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Importance of telematics systems for the reduction of environmental negative impact of Urban Freight Transport – GRASS project introduction

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ABSTRACT
The utilization of telematics solutions to support Urban Freight Transport is mainly important due to the complexity of the processes taking place in urban transport systems and the importance of the optimisation of transport operations via ensuring adequate availability of linear and nodal infrastructure, while reducing the adverse impact of the transport system on the environment. Presentation is focused on the analysis realized under international project named GRASS.

Keywords: Urban Freight Transport, city logistics, freight transport management, sustainable development, UFT environmental impact, efficiency of city logistics

1. Introduction

The dynamic development of transport in recent years constitutes an important factor in the economic development of the world, but it is also a source of problems, which can be observed especially in urban areas. Mobility plays a very important role in ensuring the sustainable development of the city. Urban transport systems generate many positive effects. In addition to the unquestionable importance for the development of urban economy, urban transport systems assist in the formation of the local community, which has a positive impact on counteracting social exclusion. This manifests itself mainly in the fast and easy access to places of culture (theatres, cinemas, museums, parks, etc.). However, air pollution emitted by motor vehicles in urban areas is the source of the greatest contamination of the atmosphere. Urban areas consume approx. 70% of energy and produce approx. 80% of greenhouse gases [9]. In the years 1990-2000, carbon dioxide emissions by road transport increased by 23% [29]. This constitutes a serious threat to human health, natural resources, as well as the quality of the raw materials necessary for the production of food.

A growing number of city users results in increased demand for cargo, the large part of which is generated by industrial, retail and service entities. This applies in particular to finished products. However, due to the location of these entities in urban areas, it also applies to raw materials and semi-finished products. Distribution function initiated by these entities causes an increase in the logistics flows on a limited area. And this leads to the situation, in which the impact of Urban Freight Transport on the urban environment becomes more and more significant. Research carried out in London shows that approx. 18% of traffic in the city is generated by delivery cars supplying these entities. The next 22% of the traffic on urban roads is generated by delivery cars and carriers, which provide services for individual customers by delivering private orders. The research also shows that some of the deliveries carried out by different carriers/delivery cars intersects and is performed with the partial use of the loading capacity [2]. In addition, one of the key problems of urban transport is congestion, understood as the overflow of transport network and means of transport caused by exceeding their capacity or its deficiency [13], which is responsible for the increase in air pollution, energy consumption, but also for longer travel time. While assessing the impact of UFT on the environment, the first step should involve making a division between the first-order and second-order impact [4]:

- the first-order impact concerns stakeholders directly involved in the MTT (wholesalers, carriers, handling service);
- the second-order impact concerns e.g. the costs of infrastructure (roads), especially in underdeveloped countries, which cause interference with the environment and global warming.

The continuous increase in the number of motor vehicles, and above all, their exploitation, not only causes the emission of pollutants from exhaust gases, which are a threat to the human health, but it also reduces reserves of oil. In recent years, a very important issue has become the reduction of pressure of transport on the environment and the scale and scope of its negative effects. Actions in this area should be conducted at different levels of government and self-government authorities with the collaboration of the private sector. On the one hand, it becomes necessary to implement appropriate legal and administrative regulations, and on the other hand, to develop the appropriate management of urban space. Urban planners must take into account the needs of residents in terms of employment, health, education and transport, as well as provide recreational facilities, shopping places and waste management plants.

For this reason, it is necessary to initiate cooperation and partnership to enable firstly the proper dissemination of knowledge and experience, including good practices, and secondly to allow the common objectives identification and the development strategies preparation, while maintaining the expectations of each party and the use of an approach based on the search for a compromise [12].

To address these challenges, many initiatives were or are realized in Europe, such as: FREIGHTWISE [5], Urban Transport Benchmarking [28], eDRUL [22], MOSCA [23], SMARTFREIGHT [26], INTERACION [8], CityMove [20], CityLog [19], BESTUFS (I, II) [17], CITY FREIGHT [18], SUGAR [27], C-LIEGE [21]. The problems presented above are also the subject of the GRASS project (GReen And Sustainable freight transport Systems in cities), which is financed under the grant from Norway through the Norwegian Financial Mechanism 2009-2014 – Polish-Norwegian Research Programme [6].

