Multidisciplinary
SCIENTIFIC JOURNAL OF
MARITIME RESEARCH

University of Rijeka
Faculty of Maritime
Studies Rijeka

Multidisciplinarni
znanstveni časopis
POMORSTVO

Multimodal route planners in maritime environment

Miroslav Vujić[1], Pero Skorput[1], Bia Mandžuka[1]

[1] University of Zagreb, Faculty of transport and traffic sciences, Vukelićeva 4, 10000 Zagreb, Croatia

ABSTRACT

Rapid development of information and communication technologies (ICT) enables complete distribution of traveler information to end-users through the whole travel. European intelligent transportation system (ITS) architecture defines traveler information as specific functional area, and it comprises static and dynamic information about transport network condition, traveler information services and support for services which perform collection, storage and management of traffic data for planning transport activities. The purpose of this research is to define the concept of development of multimodal route planners in maritime environment which are based on optimal usage of traveler and traffic data. End-users should receive complete traveler information for the entire duration of travel. Majority of present projects and studies is focused on road traveler information and services, but multimodal route planners can be extended at maritime environment, which is the basis of this research.

ARTICLE INFO

Review article
Received 21 April 2015
Accepted 31 May 2015

Key words:
Multimodal route planners
Traveler information services
Route guidance
Maritime travel information

1. Introduction

Multimodal route planners are defined through ITS architecture and ISO 14813-1 specification [1] as pre-trip and on-trip route guidance and navigation service within traveler information functional area. Based on collected and processed traffic data multimodal route planners enable travel planning for end-users, selection of different modes of transport during one trip, according to current state of transport network and their own needs [2]. Basically, existing route planners include estimated travel times to next stopover (or to the end of travel), travel times to the place of mode transition, additional information about the route, points of interests, etc.

Several European documents accentuate importance of multimodal route planners' development. Within Directive 2010/40EU and ITS Action Plan [3] optimal usage of traveler and traffic information is accented in order to encourage multimodal travels. Multimodal travels represents the key part of European Commission strategy for the future of transport. Also, European Commission produced the study *Towards a European Multimodal Journey Planner* [4] with the main purpose: support for development of regional and national multimodal route planners and their linkage with other countries. This study encourages development of complete "door-to-door" journey planners with the maritime travel information extension. Some efforts have been made regarding integration of marine and terrestrial data. EU funded BLAST project [5] is focused on "bringing land and sea together", by harmonizing and integrating data between land and sea, but there are no published researches regarding multimodal route planners in maritime environment. In Adriatic area, AdriMob strategic plan [6] considers real-time information on passenger transport system development as one objective within Strategic goal 2: ICT development which means that maritime transport information must be integrated in other traveler information systems in order to develop multimodal route planner service mainly for tourists.

This research is based on definition of advanced (extended) multimodal route planners in maritime environment, because existing multimodal route planners are based on urban, regional and national road traffic. In Section 2 the definition of multimodal route planners is presented, as well as general model of their development. Section 3 describes possible access technologies and possibilities of road travel information services integration within maritime environment.

Also, basic communication standards within ITS, in technological sense are presented. In Section 4 the architecture of extended multimodal route planners are presented, as well as their benefits.

2. Multimodal route planners

Multimodal route planners and guidance are defined as ITS service which integrates pre-trip and on-trip traveler information from different modes of transport. Basically, they answer the question: "How to complete the journey from A (origin) to B (destination) in specified time and with specified modes of transport according to defined conditions?".

First phase of development of multimodal route planner systems include definition of stakeholders (at the widest range) and their needs. Four main groups of stakeholders can be defined:

1. **want it** – users which want the development of the system in order to enable multimodal door-to-door journey as one unique service (public transport operators, road and maritime transport operators, etc.),
2. **make it** – users which can develop services and applications for multimodal travels (IT operators, service providers, tourist boards, etc.),
3. **use it** – end users which will use developed services and applications (tourists, citizens, etc.) and
4. **rule it** – local and national services and departments that prepare and issue regulations, standards, recommendations (ministries, government bodies, etc.).

