Archives of
Transport System
Telematics

Volume 10

Issue 3

September 2017

Telematics in sustainability of urban mobility. European perspective

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ABSTRACT

Development of widely understood information and communication technologies influence virtually all aspects of life, including transportation behaviours. Increase of urbanised population in the European Union, along with concentration of economic activity in urban areas pose new challenges in the area of policy planning for city transport and urban mobility. Despite existing expectation that an increase in Internet-based communication will reduce the need to travel, the amount of city traffic actually increases. The concept of sustainable urban mobility is a relatively recent one, particularly visible in the European Union's documents that are concerned with modelling city transport systems in concert with rules of sustainable development. The goal of this paper is to show how telematics can influence the implementation of the requirements of the concept of sustainable urban mobility.

KEYWORDS: urban transportation, sustainable mobility, SUMP, telematics, ICT

1. Introduction

The development and dissemination of information and communication technologies in the 1990s sparked a wave of optimism and, in retrospect, unrealistic expectations to revolutionise all aspects of life and business activity. Despite expectations of decreasing demand for transportation services due to the spread of ICT solutions, the transport sector is one of the fastest growing in Europe [1].

Almost three quarters of European Union citizens (72.4% of the population) live in urban areas (defined as cities, towns and suburbs) [2]. Urbanisation in the European Union progresses by: an increase in the proportion of the population living in urban areas, expansion of urban areas, and the blurring of boundaries between urban areas and rural areas [3]. It is impossible for a city to function without an efficient urban transport network, which would allow the public to move freely between different destinations.

The existing urban transport infrastructure was designed for lower traffic levels, and taking into consideration the amount of investments needed, other actions should be taken in order to, on the one hand prevent problems caused by congestion, air and noise pollution in city centres and on the other to better regulate and optimise traffic flows. [4]. The development of sustainable mobility in urban areas is intended to encourage economic development, employment growth and social inclusion which are in line with the overall objective of the Europe 2020 Strategy. European Union guidelines for public authorities responsible for ensuring sustainable urban mobility suggest a number of possible actions, e.g. solutions from the field of transport telematics.

Transport telematics, which is a combination of solutions from areas such as transport, information technology and telecommunications could serve as a response to the never-ending transport problems in urban areas [5]. It is generally acknowledged that transport telematics systems are able to: increase the efficiency of traffic management, increase traffic safety, use existing transport infrastructure more effectively, protect the environment better, improve cooperation between the private sector and public transport providers, and allow for more effective competition within the transport services sector [6]. The unsatisfactory situation concerning road transport in urban areas, especially the high usage of privately owned vehicles, is one of the main reasons for the implementation of transport telematics systems in urban transportation.

The article starts with a description of the concept of sustainable development which is a basis for the sustainable urban mobility idea promoted by the European Union. Later on, the transport telematics solutions recommended in European Union guidelines as a means

to ensure sustainable urban mobility for citizens and to minimise the effect of transport externalities are presented.

2. Sustainable development and a concept of urban mobility

Sustainable development is a global concept used in creating development policies at different levels of decision-making: local, national or international. This concept applies to virtually all areas of human activity. Its main idea is to balance social and economic activities with generally understood issues of protecting natural resources. For the first time the concept of sustainable development was proposed in the report „Our Common Future", published by the World Commission on Environment and Development (WCED), established by invitation of the United Nations Secretary-General. The definition presented of sustainable development, that was described as development that „meets the needs of the present without compromising the ability of future generations to meet their own needs" [7] is still one of the most popular and commonly cited. Further attempts were made to prepare A more detailed definition of sustainable development; one such example is a definition of sustainable development presented in Polish legislation. In Polish legislation sustainable development is defined as a development "in which the process of integration of political, economic and social activities takes place, while maintaining the natural balance and permanence of basic natural processes in order to guarantee the possibility of satisfying the basic needs of individual communities or citizens of both present and future generations" [8].

