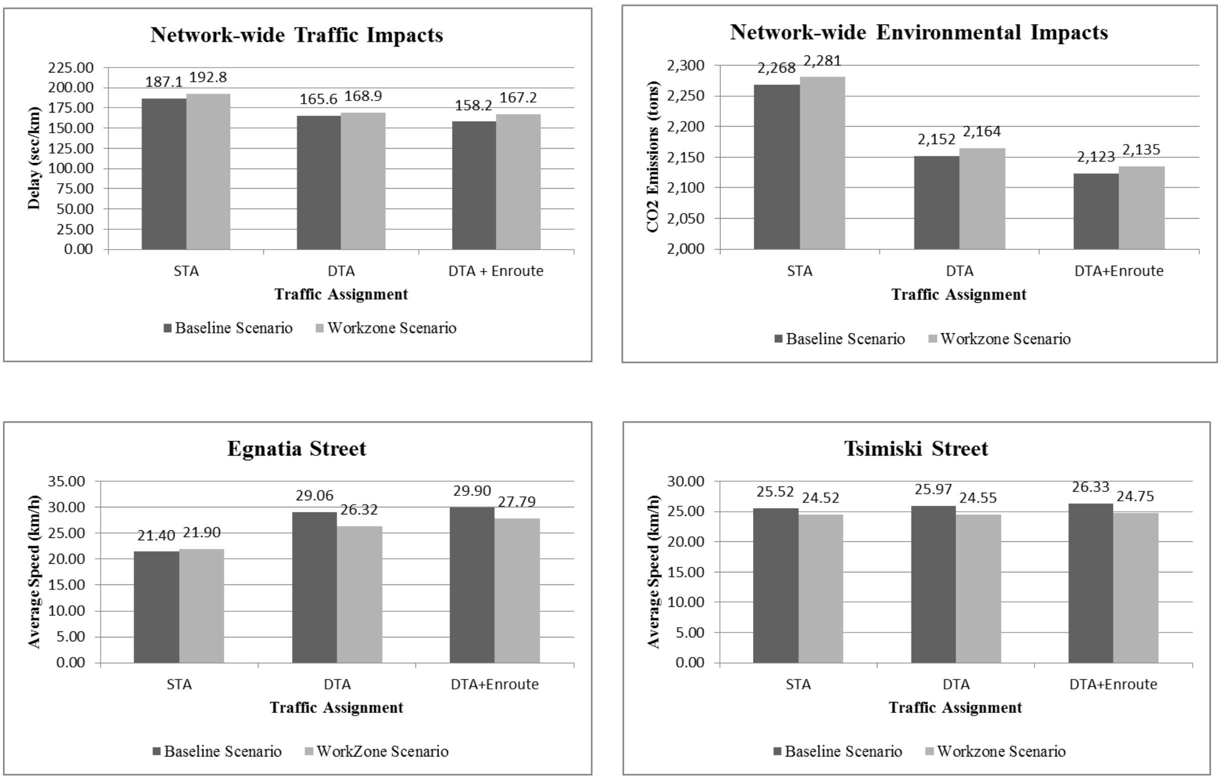


Figure 2 – Normal operating conditions vs Section closures imposed due to subway's construction site.

6. Results

The output of the simulation experiments pertains to traffic performance measures and environmental indicators. Simulation output statistics have been estimated both at subpath level (i.e. disaggregate level) and network level (i.e. aggregates). The estimated traffic performance measures are: average network delay, average subpath speed and average network speed. The environmental indicator is CO2 emissions.

The deployment of the interactive traffic management has a profound impact on the network level both from the traffic operations point of view and the environmental effects (Figure 3). Average network delay decreases by 15.5% compared to the "do-nothing" scenario when enrooting is enabled too. The reduction is also significant for the "Baseline" case when no traffic regulations are imposed, but prevailing traffic conditions are conveyed to the drivers. Accordingly, interactive traffic management yields substantial benefits with respect to CO2 emissions. They decrease by 6.4% compared to the static traffic assignment when dynamic traffic assignment with enrooting is simulated. Although traffic conditions deteriorate when the "Workzone" case is implemented due to the capacity reduction, the magnitude of the benefits is similar to the "Baseline" case when TMC and MSP cooperate.



