Technical paper 8

Interregional European Cooperation platform to promote sustainable transport through ICT – an overview of best practices

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1 Introduction

The use of IT tools in transport has brought significant improvement in transport systems performance and it is a key element in reducing carbon footprint as well as increasing the sustainability on an urban scale. The increasing road transport volumes in the EU are the primary cause of growing congestion and rising energy consumption, as well as a source of environmental and social problems (EC, 2011b). According to EC, ITS can contribute to the main transport policy objectives by reducing environmental impacts and save energy through better demand management. Therefore, the primary goals for urban transport should be the promotion of cleaner cars and fuels and the reduction of road accidents and traffic congestion. ITS tools can have a significant role to a cleaner, safer and more efficient transport system. EC with the ITS Directive (2010/40/EU) gave the necessary legal framework to their member states to accelerate the implementation of smart technologies in transport sector, giving the freedom to each country to decide their priorities (Urban ITS Expert Group, 2013).

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Regarding the mobility sector there is a clear lack of well-structured policy guidelines policy guidelines that leverages the use of ICT, sensing systems and big data to promote a more sustainable use of infrastructures. Specifically, there is still a wastage of available resources for estimation real time mobility impacts and an even a more obvious inability to use this information to implement sustainable mobility policies. The concept of sustainability in CISMOB concerns not only the carbon footprint but also the local economy and the social dimension, including active transport networks, users and the rest of citizens. Against this background, CISMOB partnership was developed in order to collect new ideas and practical experience.

1.1 Project objectives

The main goal of the Interregional European Cooperation project CISMOB is to improve the implementation of regional policies with the ultimate goal of reducing carbon footprint. This goal will be achieved by promoting the efficiency in the use of urban transport infrastructure through ICT. Low carbon essentially means less energy consumption and therefore, a more efficient use of infrastructure. However, this optimization must be performed based on a holistic perspective integrating other environmental externalities (noise, other atmospheric pollutants), ensuring equitability, and social cohesion throughout proactively addressing specific local environmental and social vulnerabilities. Subsequently, CISMOB seeks to exchange regional level experiences in developing win-win strategies to achieve common benefits in reducing mobility related carbon footprint. The strategies should be supported by the innovative technology sector, which shall provide tools to increase the promotion of sustainable multimodal urban mobility and mitigate transport related environmental and social impacts. This objective is logically targeted at competent local and regional public authorities. However, universities will have a key role by influencing local policy instruments and promoting the collaboration with innovative SMES.

The composition of CISMOB partnership was created in order to deepen the relations between regional authorities, universities and stakeholders on a European level, bringing together different regional experiences in the field of smart, low-carbon and sustainable mobility management. The partners are: University of Aveiro (PT); Stockholm University (SW), City of Águeda (PT), ITS-Romania (RO), Bucharest Transport Metropolitan Authority URO), and Agency of Energy of Extremadura (SP).

The paper is organized as follows. Section 2 describes the process of exchange of experience in the context of interregional cooperation and Section 3 summarizes a set of good practices identified in the course of cooperation. In Section 4, future directions of the project are pointed out.

2 Methodology

2.1 Achieving Policy Change

The process for achieving policy change will occur at different levels over an iterative exchange of expertise program. This process includes a set of learning events, which will lead to the development of a set of technical documents and action plans for policy improvement. Firstly, a Baseline Assessment Report (BAR) will be prepared For evaluating i) how ICT and sensor technology are used in the transportation system and, ii) how carbon footprint and sustainability indicators are considered in the European regions represented by CISMOB partners.

BAR will identify Good Practices across the CISMOB Partnership and classify them, namely, in which Extent they can be transferred for other Cities and Regions with different scales. This action fosters the knowledge at individual and organizational level (1 and 2). During the first phase of the project timeline, three

Building Capacity Workshops (BCW) and three Thematic Seminars will be performed. The BCW will be organized by local Authorities/Agencies. These events will address project's outputs and share each partner's best Practices to partner's staff and key stakeholders. The thematic seminars, organized by universities and research institutions aims at providing participants with state of the art information (at global level) in the area of capacity building toolkits, ICT and e-governance, as well as to promote social cohesion and urban sustainability (Stockholm University); monitoring and online impacts assessment (University of Aveiro), promotion of intelligent transport systems towards a low carbon mobility (ITS Romania).