Issues related to the promotion of sustainable development occupy an important place in European Union policies. The idea of sustainable development compels all participants in the common market to make their decisions based not only on a purely economic rationale and calculations but to take into account the impact of their decisions for the environment. [9]. The principle of sustainable development is one of the horizontal policies of the European Union. According to article no. 8 of the Regulation of the European Parliament and of the Council (EU) No 1303/2013 of 17 December 2013, the objectives of European Union funds are to be achieved in a manner consistent with "the principle of sustainable development and with the Union's promotion of the aim of preserving, protecting and improving the quality of the environment, (...) taking into account the polluter pays principle" [10]. Member States were obliged to ensure, during the preparation of the program documents, the implementation and promotion of requirements concerning environmental protection, efficiency of resources, adaptation and mitigation of climate changes, biodiversity, resilience to natural disaster, risk prevention and management.

The concept of sustainable urban mobility is associated with objectives concerning optimisation of energy consumption and improvement of environmental indicators in urban areas. The European Commission stresses the need to undertake actions to improve urban mobility planning according to the principle of sustainable development.

The White Paper Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system from 2011, implies that it is necessary to develop strategies for urban areas that will include, among others, issues of land use planning, pricing strategies, efficient public transport services, and infrastructure for non-motorised transport. In Annex no. 1 to the aforementioned White Paper, „List of initiatives", the possibility of introducing mobility plans as mandatory solutions for cities of a certain size was implied as one of the possible actions [11]. The provisions of the White Paper are consistent with previous considerations included in the Green Paper - Towards a new culture for urban mobility from 2007 [12] and actions recommended in Communication from the Commission: Action Plan on Urban Mobility [13]. It should be noted that the actions of the European Union institutions concerning the implementation of Sustainable Urban Mobility Plans (SUMPs) are becoming more and moe intensive. The Communication from the Commission: Together towards competitive and resource-efficient urban mobility, which was announced in December 2013 points to the need for intensified EU support in urban mobility planning [14]. In the annex for the last mentioned document, the concept of sustainable urban mobility plan (SUMP), its goals, objectives and various other important aspects like the need for participation, the need to take into consideration all relevant modes of transportation, assessment tools etc. was presented. The central goal for SUMP is "improving accessibility of urban areas and providing high-quality and sustainable mobility and transport to, through and within the urban area. It regards the needs of the 'functioning city' and its hinterland rather than a municipal administrative region" [15]. In order to fulfil such a defined goal, the SUMP should contribute to the development of an urban transport system which:

- is accessible and supports the mobility needs of all users,
- allows for better integration of modes of transport,
- follows the concept of sustainable development, taking into account economic, social and environmental factors,
- efficient, cost effective and allows for better use of the existing infrastructure,
- allows for the reduction of negative externalities (e.g. air and noise pollution) and an increase in traffic safety making cities more attractive places to live and work,
- allows for the overall better performance of Europe's transport system [15].

3. A new way of planning urban mobility - SUMPs

The concept of transport planning through mobility management is associated with the formation of such a transport system in urban areas that, on the one hand will increase the accessibility of particular areas and services, representing an important impulse for development, and on the other hand will contribute to improvement of the quality of life for the public and the environment. Transport infrastructure and transportation means are the tools facilitating movements but cannot be considered as a way to create mobility. The idea of mobility planning is based, among others, on the fact that the high economic and social costs of constructing transport infrastructure often prove to be ineffective. Expansion of road infrastructure in order to increase its capacity and reduce congestion often turns out to be

only a short-term solution. Therefore, actions undertaken should demonstrate how to create an efficient urban transport system, using all available resources and taking into account the need to promote clean and energy efficient modes of transport. It is important to plan the necessary investments in the transport infrastructure with both the increasing accessibility of key destinations and services in mind and taking into account the principles of sustainable development.

Assuring sustainable mobility requires the implementation of measures in different spheres of city and society development and often goes beyond the area of transport. The differences between traditional transport planning and sustainable urban mobility planning are presented in table 1 [16].