2. Utilization of telematics systems for reduction of environmental negative impact of Urban Freight Transport

The impact of utilization of telematics solutions in Urban Freight Transport systems should be analysed from few different points of view related to the idea of sustainable development of transport systems [10]:

- social, expressed mainly via the mitigation of the congestion effect and decreasing the number of accidents and limiting their effects;
- economic, including changes in fixed costs and operating costs (in particular in relation to the hauliers and contracting parties) – it depends on the volume of goods flows generated on a given market, being the resultant of customers' individual needs and suppliers' transport decisions;
- environmental, expressed via changes in the demand for energy, including pollution emissions and the impact on the noise level;
- mobility, taking into account, inter alia, urban traffic development, demand for transport, indicators of infrastructure availability, classification of road users, etc.

The analysis of environmental impact of UFT is mainly focused on pollution emission, which is depended directly on energy (usually fuel) consumption and noise emission level. The analysis of emissions from road transport usually takes into account the level of CO_2. This approach is justified in the global context only [3, 7, 16]. From the city perspective and influences on city dwellers (taking into account the chemical compounds directly related to the health status of the city population) most important are local pollutants, which include mainly:

- carbon monoxide (CO), which is an odourless and colourless gas with highly toxic properties,
- nitrogen dioxide (NO_2) - brown, highly toxic gas with a pungent odour;
- hydrocarbons (HC), which include carcinogenic compounds;
- particulate matter (PM) in the form of carbon-graphite compounds, ash and soot.

The basic task of telematics solutions in UFT support is to enable efficient management of the vehicles flows in the city area based on information generated in it as well as the efficient utilization of vehicles capacity and reduction of empty trips, which plays the most significant role in supporting the last mile deliveries [14]. Generally, the utilization of telematics systems in UFT management is mostly focused on:

- the systems that guide delivery vehicles entering the city centre to the planned routes,
- intelligent freight traffic routeing systems, integrating the planned routes and information aimed at delivery vehicles with navigation software, in which the data obtained from trucks in traffic, regarding their location, carried cargo and planned destination, may be connected with the road traffic data in real time;
- integrated logistics tools, being the solutions based first and foremost on web technologies application (mainly the internet and www technology), making it possible to connect and coordinate producers, receivers and logistic operators with regard to order placement, in order to streamline logistic flows.

Taking into account the usability of different UFT measures, it is possible to emphasize their two major categories, which are based on utilization of telematics systems (Tab. 1):

- measures fully based on IT and telematics systems, and
- measures supported by IT and telematics systems.

Table 1. Telematics systems in Urban Freight Transport [own study]

Measure	Description	Telematics support
Access restrictions for (un)loading and transit	Access restrictions for loading/unloading operation as well as for moving/circulating related to (a) the type of transport means, and most commonly to vehicle emissions, weights and sizes; (b) access time within specified areas; (c) preferred truck routes and designated lanes; (d) loading and unloading zones; (e) based on licences.	Support for optimization, supervision and management
Advance booking of (un) loading slots	From an environmental, business and traffic flow/security point of view it is best for freight vehicles to avoid double lane stops and reduce waiting times for getting into a loading/unloading parking space. To this end a service can be offered that gives drivers the ability to book a delivery parking space before they reach their delivery point.	Support for slots' booking and management
Alternative delivery systems	Van-sharing, cycle-logistics, night-delivery service, packstations etc	Support for booking, supervision and management
Freight traffic routing information	Channelling trucks that drive into cities of the urban agglomeration through designated truck routes, e.g. by setting up special road signs or providing special maps with designated routes and lorry-relevant road information.	Fully telematics-based
Integrated logistics tools	Web-based logistics tools linking and coordinating producers, recipients and freight operators in order to optimise logistics flows.	Fully telematics-based
Intelligent freight traffic routing	Integrating designated lorry routes and lorry-relevant information in navigation software. On this basis, data received from freight vehicles in traffic with regard to their current locations, loaded cargo and destination plans can be connected with real-time road traffic data.	Fully telematics-based
Low Emission/ Environmental Zone	Institution of protected areas that include both vehicle access restrictions and incentives for environmental or historical/heritage reasons.	Support for supervision and pollution detection
Mobility credits schemes/ congestion charging	Limiting the access of freight vehicles to an urban area by making freight operators 'pay' for each access with mobility credits that were initially distributed by the public administration (or money payments for entries in excess of the assigned credits). Access control equipment in freight vehicles record every entry to the zone and permits the implementation of a mixed pricing / enforcement scheme for different users.	Support for supervision and management