It should be highlighted that both the weaknesses and best practices identified in the BAR will influence the content for these regional events. Conversely, working groups integrating key staff of each partner will develop semiannually technical papers pointing out the best practices found in each region, taking also advantage of the scientific, technical and empirical knowledge shared by research institutions and stakeholders. These actions will broaden the level of knowledge acquisition to the third level since regional stakeholders will actively participate in the learning process.

CISMOB will also support staff exchange programs. Staff from academic institutions will learn experiences in the real world with local authorities. In turn, local authority staff will have the opportunity to exchange experiences in other regions as well as to acquire specific skills and techniques in R&D institutions. The outputs of the exchange of experience process will be consolidated in the project agenda entitled "ICT Towards Low Carbon and Sustainable Mobility a Multiscale perspective". This document will be the framework for the development of regional action plans and it will enable the dissemination of knowledge beyond the Boundaries of the regions involved in the project (Level 4).

2.2 Stakeholder Engagement

The focus of CISMOB is the engagement of pertinent stakeholders (decision and policy makers and all relevant actors, with a particular focus on ICT and transport sector) in order to speed up decision making for the advance of policies for implementation of ICT measures in transport and contributing to mitigate transport related impacts in the consortium regions. Fig.1 summarizes some stakeholder groups and their main interests.

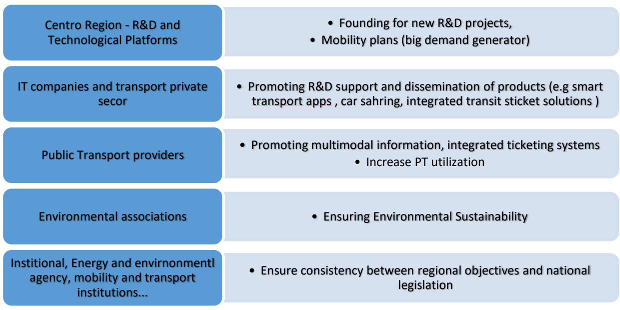

Figure 1. Example of regional stakeholder groups and their interests.

3 Exchange of Experience

3.1 Identification of Good Practices

Intelligent Transport Systems (ITS) deploy a wide range of Information and Communication Technologies to transport sector [4]. The implementation of IT tools in transport has brought significant improvement in transport systems performance and it is a key element in reducing carbon footprint. The increasing road transport volumes in the EU are the primary cause of growing congestion and energy consumption and the main cause of environmental and social issues [5]. According to EC, ITS can contribute to the main transport policy objectives by reducing environmental impacts and save energy through better demand management. Therefore, the primary goals for urban transport should be the promotion of cleaner cars and fuels and the reduction of road accidents and traffic congestion. ITS tools can have a significant role to a cleaner, safer and more efficient transport system. EC with the ITS Directive (2010/40/EU) gave the necessary legal framework to their member states to accelerate the implementation of smart technologies in transport sector, giving the freedom to each country to decide their priorities [25].

Available ITS tools vary in technologies applied, from basic management systems such as car navigation and traffic signal control systems to more advanced applications that enables the use of real-time data and involve various technologies, such as: software and sensor technologies, wireless communications, computing technologies; floating car data/floating cellular data and sensing technologies [26]. ITS applications are possible to be subdivided in four main branches based on their implementation in different aspects of transportation management: i) Advanced Traveler Information System (ATIS), ii) Advanced Public Transportation System (APTMS), iii) Advanced Traffic Management System (ATMS) and iv) Emergency Management System (EMC).

Numerous communication technologies, such as internet, cellular phones, radio, etc. are implemented in ATIS to assist road users in decision making regarding travel mode and transit route choice [22]. ATIS main aim is to provide real-time information to the commuters to improve their travel experience Trip information helps travelers and drivers in making better decision and contributes in travel time savings, mitigating congestion, reducing CO2 emissions, and relieving urban environments. ATMS is concerned with managing and controlling traffic by using real-time information to optimize the vehicles flow and is usually used by traffic police department and traffic regulation authorities. These systems seek to manage congested traffic situations by improving the efficiency of utilization of existing infrastructures. APTS is applied in public transport systems to increase their operational efficiency, reliability, and the quality of service. The use of APTS in public transport aims at providing decisions makers with more information to achieve better management of available fleets and encourage the commuters to use public transport instead of private cars. The most common examples of APTS applications are real-time passenger information systems, vehicle location systems and bus arrival notification systems. EMS is a valuable tool to deal with emergency situations in roads, as its main focus is to develop a safer transport system. The use of EMS applications can result in improved management of the emergency, as it provides the ability to transport authorities and health services to communicate and coordinate operations and resources in real-time. So far, there are only few ITS systems that focus on environmental objectives, although dealing with other transport externalities could contribute in reducing adverse environmental effects. The next sections summarize some identified good practices that may enable to a better network environmental performance through a shift to public transport in (3.2-3-4), through a more sustainable use of existing infrastructures in private vehicles (section 3.6-3.10), and through a modal shift to soft modes (3.11).