Table 1. Differences between traditional transport planning and sustainable urban mobility planning [16]

Criteria	Traditional Transport Planning	Sustainable Urban Mobility Planning
Focus	**On traffic**	**On people**
Primary objectives	Traffic flow capacity and speed	Accessibility and quality of life, as well as sustainability, economic viability, social equity, health and environmental quality
	Modal-focused	Balanced development of all relevant transport modes and shift towards cleaner and more sustainable transport modes
	Infrastructure focus	An integrated set of actions to achieve cost-effective solutions
Type of document	Sectorial planning document	A sectorial planning document that is consistent and complementary to the related policy area (e.g. land use and spatial planning, health, social services and others)
Time frame	Short- and medium-term delivery plan	Short- and medium-term delivery plan embedded in a long-term vision and strategy
Relates to	An administrative area	A functioning area based on travel-to-work patterns
Prepared by	Traffic engineers	Interdisciplinary planning teams
Participation	Planning by experts	Planning with the involvement of stakeholders using a transparent and participatory approach
Monitoring	Limited impact assessment	Regular monitoring and evaluation of impacts to inform a structured learning and improvement process

Despite European Union guidelines presented in table 1, the scope and advancement of the activities related to the planning and implementation of sustainable urban mobility vary significantly between individual Member States [17]. For example in Poland, the Public Transport Act sets a requirement for municipalities with more than 50 thousand residents and counties with more than 80 thousand residents for development and adoption of the plan for the sustainable development of public transport [18]. As in the case of traditional transport planning, the scope and extent of the plan for the sustainable development of public transport are different from sustainable urban mobility planning. The differences between the plan for the sustainable development of public transport and sustainable urban mobility planning are presented in table 2 [19].

Table 2. Differences between the plan for the sustainable development of public transport and sustainable urban mobility planning [19]

Criteria	Plan for the sustainable development of public transport	Sustainable Urban Mobility Planning
Focus	Public urban transport	All means of transport with particular emphasis on non-motorised transport
Aim	Development of infrastructure and a transport system focused mainly on collective transport	Raising the competitiveness of public transport, cycling and improving conditions for pedestrians and people with reduced mobility
Objectives	Limited to transport	Taking into account the demand for the quality of life in a comprehensive manner
Integration level	Relatively low, including transport and technical infrastructure	Wide, taking into account land use planning and social policy. Importance of optimizing the existing infrastructure is stressed.
Institutional cooperation	Cooperation limited to what is required	The wide range of cooperation between institutions, also including ones outside the transport sector
Participation	Usually limited to the legally required public consultations following the preparation of the document	Comprehensive at each stage of the plan's development

One of the key conditions for creating a sustainable mobile city is the involvement of all stakeholders, with particular emphasis on residents. Raising awareness among residents about the importance of creating urban public space friendly towards urban mobility for increasing the quality of living in cities is an important part of creating sustainable urban mobility. It is necessary to promote awareness among the inhabitants, by showing them how their decisions concerning the choice of route and mode of transport in the city influence the development of the city. Educational and promotional activities aimed at changing transportation habits of individuals and encouraging more universal use of public collective transport for daily travel are needed. Creating sustainable urban mobility requires the identification of existing barriers and proposals for appropriate actions, which could eliminate or reduce their negative impact.

4. Use of transport telematics in urban mobility

Activities related to the provision of sustainable urban mobility aim to either increase the efficiency of the transport system through better use of the existing infrastructure or to reduce its negative influence on the community and the environment [20].

Challenges of urban mobility, recommended solutions and the potential correlation between them are presented in table 3 [16].

Table 3. Challenges of urban mobility, potential solutions and their correlation [16]

