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Section: Sustainable Urban Development

# Traffic flows analysis and visualization based on data from an advanced Vilnius traveller's information system

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**Abstract**

As a subsystem of an Intelligent Transportation System (ITS), an Advanced Traveller Information System (ATIS) disseminates real-time traffic information to travellers. This paper analyses traffic flows data, describes methodology of traffic flows data processing and visualization in digital ArcGIS online maps. Calculation based on real time traffic data from equipped traffic sensors in Vilnius city streets. The paper also discusses about traffic conditions and impacts for Vilnius streets network from the point of traffic flows view. Furthermore, a comprehensive traffic flow GIS modelling procedure is presented, which relates traffic flows data from sensors to street network segments and updates traffic flow data to GIS database. GIS maps examples and traffic flows analysis possibilities in this paper presented as well.

**Keywords:** Advanced Traveller Information System; real time traffic flow; ArcGIS Online; Geographic information system (GIS).

## 1. Introduction

Visualization of traffic flows in GIS form is very important and understandable. Traffic flows are used in urban planning and in real time route optimization purposes. The deployment and operational efficiency of Advanced Traveller Information Systems (ATIS) entail the accurate modelling of driver route choice behaviour is based on real-time traffic flow information and the calibration of the associated other not main model parameters. Driver en-route routing decisions are influenced by personal attributes, response attitude to the supplied information, and situational factors such as time-of-day, weather conditions, trip purpose, and ambient traffic conditions [1]. The latent preferences of drivers towards possible routes are typically difficult to capture accurately because they are significantly affected by past experience, subjective interpretation of the traffic information provided, and personal attitudes dynamically changing traffic conditions. Most existing models are limited in their ability to capture the interacting effects of various situational factors, and typically cannot adjust model parameters in a within-day context. The latter capability is critical for consistency-checking procedures for the real-time operational deployment of advanced information systems. Driver route choice models under information provision have traditionally adopted the econometric theory on traffic flow measurements [2].

Other scientists analysing traffic flow analysis, visualisation, traffic flow environmental impact and decision making from the point of Geographic information system (GIS) View. Therefore it is necessary to provide decision-makers with up-to-date traffic flow information in an easily understandable form. To achieve this goal traffic flow measurement systems are integrating with software which has graphical user interface, which includes a GIS [3, 4].

There are researches who combine complex of three systems GIS, simulation models and (3D) visualizations in research and practice projects. Although some have successfully integrated GIS and simulation modeling or GIS and computer visualization, few have met the challenge of integrating the three technologies into one system in order to support planning and decision-making. In an effort toward reaching this goal, are developing prototypes of traffic impact systems based on traffic flows data in urban areas. Automobile traffic and travel speed are predicted with a volume/capacity ratio models. GIS is used to prepare data and execute the models and present the modeling results in a geographic context. A series of 3D models of street segments and buildings along the highway are developed and subsequently integrated with simulation results to allow a geo-referenced 3D presentation, including animations of driving experiences [5].

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Current GIS are well adapted to the management of very dynamic geographical phenomena. There are researches which are oriented towards the identification and experimentation of a new methodological and applied framework for the real-time integration, manipulation and visualisation of urban traffic data. Urban traffic behaviours are analysed either by observation of the movements of several vehicles in space, or by changes in urban network properties (i.e., micro- versus macro-modelling). Visualisation and interaction tools together constitute a flexible interface environment for the visualisation of urban traffic data within GIS. These concepts provide a relevant support for the visual analysis of urban traffic patterns in the thematic, spatial and temporal dimensions [6].

Other scientists rise the problem of ability to manipulate a huge traffic information dataset and in that process involves GIS. They analyses huge quantity of traffic information data. It is however challenging due to the huge size of the dataset and the complexity and dynamics of traffic phenomena. Analysis of floating car data method could be based on data cube for congestion pattern exploration. Also analysis of historical traffic flow data, and comparison with real time traffic data allows perform traffic congestion predictions, perform more detailed traffic trend assessments [7].

In the context of traffic flow behaviour under information provision, qualitative phenomena such as inertia, compliance, delusion, freezing, and perception of traffic information, have recently been identified [8]. Developed a multinomial model with a nested choice structure to examine inertia and compliance. Inertia represents the propensity to remain on the current path, while compliance represents the tendency to choose the path recommended by the traffic flow capture information system.