After the definition of stakeholders their specific needs can be defined. In initial phase of system development it is necessary to define the model of user needs which will be the basis for multimodal route planning service development. This approach implies WHAT/HOW concept

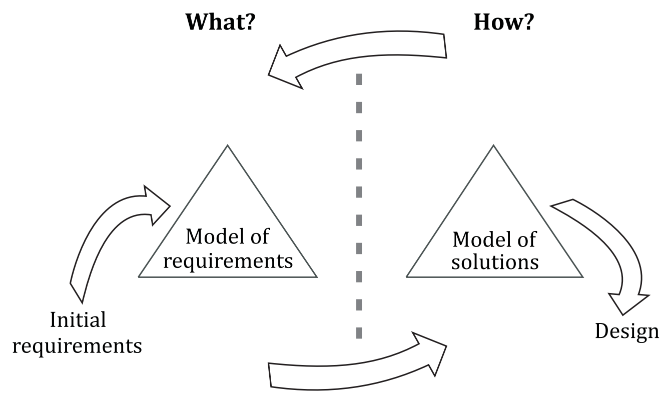

Figure 1 What?/How? concept of ITS service development [7]

(Figure 1) which means that firstly the satisfactory level of "WHAT will the system do?" among all defined stakeholders should be achieved.

Only after answering the WHAT question, the second phase can begin, which include "HOW will the system work" according to technical, technological and organizational sense.

General model of multimodal route planner service development is presented on Figure 2.

Figure 2 shows the classic V-model – initial approach of previously described methodological process. This approach provides basic principles of development of modern ITS services such as analysis of user requirements at all stages of system life cycle, but also testing of the system according to defined user needs. According to depicted V-model development of multimodal route planner service

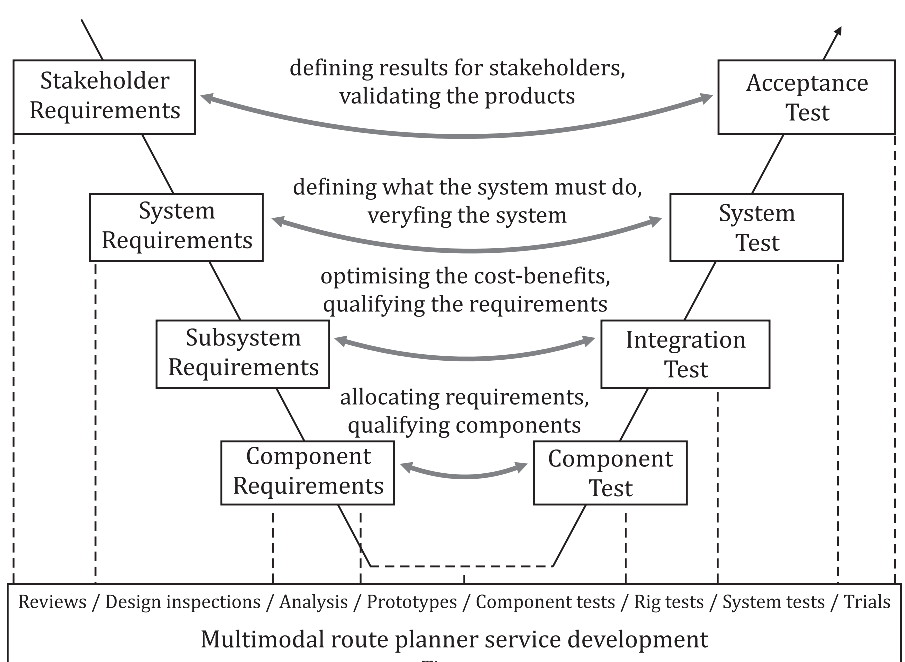

Figure 2 General model of multimodal route planner service development

can be observed separately for every level. This methodological procedure allows all stakeholders to follow level of fulfillment of their user requirements, user needs update, etc.