Solutions	Challenges					
	Health	Congestion	Safety & security	Participation	Strategic planning	Global climate change
Clean fuels and vehicles	++++	+	+	+	++	+++
Urban freight	++++	+++	+++	+++	+++	++
Demand management strategies	++++	++++	++	++++	+++	+++
Access restrictions, environmental zones	++++	++++	++	++++	+++	+++
Congestion charges	+++	++++	++	++++	+++	+++
Mobility management	++	++++	+	++++	+++	+++
Mobility agency	++	++++	+	++++	+++	+++
Ecopoints	++	++++	+	++++	+++	+++
Collective transport	++	+++	++++	+++	+++	++
New forms of public transport services	++	++++	+++	+++	+++	+++
Access for the elderly, disabled passengers	+++	+	++++	+++	+++	++
Integration of modes of transport	++	+++	+++	+++	+++	+++
Transport telematics	+	++++	+++	+	+	++
E-Ticketing	+	++	+	+	+	++
Traffic management and control	++	++++	+++	+	+	+++
Travel and passenger information	++	++++	+++	+	+	++
Less car-dependent mobility options	+++	+++	++++	++++	+++	+++
Car-sharing	++++	+++	+++	++++	+++	+++
Carpooling	+	++++	+++	+++	++	+++
Walking and cycling	++++	++++	++++	++++	+++	++++
Sustainable Urban Mobility Plans	++++	++++	++++	++++	++++	++

The teleinformatic solutions recommended to be used in supporting the implementation of the objectives of sustainable urban mobility will be further discussed, especially the recommended transport telematics solutions (e-ticketing, traffic management and control, travel and passenger information). Some of the proposed solutions for urban mobility challenges not relevant to the transport telematics category also strongly depend on the implementation of teleinformatic technologies. The best examples of that are: integration of public urban transport and shared-mobility systems like car-sharing or carpooling. It should also be emphasised that these solutions complement each other and enable better integration of modes of transport, especially with collective public urban transport.

The authorities of modern agglomerations are particularly interested in the development of public transport with the implementation of advanced technical and organisational solutions. Such an approach is consistent with the general trend, visible not only in Poland, but also in the European Union and in the rest of the world. Advancement and implementation of environmentally-friendly integrated transport solutions are seen as an opportunity to reduce road congestion caused by the mass use of privately-owned vehicles and to minimise the harmful impact of road transport on the environment. Because of that approach, transport telematics solutions supporting sustainable urban mobility will be mostly discussed from the perspective of their use in collective urban transport.

4.1. E-ticketing

Various cashless forms of payment, like contactless transactions or the possibility of purchasing tickets through the Internet are increasingly common in the transport sector, especially in urban collective public transport. In many Polish cities, electronic ticketing systems, in the form of city cards or by means of mobile telephony, are being implemented. The traditional system of ticket distribution, based on paper tickets, has numerous limitations, primarily in terms of the possibility of price differentiation or options for collecting – and later analysing – data about the demand for services. The traditional distributions systems usually have high maintenance costs [21][22].

Technological advances and solutions used in other areas of life make it possible to modify the methods of data storage used in collective public fare collection. The first electronic tickets arrived with the development of magnetic strip cards. Tickets with a magnetic strip have an advantage over traditional paper tickets but the possibility of accidental damage to the strip and the unreliability of readers are the reasons for them being replaced by newer and more reliable electronic cards. In the case of electronic cards there are two basic solutions: contact cards and contactless cards using such communication technologies as RFID (Radio Frequency Identifier) or NFC (Near Field Communication) [22] [23].

With the increasing availability and the widespread use of personal mobile devices, solutions that allow passengers to pay with them for the journey are becoming more and more popular. Several basic types of mobile tickets can be distinguished: tickets using SMS messages, tickets using optical character recognition technology (OCR) and QR codes, tickets stored in memory or a

special application on the mobile device being read using NCF technology [24].

All the types of tickets described differ also in terms of the required infrastructure, the associated costs and the ways in which they are sold. In the case of paper tickets, magnetic and electronic cards sale outlets (personal and automated) and adequate infrastructure for validating tickets are required - which translates into costs associated with employing suitably qualified staff as well as maintenance and the possible modification/extension of infrastructure. In the case of mobile tickets, a large portion of the costs associated with the sale of tickets and the infrastructure necessary to validate their use is covered by users [25].

4.2. Traffic management and control

Urban traffic management and control systems (UTMC) as a solution are part of Intelligent Transport Systems (ITS), consisting of various types of devices and sensors for the collection and transmission of data, databases created on that basis, software supporting various aspects of urban transport management and their mutual feedback. Examples of UTMC applications in urban transport include: management of urban traffic, management of public transport, accident management, providing traffic information to travellers, management systems for road tolls and fees for the use of transport services and automatic registration of traffic violations. An effectively functioning system of urban transport management requires appropriate infrastructure and integration of the various systems mentioned [26].