GIS could be also applied for the visualizing traffic flows in digital map, when it is necessary compare and analyse traffic congestion at specific time. The system offers to a user traffic flow visualisation and time based analysis. In other papers that analyse application of GIS technologies in transport task solution, an application of analysis and prediction of vehicles traffic flows could be spotted. Traffic flows information is used when solving route choice tasks within the overall urban transport system: cars, public transport, railway transport, and even pedestrians [9]. The assessment of transport jams on the street network is necessary when solving the task of the choice of the fastest route. A search algorithm, the results of which depend on the time set by a system user, has been programmed as the street capacity is different depending on the time of the day [10, 11]. This paper analyses ESRI ArcGIS Online technologies for traffic flows data presentation and visualization in digital WEB maps a system user is given WEB based GIS application. Also this research shows perspectives of historical traffic flows time based data analysis when user can perform different queries in time

## 2. Vilnius city transport system indicators and description of information system for drivers

Growing Lithuanian economy and increasing quality of the living conditions prompts population's mobility, the motorization level and increasingly high transport flow on the countries streets and roads [12, 13].

Average percentage number of Vilnius city automobiles quantity is increasing per year about 3%. The number of private cars in Vilnius increased from 265 cars per 1000 inhabitants in 1999 up to 580 in 2012. A sharp bounce of motorization level invokes increasing traffic volumes in streets of Vilnius. Growth of traffic flows rises number of accidents, rises downtime and invokes other transportation problems. In 2008–2011 saturation was reached .The main Vilnius city transport system indicators are presented in Table 1.

Table 1. Transport system indicators in Vilnius city, 1999, 2005 and 2008

| Indicator | 1999 | 2005 | 2012 |
|---|---|---|---|
| Street network density (km/km$^2$) | 1.9 | 2.4 | 3.1 |
| Public transport network density (km/km$^2$) | 0.55 | 0.62 | 0.74 |
| Average traffic flow in peak hours (aut./h) | 1275 | 1521 | 1550 |
| Percentage number of trucks in average flow | 3.4 | 2.4 | 2.1 |
| Average speed in peak traffic flow (km/h) | 37.5 | 29.3 | 31 |
| Modal split | | | |
| *– pedestrian trips in %* | 31.3 | 34.8 | 33.1 |
| *– trips by bicycles in %* | 0.3 | 0.3 | 0.3 |
| *– trip by public transport in %* | 45.4 | 34.2 | 40.9 |
| *– trips by car in %* | 23.0 | 30.7 | 25.7 |
| Transit of trucks in peak hours in % | 21.3 | 13.2 | 10.1 |

Vilnius city modal split of transportation shows that number of private cars rapidly increases (see Table 2).

Table 2. A modal split of trips in Vilnius City

| Trip mode | 1980 | 1993 | 2006 | 2012 | 2012/ 1980 |
|---|---|---|---|---|---|
| On foot | 44.1 | 38.0 | 34.5 | 35.5 | 0.80 |
| By public transport | 47.1 | 49.4 | 33.1 | 24.6 | 0.52 |
| By taxi | 2.9 | 0.1 | 0.4 | 0.7 | 0.2 |
| By train | 0.3 | 0.1 | 0.4 | 0.1 | 0.3 |
| By bicycle | 0.1 | 0.2 | 0.4 | 0.6 | 6.0 |
| By car | 5.5 | 12.2 | 31.2 | 38.5 | 7,0 |

Tendencies show that the use of public transport usage in Vilnius is rapidly decreasing due to the growth of motorization level (see Fig. 1).

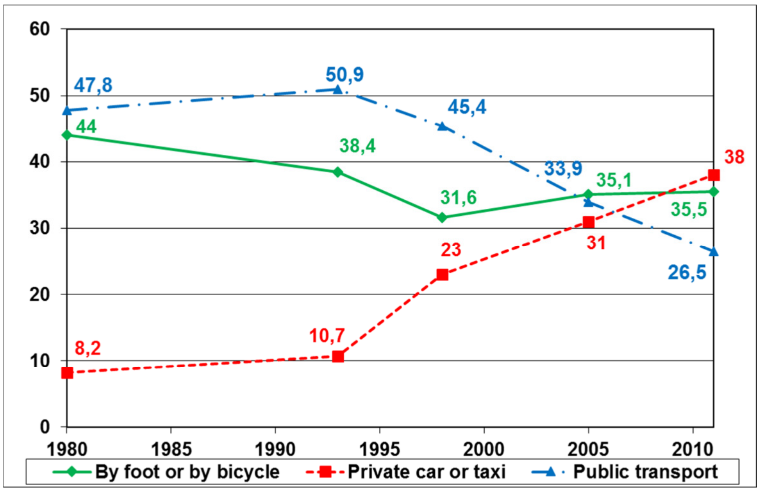


Fig. 1. Tendencies of a modal split of trips in Vilnius City

These tendencies requires more accurate traffic flows control and monitoring in Vilnius city street network. Many scientific researches analyse transport information system from the point of intelligent transportation according presentation of traffic information like weather conditions, traffic situation in different street network segments [14].