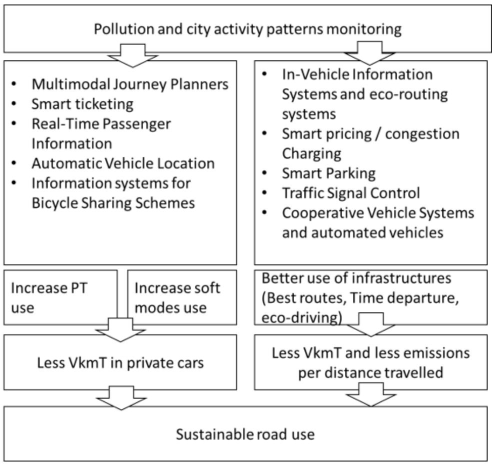

Fig. 2 Categorization of IT measures and its contribution for transport sustainability

3.2 Multimodal Journey Planners

A Multimodal Journey Planner is a software application usually accessible on computers and smartphones that provides pre-trip travel plan information to users allowing them to use multiple modes of public and private transport [23]. Over the past few years, many real-time trip planners were developed to overcome the possibility of inaccurate travel plans by taking into account delays caused of accidents, traffic congestion etc. Multimodal Journey Planners, in order to promote sustainable mobility and the use of public transport, provide door-to-door routing with visual maps, information on how to change between modes and allow commuters to easily book and pay for their journey (e.g., with the use of the application or by providing integrated tickets).

Multimodal journey planning systems and services are usually operated by transport authorities or city regions in a small scale (cities) or in a bigger scale (countries). There is also an alternative approach, where city authorities, governments, transport service providers and network and fleet operators provide their own data under a standardized data exchange format and allow private companies to use it in order to develop applications for journey planning like in Trafiklab, Stockholm (Sweden). Well known examples of journey planners are, Destineo (France), FromAtoB (Europe), Google Transit (with varying coverage around the planet), MOTUS (Milan, Italy, a real-time information system for public transport in case of delays and service disruptions), Onlymoov (Lyon, France), Rome2rio (international), Trafiken (for specific cities in Sweden),Transport for London (London, United Kingdom), Wisetrip (international).

3.3 Smart Ticketing

Smart ticketing systems are recently gaining attention as new technologies that can improve overall efficiency, level of service and attractiveness of public transport. Nowadays electronic ticketing schemes can easily be used through smart cards of mobile phones, although they are limited geographically inside a metropolitan area. The implementation of smart ticketing systems across Europe can contribute to the overall improvement of public transport and to the political goal of developing a sustainable transport policy [25]. It has the potential to achieve a significant modal shift from private cars and resulting in reducing congestion, noise pollution and vehicle emissions and in a lower carbon footprint [1]. In London, the introduction of the Oyster Card in 2003 has contributed to the increase of the distances travelled on public transport by 45% between 2000 and 2010 [9].

However, the overall vision of the development of smart ticketing schemes should be the possibility of users to combine trips and services, enabling interoperability between different transport modes with the same ticket or with different tickets on the same smart support system [25]. The integration of smart ticketing into Multimodal Journey Planners could promote the use of public transport even more. The use of internet tools and information services for providing real-time information to commuters could support the vision of smart ticketing by improving the travel experience. The aim of integrating ticketing is to encourage people to use public transport by allowing them to change transport modes easily and by increasing the efficiency of the services. Furthermore, cities in order to enhance the use of smart ticketing, should offer an attractive and simple system, combined with reasonable prices and easily accessible with sales points distributed throughout the city or through internet and mobile phones (BOKU, 2010). Some identified best practices in the area of smart ticketing are BOB Card (Bremen, Germany), E-ticket (Riga, Latvia), Octopus Card (Hong-Kong), OV-Chipkaart (Nederlands), is a contactless smart card system used for all public transport in Oyster Card (London, United Kingdom).