Based on experiences from BESTUFT project, it is possible to highlight some examples of the results with regard to the selected solutions [1]:

- Computerised Vehicle Routeing and Scheduling – vehicle routeing and scheduling systems can result in journey time savings of 10 to 15%, customers can receive more precise delivery time estimates, the proportion of first time delivery success should increase, operational costs can be reduced.
- GPS-based Route Navigation System – provides new drivers with detailed routeing instructions to travel between deliveries, overcomes lack of local knowledge – increasing speed of deliveries and driver flexibility.
- Real-time Traffic Information – still in its infancy, collection and dissemination of data to help update transport plans to maximise vehicle utilization and first time delivery success.
- Radio Frequency Identification (RFID) – still at an early stage, vehicle and transit unit identification is possible and is under trial at sites in the Ruhr and the Netherlands, transport process updates can be added to basic product information and are another way to give real time supply chain information for customers and operators, early problems of reader sensitivity, standardization of information and application costs still need to be overcome.

The critical important condition to achieve the results presented above is data availability. The proper data sets are the basis of all kinds of analysis and functioning of mentioned measures. The main problem arising in the process of analysing the functioning of the transport and distribution of goods in urban areas is the lack of data on their implementation, in particular with regard to the classification of vehicles, their routes, changes in demand for transport, etc. The main two reasons for difficulties in obtaining these data include [15]:

- transport in the cities involves mainly private companies that usually do not want to share data on their transactions, supplies and carried cargo to its competitors and the public sector;
- lack of standardized study methods in the field of freight transport and supplies in cities.

Therefore, it is very important to implement and develop the measures, which will make it possible to collect data based on independent solutions, like traffic detection systems. The implementation of efficient measures in this area, which will help not only to collect data regarding traffic but also to analyse routes or, for example, number of deliveries (stops) per route, is still a challenge.

3. GRASS project – introduction

The major aim of GRASS project is to support municipalities in implementation of sustainable Urban Freight Transport measures in accordance with the expectations of different stakeholders groups and requirements regarding utilization of technologies that limit the negative impact on environment [6]. Project is realized by two partners – Maritime University of Szczecin (Department of Logistics and Transport Systems) from Szczecin, Poland and the Institute of Transport Economics from Oslo, Norway. Both partners have big experiences in the area of the research regarding the development of sustainable UFT systems.

To address the challenges and needs raised from the UFT problems, the objectives of GRASS are threefold:

- Review, compare and analyse effects of current practices and adaption of public regulations and stakeholders requirement on use of energy and technologies that impact limiting of greenhouse gases in Oslo and Szczecin. This includes analysing the effects of different measures (i.e. in night deliveries, use of electric vans and trucks in last mile distribution, zero emission zones, regulations on truck size) on reduction of air emissions, vibration and noise level and environmental degradation.
- To determine the conditions for the implementation and development of energy-efficient Urban Freight Transport in the Polish and Norwegian cities and regions, taking into account the often conflicting expectations of key stakeholders of the transport market. Norway is a country that has a much higher experience in this area than Poland. Due to that it is planned to utilize the best Norwegian and European practices and identify the opportunities to adapt them to the needs of Polish cities. Szczecin is the area covered by the pilot experiment that allows analysing specific examples. Both cities – Oslo and Szczecin – will work together using the approach based on "mentor city-training city" idea.
- The promotion of a platform for the exchange of knowledge and mutual cooperation in a partnership (Freight Quality Partnership). In this experiment different stakeholders (representing different groups of interest) will be invited to participate in partnerships. Solutions based on the use of alternative energy sources and alternative methods of delivery, which will reduce CO_2 emissions in Szczecin, will be searched for during the working meetings (round tables). The choice of solutions that will be recommended for future implementation will be developed based on the compromise approach and consideration of the interests of particular groups. An important aim of the Project is the preparing the set of guidelines for the effective development of environmentally friendly Urban Freight Transport. All advices and implementation recommendations will be based on the activities focused on cooperation and co-financing under the public-private partnerships as well as utilization of a new technology for management, dissemination and data acquisition, such as Internet applications.

Project has started in June 2013 and will finish in April 2016. During this period 6 work packages are realized:

- WP1 – Comparative analysis of activities for more environmentally friendly Urban Freight Transport (UFT) systems in Norway and Poland;
- WP2 – State of the art review and requirements for environmentally friendly Urban Freight Transport ;
- WP3 – Analysis of freight transport impact on the environment in Szczecin and Oslo areas;
- WP4 – Modelling of transport pollution propagation in urban areas;
- WP5 – Joint and cooperative activities for environmentally friendly UFT in Szczecin – the pilot experiment;
- WP6 – Communication and dissemination of the results.

All results are available on the project web-site: **grassproject.eu** (in both Polish and English versions).

4. Utilization of telematics systems in the activities realized under GRASS project

The telematics-based activities under the project GRASS are focused on two major actions:

- independent data collection process, based on mobile detectors system
- implementation of web tools for drivers, which will be used for:
  - analysis of the pollution propagation at the research area;
  - the routing at the area of Szczecin, including the environmental impact of UFT., based on the model of pollution propagation.

Preparation of the model of transport's pollution propagation at the urban area and its implementation on free web-site for unlimited use by transport and logistics operators is the most important challenge during the project period. The basis of this work are data collected for the analysis of the influence of Urban Freight Transport on environment and quality of life at the area of Szczecin (Poland) and Oslo (Norway). This process is divided into four stages. Two first of them (already done) were focused on surveys based on standardized questionnaire. During the third and fourth stage in Szczecin the mobile traffic detectors are used for analysis of the traffic, including vehicles categories and their speed. Data collection in these stages is realized on nine chosen road sections. In the case of Oslo the data is collected based on detectors used by municipality.

The research in Szczecin is realized at chosen area of city centre (Fig. 1). Delimitation of the research area was based on the accumulation of entities in a particular area, the operation of which generate increased demand for deliveries, as well as the present emissions of toxic compounds (particularly NO_2), according to data from the Voivodship Inspectorate of Environmental Protection. Finally the research area included a total of 1210 entities, divided into four categories: retail entities (58%), HoReCa sector (11%), service entities (28%) and production plants (3%).

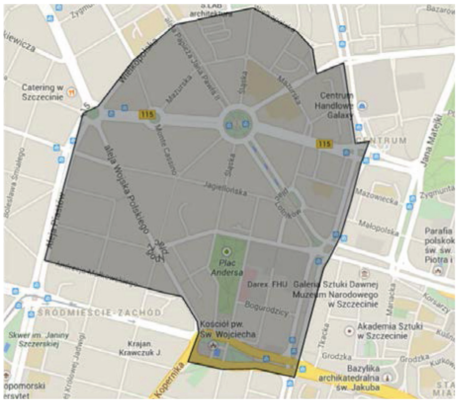

Fig. 1. Research area in Szczecin [own study]

Data collection process regarding traffic flows in analysed area of Szczecin is realized with utilization of two detectors Sierzega SR4. It is a side discharge radar traffic measuring system makes the most exact and simple recording of road traffic possible. The included PC analysing software enables to make a detailed analysis and evaluation of the traffic data. Thanks to its inconspicuous appearance, the radar device can record every vehicle without hindering the flow of traffic. Besides the measurement of the length of the vehicle and the safety margin (gap) to the vehicle in front, the monitoring of the speed is the most important component of the recording. The data on every vehicle recorded by SR4 is then saved together with the date and time of the recording. SR4 is supplied by two 6 Volt, 12Ah batteries. It can work from 7 to 10 days and store the data about up to 209,700 vehicles. One device is able to collect data from two lines of the road [25].