Portal of Vilnius information system for drivers has a lot transportation data presentations in different forms accidents data, data from traffic cameras, route planning functionality etc. Bus system do not have ability for user to control visualisation of traffic flows and to have time based traffic flows analysis capabilities. The interface of the Vilnius information system for drivers is presented in the Figure 2.

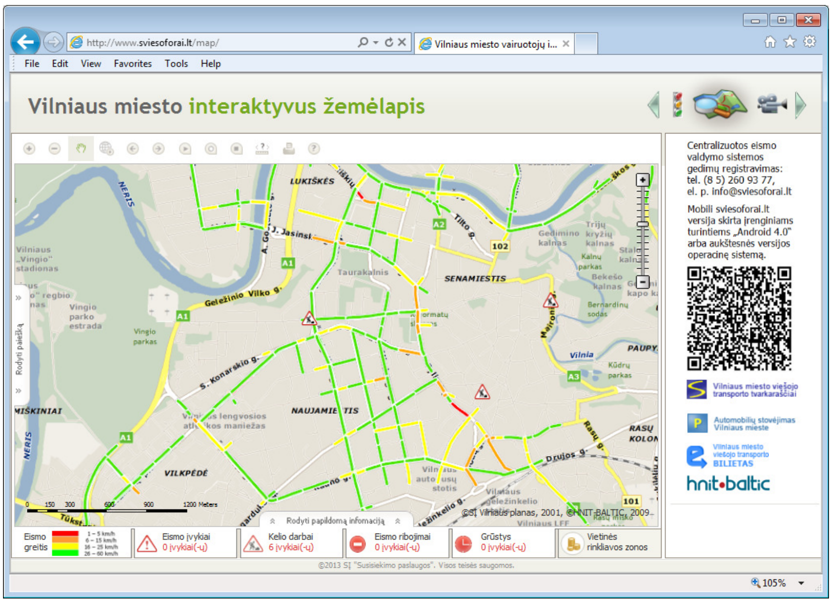


Fig. 2. Example of ME Susisiekimo paslaugos WEB based information systems for drivers

## 3. Traffic flows data collection in Vilnius ATIS

Equipped flow of traffic flow data collection in Vilnius ATIS allows to perform traffic flows visualisation. Attribute data of road and street segments are periodically updated by real time driving traffic flow information from equipped video detection and induction loops (see Fig. 3).

Fig. 3. Video detection in left side, induction loop in right side

All driving time data from traffic sensors (video detection and induction loops) are generating to one xml file. Each minute are generating the new xml file. According xml file road network database is updated periodically in 5 minutes. Updated GIS road network attribute data contains one week travel time data in one hour intervals and there are two fields which are updated periodically in 5 minutes. So these fields contain almost real time traffic flow data. Historical travel time data which is later than one week is stored in separate table. In the Figure 4 is presented traffic data flow from equipped traffic sensors on a street to road network GIS data base.