3.4 Real-Time Passenger Information

Travel information is a key aspect of ITS deployment in public transport. As already mentioned, the real-time passenger information systems are a common application of AVL tools. These systems can provide information about arrivals and departures times of public transport vehicles base on AVL data, through visual, voice or touchable media on street displays or available online. Even more, they could inform travelers about delays, alternative route or mode choices, the available capacity of vehicles etc. Real time information about all the available transport modes and services allows users to manage efficiently their journey by taking into account their own preferences (e.g., choosing modes with greater capacity or faster routes, etc.)

Transit authorities by providing real time information to commuters about their services enhance their reliability and encourage greater use of public transport. The need for high quality and up-to-date information is essential to maintain the competitive position of public transport relative to private vehicle. IT role is to increase the availability and quality of the required data and contributes in that way to the creation of a more integrated transport system that will promote sustainable mobility.

3.5 Automatic Vehicle Location

ITS have an important role to play in modal shift, as frequent services (27%), better coverage (26%) and cheaper or seasonal ticket options (25%) are the main reasons that could affect travellers to leave their cars and use public transport [24]. Automatic Vehicle Location (AVL) is one of the emerging applications in the field of public transport that could contribute in the overall improvement of its services. They have been increasingly used during the last years by public transport authorities in fleet management and in passenger information systems as a means of tracking the locations of vehicles in real-time [18].Tracking vehicle location is the most common function of AVL systems, giving to public transit authorities the possibility of real-time monitoring of their fleet and allow them to quickly respond to emergency situations in the field. The provision of accurate and reliable travel time and location information can also assist commuters in their travel decisions. By having knowledge of the expected arrival and departure times of vehicles, as well as on-route information can help them in gaining time savings and also result in making public transport services more attractive [20]. Moreover, AVL systems have the potential to increase operational performance, reduce cost of running services and fuel demand, improving the fleet management, minimizing traveling and waiting times and increase reliability by providing real-time information. Notable examples of AVL systems in public transport services are ATI - Saluzzo (Cuneo, Italy), Malmö, Sweden, city buses, Park for Truro (Truro, United Kingdom), and Sabimos (Almelo, Nederlands).

3.6 In-Vehicle Information Systems and Eco-routing Systems

Due to the increasing problems of traffic congestion in urban areas, information and communication systems are increasingly present in road vehicles. In-vehicle Information Systems (IVIS) include navigational and traffic information systems, warning and emergency help systems and can provide drivers with information such as road and traffic conditions, navigation information, emergency road conditions etc.

Real-time traffic information and navigational systems could promote fuel-efficient driving and reduce travel times. Drives base their route choices on real-time and accurate information about traffic conditions and road incidents that could cause delays. Real traffic information on road hazards ahead could reduce accidents, as it could provide type and location of incidents, inform about dangerous road conditions, and suggest alternative safer routes. Recent initiatives focus on developing a new approach called "eco-routing" that provides information about routes that require least amount of fuel and/or produces the least amount of emissions (e.g., MyFord Touch, Garmin, -etc.). The aforementioned systems are usually provided form the carmakers and data is collected from road sensors, transport authorities, etc. Research projects also developed eco-routing applications such as SMARTEDECISON in Portugal and in GREECE.

3.7 Electronic Fee Collection / Congestion Charging

Urban toll schemes were developed as a measure to decongest downtown areas, while the use of Electronic Fee Collection (EFC) systems and video recognition technologies was a revolutionary step toward that target. EFC systems offer the possibility of charging road vehicles in congested urban areas in a flexible way by electronically debits the accounts of the passing vehicles owners, aiming at eliminating the delay on toll roads.