User requirements must be conceived in order to respect features of proposed system which will enable smooth and normal work. The features of the system with which user requirements should not enter into conflict are:

- **secured data flows** – sending of information in right time before, or during the journey,
- **adaptability** – the ability to alter the system according to user requirements,
- **limitations** – rules and regulations that need to be accepted,
- **continuity** – the ability to maintain service running in time and space,
- **financial viability** – system is built only if it is profitable to end-users,
- **quality of information** – information must be as simple as possible and must be designed to provide all the necessary information without additional (unnecessary) additions,
- **user-friendly** – system must be simple and expedient so that is easier to use.

After the completion of the first stage of service development (definition of user requirements), it is necessary to define the process of gathering relevant traffic and traveler data, and to define how will collected data be transformed in single service. Complete information "packed" in service must fulfill user requirements, so it is necessary to extract a concise, understandable and important information (from collected data), that needs to be delivered in right time and on right place [8]. Cyclic procedure of data processing is shown on Figure 3.

According to Figure 3, first step in producing complete multimodal route planner service is collection of relevant traffic and traveler data from real traffic network(s). After collection, raw data is processed and adjusted for distribution to end-users. Final step in this procedure is packaging of information into final product which is via different information and communication technologies distributed to end-users.

3. Access technologies for information exchange

For development of complete multimodal route planner service it is necessary to define access technologies and data types which will be used for information exchange in all modes of transport and phases of travel. Technological development of ITS services (including multimodal route planners) is coordinated among several European bodies: ETSI – European Telecommunications Standards Institute, CEN – European Committee for Standardization and ISO – International Organization for Standardization.

In technological sense the main goal is to assure information exchange in all domains of ITS service development. Access technologies can be realized as short range systems and "ad-hoc" systems, cellular systems and digital broadcast systems. Fixed (wired) systems is mostly used for internal communication. European ITS 5,9GHz communication system is based on WLAN (Wireless Local Area Network) and is focused on "ad-hoc" communication between vehicles traffic entities. This system is an excellent solution for quick exchange of traffic and traveler information (traffic conditions, estimated travel times, departure of vehicles of different modes, possible delays, alternative routes, etc.). Also, for complete usage of possibilities of multimodal route planners, mobile communication services are widely used.

The main problem for multimodal route planner service for all EU countries (and for all modes of transport) is

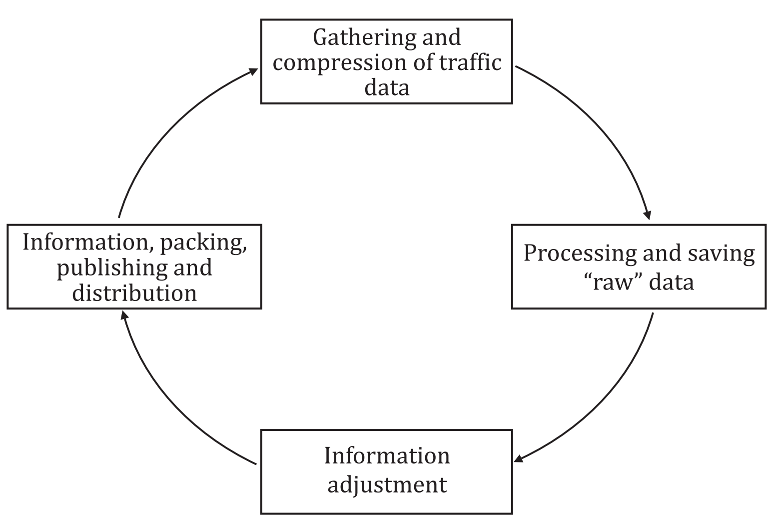

Figure 3 Cyclic procedure of traffic data processing [8]

to enable open and standardized information exchange. The European Commission has been supporting the development of information exchange mainly between the actors of the road traffic management domain, so the DATEX standard was developed for information exchange between traffic management centers, traffic information centers and service providers and constitutes the reference for applications that have been developed in the last 10 years. The second generation DATEX II specification has a wider scope and it consolidates all actors in the traffic and travel information sector, including maritime environment and its information exchange with other modes of transport. Information exchange within DATEX II is composed of the following elements [9],[10]:

- **traffic elements** – events not initiated by any traffic operator,
- **operator actions** – network management, regular maintenance and sign settings referring to variable message signs (VMS) messages,
- **elaborated data** – derived or computed data (e.g. travel times, traffic status, etc.),
- **measured data** – information measured by sensors and detectors.

Additional information exchange is possible with the implementation of cooperative concept which enables communication between vehicle, infrastructure and end user. Within EU FP7 ICSI project [11] advanced system architecture is defined to enable cooperative sensing services targeting to improve transportation efficiency and performance. Developed ICSI platform is based on Wireless Sensor Network (WSN) and vehicular networks (VN) which means that thus system is able to collect and process a large amount of sensed data in reliable way. This concept can be applied in extended maritime multimodal route planner service which is presented on Figure 4.

As presented on Figure 4, proposed system architecture is composed of various components:

- **control centers** – for collection, storage and processing travel and traffic data,
- **roadside units** (RS) – infrastructure elements for data collection,
- **gateways** (GW) – allows data exchange with attached sub-systems such as Wireless Sensor Networks (WSN), and can share data with other gateways,
- **local areas** – set of gateways that cooperate in order to offer cooperative sensing to services and applications,
- **global area** – the overlay network connecting all the gateways in the multimodal route planner system.

Regarding maritime information several regional information management centers (North Sea, Baltic Sea and Mediterranean regional centers) are established within European Maritime Safety Agency (EMSA). The main engine of the system is a regular Automatic Identification System (AIS) web application, which is distributed to con-