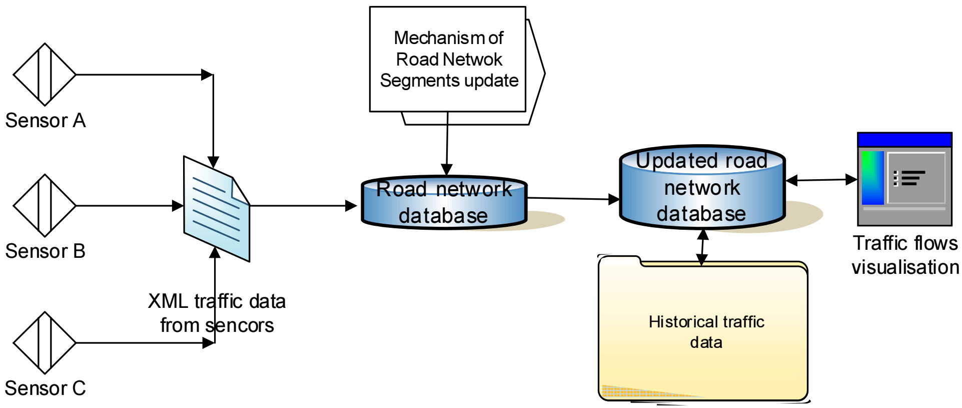


Fig. 4. Traffic volumes data workflow

System takes into account real time traffic flows information and presents it in ATIS portal, but portal do not have availability to perform historical traffic flow data analysis. WEB application in map window shows almost real time traffic volumes. Street segments are marked in different colours regarding flow level: red – saturation, yellow – average traffic volumes, greed – free traffic flow (see Fig. 5).

## 4. ArcGIS Online solution used for traffic flow analysis

ArcGIS Online is a collaborative, cloud-based platform that allows to use, create, and share maps, apps, and data, including authoritative basemaps published by Esri. Through ArcGIS Online it is possible to access to Esri's secure cloud, where users can manage, create, store, and access data as published web layers, and because ArcGIS Online is an integral part of the ArcGIS system. ArcGIS online has time based analysis capabilities, in that reason this solution was used in Vilnius traffic flow data analysis purposes. Spatial phenomena collected with time information allows map users to see what happened at a specific time, or what may happen in the future; by animating time-based data you can visualize it at each step and see patterns or trends emerging over time. Vilnius city time based traffic flows analysis is presented in Figure 5.

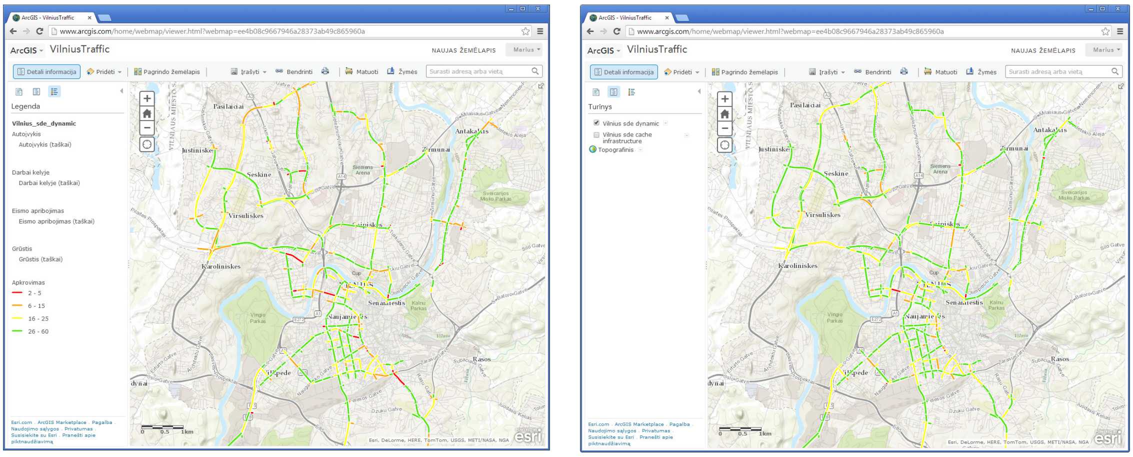


Fig. 5. Visualisation of traffic volumes. From the left to the right: morning traffic flow at 8:00 and 9:00 o'clock

## Acknowledgements

1. ArcGIS online provides wide range of capabilities in time based spatial data analysis. This kind of traffic volumes analysis helps traffic information centre workers to accept better decisions because they can do Vilnius city traffic volumes analysis over time.
2. The developed ArcGIS online Vilnius city traffic flows digital map could be reused in other traffic management systems as input data. Also traffic volumes map services could be integrated in public information portals with the help of ESRI technologies.
3. Created ArcGIS Online based mechanism of traffic volumes presentation and visualization could be adopted in other traffic management systems which has real time and stores historical traffic volumes data. Otherwise ArcGIS Online could be used like integration platform for visualisation and time based analysis of traffic flow data from different many traffic management centres.
4. ArcGIS Online could be also applied for visualization and analysis of other traffic data: accidents, road works, traffic restrictions and etc. Using mapping and spatial analysis ArcGIS online tools allow to quantify patterns, aggregate points, perform proximity and hot spot analysis. ArcGIS online has range of tools which could help estimate relationships in the data and display the results as maps, tables, and charts. This empower to answer questions and make important decisions using more than a visual analysis.

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