The implementation of EFC systems could contribute in improving the speed and efficiency of traffic flows, travel time savings and reducing congestion and air pollution [19]. Moreover, they could play an essential role in the greening of transport as a way to influence traffic demand [4]. The main technologies used in EFC today across Europe today are the dedicated short range communications (wireless communication channels specifically designed for automotive use) and the video-based charging, which recognise the plate number of the vehicle automatically. Types of EFC are the Open Road Tolling, which allows the toll collection without the use of tollbooths and the GNSS (Global Navigation Satellite System) tolling with the use of sensors inside vehicles allowing tolling by distance. Examples of European EFC are AutoPass (Norway), Congestion Charge (London, United Kingdom), Milano Area C (Milan, Italy), Stockholm Congestion Charge (Stockholm, Sweden).

3.8 Smart Parking

Smart parking systems can improve the traffic flow, reduce congestion and fuel emissions, and contribute to the more efficient parking space management by helping to locate available on street parking places. Drivers searching for a vacant parking spot is an important factor to traffic congestion (up to 30%), while vehicles stuck in traffic result in air pollution and greenhouse gas emissions [8]. The more efficient approach in the management of street parking can minimize the need for investments in infrastructure and improve the use of the existing transport systems. Current transportation infrastructure and car parking facilities are unable to deal with number of vehicles on the streets and the extensive deployment of smart parking systems could be a key tool to reduce carbon footprint and improve sustainable mobility in urban areas, as they reduce parking's environmental footprint [16]. With the use of smart parking applications drivers could easily be guided to empty slots saving time and fuel, through a mobile app.

Sensors technologies are currently widely applied in smart parking systems as is entirely placed underground and do not interfere with road users or suffer from vandalism or extreme weather conditions. The sensors are able to detect the presence of vehicles and to inform the driver about the nearest available parking space. Although, the use of these systems are highly employed because of their high performance among operators of off-street parking lots, city wide monitoring of on-street parking space however is not as common [8] as they consume a significant amount of power to transfer the information [21] and require higher deployment costs. Some notable examples are SPIN (Street Parking Information Network) or SFpark

(San Francisco, United States). SFpark has significant impact in dealing with phenomena of overcrowding or low occupancy blocks [3].

3.9 Traffic Signal Control

Traffic Signal Control Systems were one of the first traffic management solutions used in urban areas. They function were based on fixed cycle times with their initial role inevitably limited in separating conflicting movements at individual junctions. The introduction of advanced technologies enables the development of features such as the use of traffic data to optimise traffic flow, public transport prioritization and the control and management of a wider network area. Traffic Signal Control Systems can contribute in improving vehicle journey times, reducing congestion, and promote the use of public transport, while the use of floating vehicle data and cellular data could minimize the need for road infrastructure (e.g., detectors) [13]. The most two common traffic management strategies are the dynamic control and the adaptive traffic control. In the first occasion, based on data from the detectors, traffic control centres can change the signal timing and phasing within the time limits of the programme giving priority to the lanes that are experienced heavy traffic. On the latter occasion, traffic signal timing is continuously adjusting based on real traffic demand, changing also the green time to each approach from cycle to cycle.

3.10 Pollution Monitors

The last few years a new approach in traffic management is employed aiming at optimizing traffic flow and minimizing air pollution. This innovative solution deploys air quality monitoring systems to measure air pollution and provide traffic management authorities with real-time data about vehicles emissions. The use of pollution monitors contributes in developing strategies to alleviate congested urban areas by redirecting traffic away from those areas [13]. The data collected from pollution monitors except of assisting transport authorities in deploying informed traffic strategies, can also influence transport policies, governments priorities and helping local authorities meeting their policy targets [7]. Notable examples of using pollution monitors for traffic management are: i) the Swansea Project (Swansea, United Kingdom) aimed to develop a working traffic emissions forecast model (Nowcaster) that would have the ability to estimate air quality conditions in advance, contributing in a more efficient traffic management control, and ii) Leicester Area Traffic Control Centre (Leicester, United Kingdom), which deploys 13 pollution monitors as traffic management tool [7].

3.11 Cooperative Vehicle Systems and Automated Vehicles

Cooperative Vehicle Systems are currently the main direction towards the future of ITS. Cooperative Intelligent Transport Systems (C-ITS) enable the direct interaction between vehicles, road infrastructure and transport authorities, allowing them to share data and information. This cooperation is empowered by mobile communication networks and aims at improving road safety, transport system efficiency, increasing sustainability and reducing air emissions.