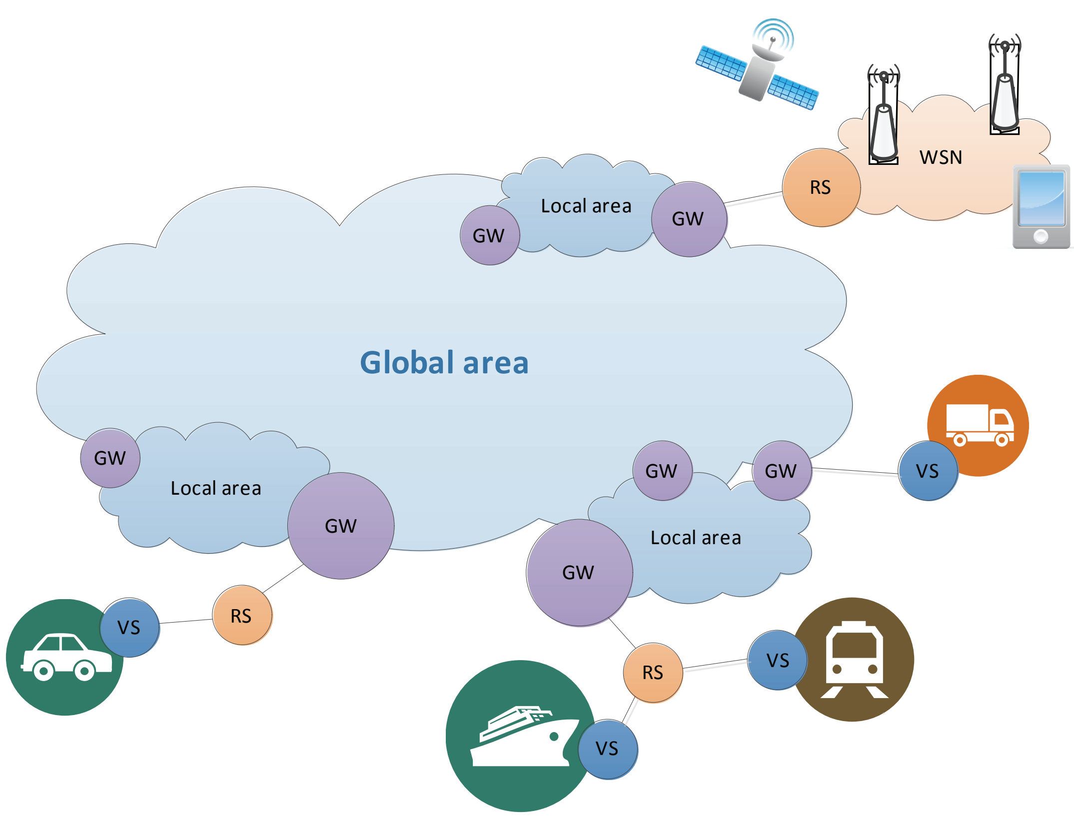

Figure 4 Cooperative maritime multimodal planner architecture based on ICSI platform [10]

tracted partners via the Internet, and creates a two way AIS data stream between the partners. The AIS web application visualizes the ships on a geographical system, allowing the use of any type of chart as a background.

The first step in development of multimodal route planners in maritime environment is information exchange between maritime information centers, traffic management centers, transport operators and other relevant data sources. The architecture of multimodal route planners in maritime environment is presented in the next chapter.

4. Architecture of multimodal route planners in maritime environment

To achieve extended multimodal route planner service with traffic and traveler information from maritime environment, it is necessary to define interconnection from different bodies, agencies and service operators both from road and maritime networks. In terms of system architecture, three main types of architecture can be defined [4]:

1. fully decentralized architecture,
2. decentralized architecture with central application,
3. centralized architecture.

Regarding of multimodal route planner service type and goals, proper architecture can be chosen – the best choice must consider the whole set of technical requirements, the characteristics of the networks to be interconnected and the organizational framework.

4.1. Fully decentralized multimodal planner architecture

The first step in development of multimodal route planner system is creation of decentralized system architecture because various data sources are not integrated. Regional sites are already created, but do not have long distance timetables. Ovreall journey is created by sending multiple elementary requests to each of the interconnected journey planners (Figure 5).

Data processing and distribution to users is slow because there is no central management of common references to interconnection points. When user sends door-to-door itinerary request, separate request is sent to specific data source. Data sources are not connected, so full multimodal route planner service cannot be developed.

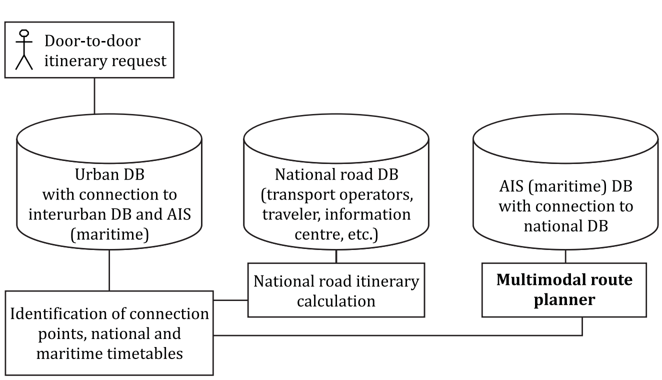

Figure 5 Fully decentralized multimodal route planner architecture

4.2. Decentralized system architecture with central application

If the traffic infrastructure is half-integrated, it is possible to gather information from different data sources independently, but the journey planning can be executed in central multimodal planner site. Door-to-door itinerary is calculated according to limited number of predefined transition points between the interconnected journey planners.

According to Figure 6, the central multimodal planner site sends a single set of requests to each of the interconnected journey planners, and to construct the overall journey on the combination of the respective sets of responses. This type of system architecture cannot provide real-time traveler information because databases from different sources are not connected.