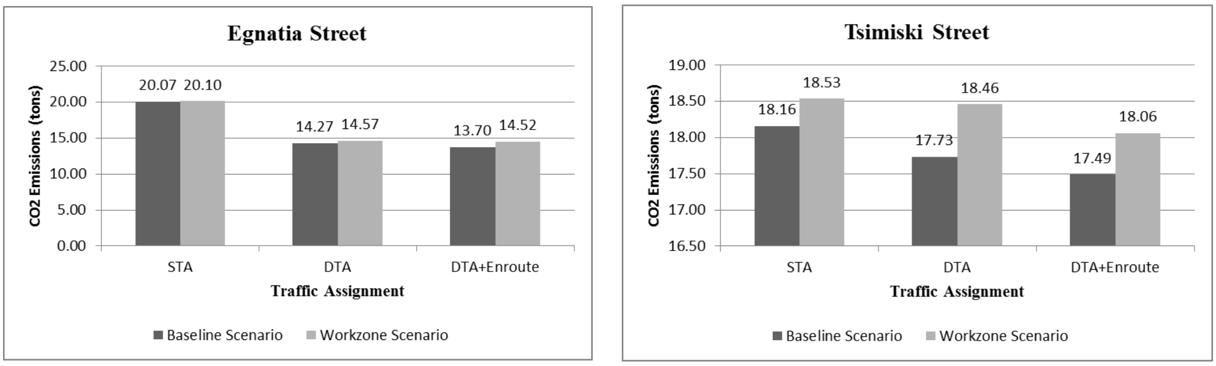


Figure 3 – Traffic and environmental impacts of interactive traffic management.

The traffic and environmental impacts of interactive traffic management have been also assessed on a local level as well (Figure 3). Average network speed and CO2 emissions have been estimated on the two main arterials (i.e. Egnatia St. and Tsimiski St.) intersecting the CBD of the city of Thessaloniki. Egnatia St. is a two-way street located in the proximity of the area where the traffic regulations have been imposed, while Tsimiski St. is a one-way street located away from the construction site. However, results indicate that in both cases the provision of information to the drivers with respect to the implemented restrictions increases the average speed on the respective corridors, and accordingly CO2 emissions decline. Overall, it is apparent that interactive traffic management impacts positively the operation of the network both at local and network-wide level.

7. Conclusions

This work aims to demonstrate how created synergies between actions of individual travellers and the collective mobility objectives improve the mobility services and bridge the innovative developments in the vehicle and in the traffic management while giving value to the legacy and creating new business opportunities, through the definition of detailed methodology that can be applicable for any case where a TM2.0 scheme is implemented.

The cooperation of TMCs and MSPs can yield a more efficient redistribution of traffic on the road network after the deployment of different traffic management schemes from the traffic management operator. Thus, significant benefits in terms of traffic operations and the environment can be realized. The more robust this cooperation becomes the more substantial the resulting benefits become. In this case study the capability of interactive traffic management to accommodate the imposition of traffic restrictions has been evaluated and verified. It is suggested that the effects of a network-wide traffic control plan change based on the prevailing traffic conditions is also assessed in future research on the premises of this methodology that has been proposed within the context of the TM2.0 platform.

References

1. Carter, C.R. et al. (2011). Sustainable supply chain management: evolution and future directions, *International Journal of Physical Distribution and Logistics Management*, vol.41 No.1, 2011, pp.46-62.
2. “Traffic Management 2.0 Platform” www.tm20.org, accessed: 15-Apr-2016.
3. Coconea, L. et al. (2015). Enabling next generation transport infrastructure: TM 2.0 paradigm, ITS World Congress 2015, Bordeaux, France.
4. TSS, 2011a. TSS (2011a). Aimsun Dynamic Simulator User Manual. Transport Simulation System, version 7.0, Barcelona.
5. Barceló, J., J. Casas (2005). Dynamic network simulation with AIMSUN. *In Simulation approaches in transportation analysis*, Springer US, pp. 57-98.
6. Panis, L. I., S. Broekx, R. Liu (2006). Modelling instantaneous traffic emission and the influence of traffic speed limits. *Science of the Total Environment*, vol.371, pp.270-285.
7. Rakha, H., R.K. Kamalanathsharma (2011). Eco-driving at signalized intersections using V2I communication. *14th International IEEE Conference on Intelligent Transportation Systems*, Washington, D.C., U.S.A.
8. Stamos, I., J.M. Salanova Grau, E. Mitsakis (2013). Macroscopic Fundamental Diagrams: Simulation Findings for the road network of Thessaloniki. *6th International Congress on Transportation Research "Energy, Environment and Transport"*, Thessaloniki.
9. Mitsakis, E., I. Stamos, J.M. Salanova, E. Chrysochoou, P. Iordanopoulos, G. Aifadopoulou (2013). Urban mobility indicators for Thessaloniki. *Journal of Traffic and Logistics Engineering*, vol.1, pp.148-152.