The development of cooperative vehicle systems is also essential to increase the safety regarding the full integration of automated vehicles into transport systems, while major areas of ITS such as eco-driving and dynamic passengers information, could take advantage of the new capabilities [11]. The possibilities that will arise of their instalment, except the introduction of new innovative technologies, include also the more effective use of existing ITS. Cooperative vehicle systems can deploy various services such as hazardous location notifications, signage applications, navigation systems, traffic and parking information etc. [6]. Examples of cooperative vehicle systems are the truck platooning, emergency braking, optimal speed advice, etc.

In recent years, research focus on the development of vehicles that would take full advantage of the capabilities that are offered from the available ITS tools. Automated vehicles deploy a wide range of technologies and services as their function based on informed decision after exchanging data with other vehicles, infrastructure, or traffic centres. These technologies are able to guide the vehicles with minimal or no driver effort providing increased safety and mobility and environmental benefits, as the driving would be more secure, efficient and environmentally friendly. Among the anticipated benefits of automated cars would also be the reduction of road accidents and traffic congestion, the increase of traffic flow, the lower fuel consumption, the travel time savings, etc. [2].

Automated vehicles have the potential to change drastically transport systems. These technologies are also find application in public transport. For instance, CityMobil2 was a research project co-funded by the European Commission, designed to support current public transport systems. The project has conducted pilot programs of their driverless electric shuttles in urban areas, offering rides to travellers to bus stations, in order to continue their journey.

3.12 Bicycle Sharing Schemes

In recent years, transport planners and policy makers in order to achieve a modal shift from motorized transport to more environmentally friendly ways have set the promotion of cycling as a top priority [10]. Bicycles could be an alternative transport choice for daily commuters and a low-cost measure to alleviate transport issues, as their use contribute in reducing motor traffic volumes, less traffic noise and pollution, fewer traffic jams etc. However, only a small proportion of people choose to use a bike to cover their daily mobility needs due to their many disadvantages e.g. riding a bicycle is extremely dangerous and inconvenient especially during rush hour traffic and is not recommended in adverse weather conditions. Moreover, cycling requires a great physical effort and is slower than a private car or public transport, while the distance that a rider can travel depends greatly on these two factors [14].

Over the last few years, many cities have launched bike sharing programs in almost every region of the world, although until now they failed to fulfil their primary goal which was to establish cycling as a daily transportation mode. On the other hand, electric bicycles are a promising measure, as they could deal with various factors that limit traditional share systems such as the distance that can be covered, steep terrain, dispersed land use patterns, potential users' fitness and comfort levels or the level of effort that needs to be expended in making a trip [17]. A bike sharing scheme usually includes a series of ITS applications such as smart card access, automatic docks and stations, real time information about number of bicycles in use, capability of stations, etc. Some notable bike sharing programs are Vélib (Paris, France) - 23,600 bikes and almost 1,800 stations; Bicing (Barcelona, Spain) 6,000 bikes, 400 stations, OV-Fiets (Nederlands), (Gothenburg, Sweden) and Velo'v (Lyon, France) - self-service bike system with 4,000 rental bikes found at 348 stations.

4 Concluding remarks and Future Work

Simulations from different ICT solutions will be tested in multiple case studies approach with three regions as exemplars of urban areas with very different features. Through different scenarios, based on the latest methods for calculating external costs, road transport externalities (congestion, road accidents, air pollution, and noise) will be estimated before and after the use of ICTs applications. Although the estimation of external costs has to consider several uncertainties, it allows the comparison between different areas and the selection of measures based on an insightful analysis of fleet composition, territories' socioeconomic and environmental characteristics.

Policy Learning Platforms are a feature to Interreg Europe to open up the programme's knowledge for the benefit of all the project partners and the whole community of regional policy stakeholders. The platforms are a hub of interaction, information for continuous learning bringing together communities of like-minded policy makers, practitioners and experts dealing with regional development policies in Europe. The aim of the learning and collaboration is to improve structural funds and other regional development policy. The identified best practices solutions in CISMOB platform are available in an open google map environment which can be updated by any user.

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References

1. AECOM. 2011. Study on Public Transport Smartcards – Final Report.

2. James Anderson, Nidhi Kalra, Karlyn Stanley, Paul Sorensen, Constantine Samaras, and Oluwatobi Oluwatola. 2016. Autonomous Vehicle Technology: A Guide for Policymakers. RAND Corporation. https://doi.org/10.7249/RR443-2

3. Volker Busher, Léan Doody, Molly Webb, and Charbel Aoun. 2014. Urban mobility in the smart city age. Smart Cities cornerstone series.