Detection system is utilized on selected road sections. The sections were chose on the basis of the results from previous two stages of analysis, which helped to point out the most problematics streets in the analysed area of Szczecin. Finally nine sections were chosen (Fig. 2). Thanks to utilization of two SR4 devices, it was possible to analyse each road section at the same time in both directions. Each road section is analysed through one week from Monday to Friday, between 6 AM and 6 PM.

Fig. 2. The road sections analysed in Szczecin with the use of traffic detector SR4 [own study]

The result of data collection process will be the basis for modelling of road transport's pollution propagation from line sources. The study on emissions from line sources (road transport) at urban areas, which takes into account the mathematical pollution propagation modelling, is quite a complex issue. Distribution of pollution for such a system is variable in time and space. Pollution propagation model for road network is described by a number of variables related to the traffic of vehicles, road infrastructure, and the type of vehicle or environmental and weather conditions. Therefore, during the traffic detection process it was necessary to divide vehicles into categories, which forms the basis for determining the characteristics of the emission. SR4 device helps to divide vehicles into four categories: motorcycles (length to 20 dm), passenger cars (length between 20 and 60 dm), trucks (length between 60 and 95 dm) and long trucks (length between 95 and 255 dm). In addition, in order to simplify the system, modelling will be performed for a constant average speed of vehicles in a given road section, which allows for assuming a constant emission intensity over the entire length of the road for the given vehicle category. The basis for the modelling of pollution propagation will be the Gaussian cloud dispersion model (Fig. 3).

Data collected during the third stage of analysis will help to evaluate this model. During the fourth stage the area of the analysis will be expanded by chosen additional road sections.

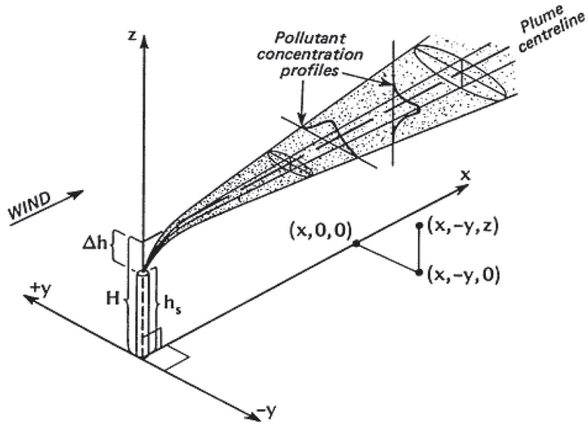

Fig. 3. Gaussian cloud dispersion model [24]

5. Conclusion

Utilization of telematics systems to support the functioning of the Urban Freight Transport systems in the context of their impact on the urban environment is manifested not only in the immediate use of these solutions to manage transport services realization, but also in using them to obtain data regarding the traffic flows, types of vehicles, speed, etc. This is the basis of efficient functioning of all other measures utilized in UFT.

The presented topics are focused on experiences resulted from activities realized under GRASS project. This project aims to analyse the UFT negative impact on city environment as well as to find measures, which will help to reduce it. Since the project is still being realized, only general assumptions regarding the results planned to achieve and regarding present area of telematics solutions utilization were introduced. The completion of activities presented in the paper is scheduled to November 2015.

Finally, the aim of this activity is to implement prepared model as open, free of charge web application. This application will be focused on two major functions: presentation of the pollution propagation at the research area and the route optimization of UFT vehicles, including their environmental impact as the major condition, based on the model of pollution propagation as well as the data regarding vehicle type, freight weight etc.

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