The main task of telematics transport technology as a tool for the effective management of the urban transport system is information management. Enhanced quality of the transport system and increased ability to control resulting from the efficient management of information flows increase the overall performance of the whole urban transport system. In addition, the solutions applied allow for the collection of a large amount of detailed information (about vehicles, passengers, loads on individual lines, accidents, traffic jams, etc.). This information not only supports decision making in the institutions responsible for the effective functioning of the urban transport system, but can also be the basis for creating various types of applications supporting the decision-making of passengers (which are described in more detail later on) [27].

4.3. Travel and passenger information

Availability of information on possible means of transportation in an urban area can have a significant impact on the choice made by passengers, particularly in the case of collective public urban transport and its interchange points with other modes of transport (e.g. location of interchange points or location of Park & Ride parking). The basic passenger information system allows only for one-way communication to the passenger, providing him with information about the functioning of the urban transport system. The opportunity to establish and maintain communication with the passenger is essential for providing high quality services and monitoring the performance of the urban transport system. Two-way communication allows service providers to convey relevant information to the customers/passengers (e.g. about planned changes to the timetable) and customers to relay their comments and assessments concerning the provision of transport services.

Transport service providers can use different communication channels to provide passengers with relevant information. The form, completeness and timeliness of information available to passengers significantly affect the attractiveness of the services offered. The information can be made available to passengers in different ways, e.g. on the bus stop, in the vehicle, by telephone or via the Internet (which is becoming more important with the growing popularity of mobile devices that allow users access to the Internet at any time and place). Information concerning disruption in the provision of collective public transport services or urban transport systems are of greatest interest to passengers [28].

The Real-Time Passenger Information System (RTPIS) is one of the commonly used elements of modern urban public transport. The main task of the RTPIS is to inform passengers about current arrivals and departures from a particular bus stop and on the possible interchanges with different lines or different modes of transport. Passenger information is usually presented in a visual form on electronic boards specially designed for this purpose (LED/LCD), located at bus stops or in public transport vehicles [29]. The information presented usually includes updated real-time arrivals and departures depending on the traffic load (using information provided by compatible onboard equipment installed in public transport vehicles) as well as other information such as stop name, line number, direction, special messages (information on traffic jams, diversions, ticket prices, etc.) and advertisements [30].

Internet timetables are also becoming a common feature of urban passenger information systems. If the RTPIS is in use in a given city, usually the same information can be accessed on the Internet or with the use of a dedicated mobile application. [31].

4.4. Shared-mobility solutions for urban mobility

The use of teleinformatic solutions facilitates, or even in some cases, enables shared use of the vehicle by multiple users. Such solutions may involve different vehicles (mainly cars and bicycles) and may by organised by various institutions (public transport operators, businesses, or individuals).

In the case of programs based on the concept of single car use by many users, there are more options. Car-sharing schemes may be offered by commercial entities, individuals, or even as part of public urban transport [32]. In the latter case, there are several options: car-sharing (when one vehicle is used by several people at different times), carpooling (when several people use the same vehicle at the same time to reduce costs), taxi-sharing (when several people decide on a joint journey by taxi) [me]. All solutions allow use of the vehicle, but without the expense and responsibilities associated with ownership of a private vehicle. These solutions differ from each other in terms of use, possibilities of use, payment options, reasons for use and usually typical length of the journey. Also, the type of vehicle (due to the type of drive) a way to access the vehicle (point-to-point or free-floating) will change between the solutions used in different cities [33]. Vehicle-sharing schemes

potentially reduce the number of vehicles involved in traffic and traffic load for other participants and the environment, but it is not an ideal solution as it further requires the allocation of public space for the infrastructure needed by cars (e.g. dedicated parking spaces).