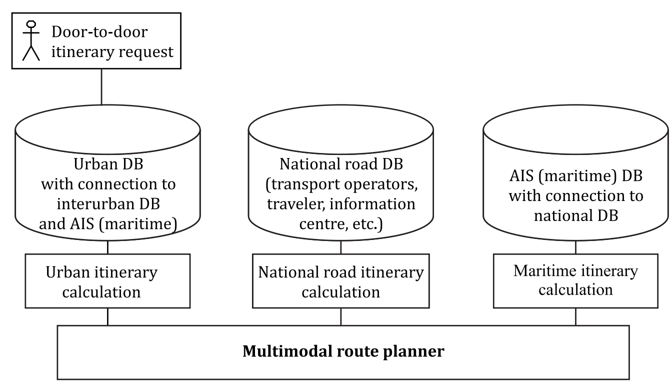

Figure 6 Decentralized multimodal route planner architecture

Itinerary is calculated separately for journey segments and central multimodal route planner just packs them in one unique travel information. If particular delays occure on a part of multimodal journey, real-time feedback is not possible. Also, the responsibility for data quality assurance and the control of data usage is limited to each data source.

4.3. Centralized multimodal route planner architecture

The best performance can be achieved when existing infrastructure can enable fully centralized system architecture. This architecture aggregates multiple data sources in one unique central database, and performs the itinerary calculation locally (Figure 7).

Regarding what type of itinerary calculation end user needs, central database collects data from specific traffic information source (urban level, national level or complete multimodal door-to-door level). After user makes a

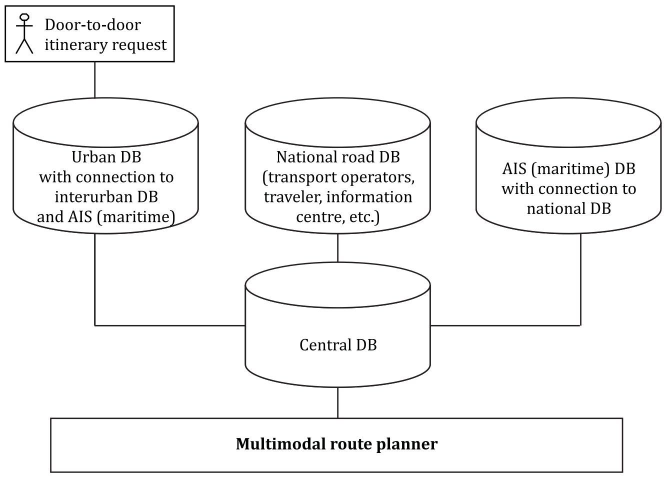

Figure 7 Centralized multimodal route planner architecture

door-to-door itinerary request, multimodal route planner seeks for connection points and possible routes which are delivered to user. If user requests multimodal journey, data is gathered from all possible sources for completion of selected journey (Figure 8). According to gathered data, central server calculates routes, travel times and additional data (points of interest, journey costs, etc.). Calculated information is send to user via online application periodically during the journey with refreshed information and possible delays.

The main benefit of centralized architecture is that itinerary calculation is generally faster, additional information can be sent to user and that travel information is refreshed during the journey, but centralized architecture comprises advanced data management with larger data volumes.

4.4. Benefits of multimodal route planners in maritime environment

There is huge amount of benefits of such extended multimodal route planners, but in overall, if the service is properly developed and has real-time information distribution, such services can provide better quality solution to address user needs [12].

Firstly, extended multimodal route planners provide users information about all possible travel options (regarding modes of transport, routes, costs, travel time, etc.) so that users can make the best choice according to their needs. Also, with development of multimodal route planners, integration of transport modes and sustainability is achieved – users can select the most suitable combination of modes of transport.

This can help in greater sustainability, but also, in encouraging maritime transport for end users. When users are provided with real-time and accurate information, their travel can be more flexible according to delivered information – they can choose alternative routes, alternative departures wich also allows better use of existing transport infrastructure.