4. EC. 2008. Action Plan for the Deployment of Intelligent Transport Systems in Europe. Brussels .

5. EC. 2011. White Paper - Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. Comission staff working paper COM(2011), 144 final: 170. https://doi.org/http://ec.europa.eu/transport/strategies/doc/2011_white_paper/white_paper_2011_ia_full_en.pdf

6. EC. 2016. A European strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative, connected and automated mobility. Brussels.

7. S. Edwards and G. Evans. 2010. GUIDELINES FOR IMPLEMENTERS OF Using Environmental Pollution Data in Traffi c Management Centres.

8. S. Evenepoel, J. Van Ooteghem, S. Verbrugge, D. Colle, and M. Pickavet. 2014. On-street smart parking networks at a fraction of their cost: performance analysis of a sampling approach. Transactions on Emerging Telecommunications Technologies 25, 1: 136–149. https://doi.org/10.1002/ett.2776

9. EY. 2014. Smart ticketing on transport.

10. Juan Carlos García-Palomares, Javier Gutiérrez, and Marta Latorre. 2012. Optimizing the location of stations in bike-sharing programs: A GIS approach. Applied Geography 35, 1–2: 235–246. https://doi.org/10.1016/j.apgeog.2012.07.002

11. A Gelencser, J Hopkin, D Tindall, and J Francsics. 2010. Cooperative vehicle highway systems – implications for the Highways Agency.

12. Phil Govier. Traffic Management Systems with Air Quality Monitoring Feedback.

13. Albrecht Hanfried, De BEASLEY Simon, Franco Gino, Swarco IT HASELBERGER Rainer, At SE HEDIN Johan Hybris Konsult IZDEBSKI Piotr ZTM Warsaw PL JENSEN Helge, and No KEARNS Steve. 2013. Guidilines for ITS Deployment in Urban Areas - Traffic Management.

14. Eva Heinen, Bert van Wee, and Kees Maat. 2010. Commuting by Bicycle: An Overview of the Literature. Transport Reviews 30, 1: 59–96. https://doi.org/10.1080/01441640903187001

15. Institute for Transport Studies, University of Natural Resources and Applied Life Sciences, and (BOKU). 2010. Innovative ticketing systems for public transport. Vienna.

16. ITS America. 2013. Smart parking key to sustainable urban mobility.

17. J. Olson, C. Hodges, and J. Bouget. 2015. Electric Bicycle Share Feasibility Study. New York.

18. Zhong-Ren Peng, Danlin Yu, and Edward Beimborn. 2002. Transit User Perceptions of the Benefits of

Automatic Vehicle Location. Transportation Research Record: Journal of the Transportation Research Board 1791: 127–133. https://doi.org/10.3141/1791-19

19. Khali Persad, Michael C Walton, and Shahriyar Hussain. 2006. Toll Collection Technology and Best Practices. Austin, Texas.

20. Bratislav Predic, Dejan Rancic, and Aleksandar Milosavljevic. 2010. Impacts of Applying Automated Vehicle Location Systems to Public Bus Transport Management. Journal of Research and Practice in Information Technology 42, 2.

21. R Ranjini and D Manivannan. 2013. A Comparative Review on Car Parking Technologies. International Journal of Engineering and Technology 5, 2: 1763–1767.

22. Bhupendra Singh and Ankit Gupta. 2015. Recent trends in intelligent transportation systems: a review. Journal of Transport Literature 9, 2: 30–34. https://doi.org/10.1590/2238-1031.jtl.v9n2a6

23. Rémi Tempier and Peter Rapp. 2011. ITS ACTION PLAN Study "Towards a European Multi-Modal Journey Planner" Brussels.

24. TNS Opinion & Social. 2014. Special Eurobarometer 422a “Quality of Transport.” https://doi.org/10.2832/783021

25. Urban ITS Expert Group. 2013. Guidelines for ITS Deployment in Urban Areas.

26. Robert Yen and Céline Lyoen. 2012. ITS ACTION PLAN D6 – Final Report of the Study regarding liability aspects of ITS applications and services EUROPEAN COMMISSION Directorate-General for Mobility and Transport.