Most of the available car-sharing and car pooling schemes are based on modern information and communication technologies and, increasingly rely on mobile applications, allowing for booking the vehicle, access to and opening of the vehicle and the settlement of user fees. The growing popularity of social media facilitates peer-to-peer car-sharing initiatives, allowing owners to share a private vehicle at a time when it is not in use [34]. At times car-sharing or carpooling schemes are part of the public transport system and can be used with Citicard as an extension of collective urban transport. From the point of view of the public transport authorities, the most attractive are those car-sharing schemes that use more fuel efficient cars such as hybrid cars or electric vehicles (EVs). Public transport authorities may decide on financial support for such solutions, not only because of the lower environmental impact of EVs, but also to allow potential customers to try this type of vehicle before the possible purchase [35] [36].

5. Conclusion

Ensuring sustainable urban mobility is not a simple task and is associated with overcoming the many challenges of urban transport, including: traffic congestion and parking difficulties, longer commuting, public transport inadequacy, difficulties for non-motorised transport, loss of public space, high maintenance costs, environmental impacts and energy consumption, accidents and safety, land consumption and freight distribution [37].

Activities related to the provision of sustainable urban mobility while reducing the negative impacts of transport are increasingly of interest to both scientists and policy makers at EU and local level. Unfortunately, research carried out within the framework of Eurobarometer 406 on the attitudes of citizens of the European Union shows that ensuring sustainable urban mobility will not be all that easy. Table 4 identifies the main results of the Eurobarometer on urban mobility [38].

Table 3. Main findings of Eurobarometer 406 concerning attitudes of Europeans towards urban mobility [38]

%	Findings	Perspective
50%	Europeans use a car everyday	Problem
38%	Europeans encounter problems when travelling within cities	Problem
81% 76% 74% 73% 72%	European believe that: – air pollution – road congestion – travelling costs – accidents – noise pollution are important problems within cities.	Chance
56% 59%	Europeans believe that: – better urban transport – lower price for urban transport would be the best ways to improve urban travel.	Chance
37%	Europeans believe that the urban traffic situation will get worse.	Problem

The findings clearly indicate that European citizens are not overall optimistic about the situation regarding the urban transport system and that there is still a lot to do in that respect. The actions mentioned both in European Union documents as well as by the academic community indicate the four main areas of action: the use of modern technology, adaptation and adjustment of prices to take into account the external costs of transport, integrating land-use planning with transport policies and assuring social acceptance of mobility solutions [39].

Transport telematics solutions described in the article are in line with the recommendation for investment and implementation of modern technologies in order to facilitate sustainable urban mobility (e.g. by more efficient management of urban transport systems or increasing integration of public urban collective transport) and/or to minimise the negative externalities of the urban transport system for the environment (e.g. by facilitating the use of such shared-mobility solutions as car-sharing or carpooling).

Bibliography

[1] DECKER, B., HEĆIMOVIĆ, H., WOŁEK M.: Sustainable Urban Mobility Planning in Central Eastern Europe: case examples from Poland and Croatia. Procedia - Social and Behavioral Sciences (2012). [On-line]. 48. Available: doi: 10.1016/j.sbspro.2012.06.1244 [date of access: 27.01.2017]

[2] Eurostat. Eurostat regional yearbook 2015. Internet: http://ec.europa.eu/eurostat/documents/3217494/7018888/KS-HA-15-001-EN-N.pdf/6f0d4095-5e7a-4aab-af28-d255e2bcb395, 2015 [date of access: 31.01.2017]

[3] European Environment Agency. Urban environment. Internet: http://www.eea.europa.eu/themes/urban/intro, Jun. 3, 2016 [date of access: 31.01.2017]

[4] MIKULSKI, J.: The possibility of using telematics in urban transportation, in Mikulski J. (ed) Modern Transport Telematics, Springer Verlag, Berlin Heidelberg, CCIS 239 (2011)

[5] WYDRO, K.: Telematyka – znaczenie i definicja terminu. Telekomunikacja i techniki informacyjne, 1-2, pp. 116-130, 2005.

[6] BARTCZAK, K.: Technologie informatyczne i telekomunikacyjne jako podstawa tworzenia systemów telematycznych w transporcie, in Współczesne procesy i zjawiska w transporcie, E. Załoga, Ed. Szczecin: Wydawnictwo Uniwersytetu Szczecińskiego, 2006, pp. 10-20.