Other substantial benefit of multimodal route planner service (especially considering urban networks and road transport) is possibility to reduce environmental and socio-economical impact of transport.

Multimodal information contributes to an increaced usage of public transport system, but also other "soft" modes of transport (bycicles, walking, etc.) which encourages more users to choose a cleaner transport mode. For example, Lyon conurbation saved 10 Euros per ton of CO_2 just by developing basic service of multimodal route planner [13].

Figure 8 Example of multimodal route planner with maritime traveler information

5. Conclusion

Existing multimodal route planners are mostly oriented to road transport, especially traveler information in urban areas (public transport information). This research was oriented in extending existing multimodal route guidance architecture to maritime environment. The main problem was to define acces technologies and information exchange, so within this research several standards were proposed. Also, multimodal route planner architecture was defined, with expansion with maritime traveler information. Firstly, integration of traveler information from several modes of transport is needed, so centralized architecture of the system is proposed. Distribution of real-time traveler information with updated and estimated information is basis for future research, because up-to-date communication technologies allow real-time distribution of traveler information, regardless information source or mode of transport.

Acknowledgement

Part of this research was conducted within FP7 STREP project Intelligent Cooperative Sensing for Improved traffic efficiency (Grant Agreement Number: 317671).

References

[1] ISO 14813–1:2007 – Intelligent transport systems – Reference Model Architecture for the ITS sector – Part 1: ITS Service Domains, Service Groups and Services, 2007.

[2] Škorput, P.; Mandžuka, B.; Vujić, M.: The Development of Cooperative Multimodal Trevel Guide, Proceedings of the 22th Telecommunications Forum – TELFOR 2014, Beograd: Telecommunications Society, School of Electrical Engineering, IEEE Serbia and Montenegro COM Chapter, Belgrade, Serbia, 25.-27.11.2014. (ISBN: 978-1-4799-6190-0).

[3] Directive 2010/40/EU of the European Parliament and the Council, COM (2008)887, European Commission, 2010.

[4] ITS Action Plan – Towards a European Multi-modal Journey Planner, D6 – Final Report, Brussels, Belgium, 2011.

[5] Rust, A.M.: BLAST – Bringing Land and Sea Together, INTERREG IV, North Sea Region Program, Work Package 3: Developing the Marine & Coastal Reference Base, Summary Report, 2012.

[6] AdriMob – Adriatic Multimodal System, Strategic Plan for a Multimodal Mobility in the Adriatic Area, Adriatic IPA Project, WP3, 2011.

[7] Bosnjak, I.: Intelligent Transportation Systems 1, University of Zagreb, Faculty of Transport and Traffic Sciences, Zagreb, 2006 (ISBN: 953-243-016-4), pp. 165–169.

[8] Vujic, M., Cavar, I., Bosnjak, I.: Distribution of Travel Information and Driver's Perception, Proceedings of 14th International Symposium on Electronics in Traffic – ISEP 2006, Ljubljana, Slovenia, 2006 (ISBN: 961-6187-45-7), pp. C6–C6.

[9] Rinne, M: Towards Interoperable Traffic Data Sources, Proceedings of 10th ITS European Congress, Helsinki, Finland, 16–19 June 2014.

[10] Mandžuka, B.; Brčić, D.; Škorput, P.: Open data set for multimodal journey planner, 23nd International Symposium on Electronics in Transport (ISEP2015), 23–25 March.

[11] ICSI – Intelligent Cooperative Sensing for Improved traffic efficiency, FP7 Project, WP1, Report D1.1.1 – Use Cases Definition and Analysis, 2014.

[12] Mandžuka, B.; Brčić, D.; Škorput, P.: Application of multimodal travel guides for city and intercity travel, 34th Conference on Transportation Systems with International Participation "Automation in Transportation" 2014, 5–9 October 2014, Dubrovnik, Croatia.

[13] Guidelines for ITS Deployment in Urban Areas – Multimodal Information, Urban ITS Expert Group, 2013, pp. 9–11.