[7] World Commission on Environment and Development (WCED). Our Common Future. Suffolk: Oxford University Press, 1987.

[8] Ustawa Prawo Ochrony Środowiska z dnia 27 kwietnia 2001 roku (Dz.U. 2001, nr 62, poz. 627, Art. 3). Internet: http://isap.sejm.gov.pl/DetailsServlet?id=WDU20010620627 [Feb. 1, 2017]

[9] PAWŁOWSKA B.: Zrównoważony rozwój transportu na tle współczesnych procesów społeczno-gospodarczych. Gdańsk: Wydawnictwo Uniwersytetu Gdańskiego, 2013.

[10] [m5] Regulation (EU) No 1303/2013 of the European Parliament and of the Council of 17 December 2013 laying down common provisions on the European Regional Development Fund, the European Social Fund, the Cohesion Fund, the European

Agricultural Fund for Rural Development and the European Maritime and Fisheries Fund and laying down general provisions on the European Regional Development Fund, the European Social Fund, the Cohesion Fund and the European Maritime and Fisheries Fund and repealing Council Regulation (EC) No 1083/2006. Internet: http://data.europa.eu/eli/reg/2013/1303/oj [date of access: 30.01.2017]

[11] European Commission. White Paper Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, COM(2011) 144 final. Brussels. Internet: http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52011DC0144, Mar. 28,2011 [date of access: 30.01.2017]

[12] European Commission. Green Paper - Towards a new culture for urban mobility, COM(2007) 551 final. Brussels. Internet: http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52007DC0551, Sep. 25, 2007 [date of access: 30.01.2017]

[13] European Commission. Action Plan on Urban Mobility, COM(2009) 490 final, Brussels, Internet: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52009DC0490, Sep. 9, 2009 [date of access: 30.01.2017]

[14] European Commission. Together towards competitive and resource-efficient urban mobility, COM(2013) 913 final, Brussels. Internet: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52013DC0913, Dec. 12, 2013 [date of access: 30.01.2017]

[15] European Commission. Annex a Concept for Sustainable Urban Mobility Plans to the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Together towards competitive and resource-efficient urban mobility, COM(2013) 913 final, Brussels. Internet: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52013DC0913, Dec. 17, 2013 [date of access: 5.02.2017]

[16] WEFERING, F., et al.: Guidelines. Developing and Implementing a Sustainable Urban Mobility Plan, Rupprecht Consult-Forschung and Beratung GmbH, European Commission Directorate – General for Mobility and Transport, Brussels, 2014.

[17] Eltis, The urban mobility observatory. Member State profiles. Internet: http://www.eltis.org/mobility-plans/member-state-profiles [date of access: 9.02.2017]

[18] Ustawa o publicznym transporcie zbiorowym z dnia 16 grudnia 2010 roku (Dz.U. 2011 nr 5 poz. 13). Internet: http://isap.sejm.gov.pl/DetailsServlet?id=WDU20110050013 [date of access: 5.02.2017]

[19] WOŁEK, M.: Planowanie zrównoważonej mobilności miejskiej w Polsce i w Europie. Technika Transportu Szynowego, No. 10 (259), pp. 20-24, 2015.

[20] KOS-ŁABĘDOWICZ, J.: ICT and the Future of Urban Transportation. European Perspective, in Mikulski J. (ed) Challenge of Transport Telematics, Springer Verlag, Berlin Heidelberg, CCIS 640 (2016)

[21] AMPÉLAS, A.: Automatic fare collection, in 2001 IEEE Intelligent Transportation Systems Proceedings, 2001, pp. 1164-1166.

[22] URBANEK, A.: Pricing Policy After the Implementation of Electronic Ticketing Technology in Public Urban Transport: An Exploratory Study in Poland, in Mikulski J. (ed) Telematics - Support for Transport, Springer Verlag, Berlin Heidelberg, CCIS 471 (2014) pp. 322-332

[23] KOS-ŁABĘDOWICZ, J.: Integrated E-ticketing System – Possibilities of Introduction in EU, in Mikulski J. (ed) Telematics - Support for Transport, Springer Verlag, Berlin Heidelberg, CCIS 471 (2014), pp. 376-385

[24] PUHE, M., EDELMANN, M., REICHENBACH. M., Integrated urban e-ticketing for public transport and touristic sites final report on application concepts and the role of involved stakeholders. Internet: http://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/513551/IPOL-JOIN_ET(2014)513551_EN.pdf, Jan. 2014 [date of access: 10.02.2017]

[25] FERREIRA, M.C. NÓVOA, H., DIAS, T.G. CUNHA, J.F.: A Proposal for a Public Transport Ticketing Solution based on Customers' Mobile Devices. Procedia - Social and Behavioral Sciences (2014). [On-line]. 111. Available: doi:10.1016/j.sbspro.2014.01.056 [date of access: 10.02.2017]

[26] JAMROZ, K., OSKARBSKI, J.: Inteligentny system transportu dla aglomeracji trójmiejskiej. Telekomunikacja i techniki informacyjne, 1-2, pp. 66-76, 2009.

[27] MACIOSZEK, E.: Architecture of intelligent transportation systems in the world and in Poland. Archives of Transport System Telematics. Vol. 7, Iss. 3, pp. 22-26, 2014.

[28] LUBIENIECKA-KOCOŃ, K., et al.: Modern tools of passenger public transport integration. in Mikulski J. (ed) Activities of Transport Telematics, Springer Verlag, Berlin Heidelberg, CCIS 395 (2013) pp. 81–88

[29] ROJOWSKI, R., GANCARZ. T.: System dynamicznej informacji pasażerskiej. Autobusy: technika, eksploatacja, systemy transportowe. R. 10, Nr 4, pp.24-32, 2009.

[30] CHANDURKAR, S., et al.: Implementation of real time bus minitoring and passenger information system. IJSRP. [On-line]. Vol. 3, Iss.5. Available: http://www.ijsrp.org/research-paper-0513/ijsrp-p1716.pdf [date of access: 8.02.2017]

[31] PARK, D., KIM H.: SBISURBAN - Secure Urban Bus Information System based on Smart Devices. International Journal of Security and Its Applications (2015). [On-line]. Vol. 9, No. 1. Available: http://dx.doi.org/10.14257/ijsia.2015.9.1.21 [date of access: 8.02.2017]

[32] SILVA CRUZ, I., KATZ-GERRO T.: Urban public transport companies and strategies to promote sustainable consumption practices. Journal of Cleaner Production (2016). [On-line]. Available: doi: 10.1016/j.jclepro.2015.12.007

[33] FIRNKORN, J., MÜLLER. M.: Free-floating electric carsharing-fleets in smart cities: The dawning of post-private car era in urban environments?. Environmental Science & Policy, 45, pp. 30-40, 2015.

[34] SHAHEEN, S., MALLERY, M., KINGSLEY, K.: Personal vehicle sharing services in North America. Research in Transportation Business & Management, 3, pp. 71-81, 2012.

[35] YSTMARK BJERKANA, K., et al.: Incentives for promoting Battery Electric Vehicle (BEV) adoption in Norway. Transportation Research Part D, Vol. 43, pp. 169–180, 2016.
[36] KIM, D., KO, J., PARK, Y.: Factors affecting electric vehicle sharing program participants' attitudes about car ownership and program participation. Transportation Research Part D, 36, pp. 96-106, 2015.
[37] RODRIGUE, J.-P.: Urban transport challenges. Internet: http://people.hofstra.edu/geotrans/eng/ch6en/conc6en/ch6c4en.html, 2013 [date of access: 10.02.2017]
[38] European Commission. Attittudes of Europeans towards urban mobility, Report. Special Eurobarometer. [On-line]. 406. Available: http://ec.europa.eu/public_opinion/archives/ebs/ebs_406_en.pdf [date of access: 10.02.2017]
[39] BANISTER, D.: The sustainable mobility paradigm. Transport Policy, 15, pp. 73-80, 2008. doi:10.1016/j.tranpol.2007.10.005.