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THE IMPORTANCE OF OPEN DATA ACCESSIBILITY FOR MULTIMODAL TRAVEL IMPROVEMENT*

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ABSTRACT

The dynamic urban network continues to face a number of problems caused by traffic. One of the main problems is the increasing use of personal vehicles (especially for shorter journeys) and an unattractive alternative – public transport. In this context, *Intelligent Transport Systems* can be defined as a holistic, management and information communication upgrade of the classic transport and traffic system. From the passengers' point of view, the usage of personal vehicles is still more pronounced compared to public transport. The main reason is that the public transport service quality needs to be improved if compared to the personal vehicles. The concept of *multimodal travel* is not new, but with the usage of adequate Intelligent Transport Systems services, it is possible to support and encourage modal shift, optimise the use of public space and influence passengers' behaviour patterns. *Multimodal Journey Planners* provide travellers with better and more complete information when choosing a mode of transport so they can select the most suitable option for their needs. The *open data* approach is crucial for defining a system that responds to the end-users' actual needs and aspirations (personalisation of the service). Another major challenge in providing a high-quality multimodal journey planning service is the availability and accessibility of data. EU directives require each Member State to establish a *National Access Point*. The National Access Point is a digital interface, a single/unique access point providing all information regarding travel and traffic. In this article, the importance of traffic data collection, acquisition and distribution according to the open data concept is described.

KEY WORDS

intelligent transport systems, multimodal travel, multimodal journey planners, national access point, open data

CLASSIFICATION

JEL: O18

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INTRODUCTION

The lifestyle of urban commuters is changing significantly due to rapid urbanisation and economic globalisation, as well as the continuous development of information and communication technologies. According to projections [1], 68 % of the world's population will live in urban areas, placing a significant burden on environmental management and existing infrastructure. One of the most important aspects of the social ecosystem is urban mobility.

Urban mobility is essential for the survival of urban agglomerations. The need for mobility in urban areas is constantly growing and is met by the use of personal vehicles. The spread of personal vehicles has increased people's mobility, but it has also had unforeseen effects on the sustainability of urban ecosystems. With the increasing level of motorisation, a number of problems are emerging that threaten the long-term viability and mobility of the population [2, 3].

Inadequate transport infrastructure, lack of space for people, limited mobility and accessibility, and negative environmental impacts are just some of the problems that need to be addressed comprehensively. The EU Urban Mobility initiatives and policies [4, 5] emphasise seamless mobility for all user groups and offer a range of attractive, efficient and environmentally friendly public transport options. Transforming urban transport towards innovative mobility solutions and services that meet the real needs of residents could be a response to existing challenges. However, it is important to stress out that the transition should start at a personal level, at the level of the users of such a system (of course, if the quality of public transport system is equal or better than the usage of personal vehicles). According to the literature, this transition has already begun and is referred to as the "socio-technical" transition [6].

By applying modern Information and Communication Technologies (ICT) in transport – specifically Intelligent Transport Systems (ITS) services, it is possible to achieve a sustainable, clean, and energy-efficient transport. ITS offers new approaches, models and technologies to solve a variety of traffic and transport problems [7].

"Multimodal mobility" is one of the possible solutions for establishing sustainable public transport and, as a result, liveable urban spaces. The approach combines different modes of transport into everyday transport routines. In other words, the concept represents the transition from owning a vehicle to using the public transport system. In this regard, the transition to sustainable mobility is seen as a major challenge in the upcoming decades, aiming to eliminate or at least mitigate the negative effects currently caused by traffic [6, 8, 9].

In order to simplify multimodal journeys and overcome barriers (waiting time, transfers, switching to another mode of transport), it is necessary to offer users a service that will cover the journey from point A to point B. This is especially important for modern users who are more inclined to use technology (technophiles) [10]. To achieve the quality and efficient functioning of such systems, modern technologies (smartphones and other digital gadgets) need to be used. In addition, data and interoperability for cross-border journey planners play an important role in the quality provision of travel planning services. In this sense, specific data quality requirements and appropriate data exchange protocols are prerequisites for implementing travel planning services [11, 12].

The aim of the LinkingDanube project (Interreg – Danube Transnational Program) was to encourage the provision of transnational, interoperable and Multimodal Journey Planners (MJPs) covering urban and rural areas. The project "Coordination mechanisms for multimodal cross-border traveller information network based on OJP for Danube Region (OJP4DANUBE) explores the possibility of personalised cross-border travel choices based on a distributed architecture [13, 14].

In recent years, opening data has become easier due to sensor technology integrated into our urban environment. In that matter, opening up is cheaper and easier than building a new transport infrastructure. The project "TODO – Twinning Open Data Operational", approved by the Horizon2020 programme – Twinning, is important in terms of interdisciplinarity and raising awareness of the importance of open data approach [15].

According to EU Directives, each Member State is required to create a National Access Point (NAP), which will be a single/unique access point based on open data [16]. Furthermore, data security and privacy concerns are prevalent, particularly when collecting data and providing personalised multimodal information for multimodal journeys [17].

The purpose of this article is to emphasise and elaborate the importance of open data in the implementation of advanced ITS solutions such as multimodal journey planning services. This article aims to provide an analysis of the state- of- the- art research on multimodal travel, multimodal journey planners, and the open data concept. The key steps for the realisation of multimodal journey planners based on open data are presented in the final section.

THE CONCEPT AND NEED OF MULTIMODAL TRAVEL

There are many strategies that focus on shifting from personal vehicles to environmentally friendly travel solutions. The Avoid-Shift-Improve strategy (Germany) is a holistic approach to creating a sustainable transport system. The strategy is based on three pillars: "Avoid/ Reduce", "Shift/Maintain" and "Improve". According to [18], the first pillar refers to improving the overall efficiency of the transport system, minimising the length of trips and the need for personal vehicle. The second pillar is based on the idea of improving individual travel by focusing on the use of alternative transport modes (from personal vehicle to public transport). This is particularly important in promoting multimodal travel. This includes walking and cycling, the most environmentally friendly options, but also public transport (lower CO_2 emissions per passenger-kilometre compared to personal vehicles). The third pillar, "Improve", means, among other things, increasing the attractiveness of public transport.

The question of establishing sustainable urban mobility is so complex because a rethinking and a new understanding of sustainable urban mobility must be initiated at the individual level. When it comes to choosing a means of transport, the personal vehicle still dominates because it meets the need for flexibility and independence.

In order to achieve sustainable travel behaviour, public transport must meet the needs of the individual and work towards modal shift, i.e., the transition from the personal vehicle to sustainable modes of transport. In this sense, it is crucial to know users' reasons and triggers (at the individual level) for switching to more sustainable transport.

In [19], it is stated that the increasing number of passengers in urban areas has encouraged new travel options (in addition to traditional ones), with multimodal travel being a promising option. This research was conducted to address the research gap between the obvious/standard criteria (that guide passengers in choosing a trip) and the actual needs of passengers. In addition to some key determinants of travel mode choice that are consistent with the findings of previous analyses, five new key findings for urban transport were identified. Particular attention is paid to the perception of sustainability, which passengers perceive as a cost-related element of urban travelling.

In other words, urban travellers increasingly perceive the pollution associated with the use of certain modes of transport as a cost that impacts the environment. Furthermore, the newly identified perceptual dimension - individualisation - is particularly highlighted. This

perceptual dimension indicates that the urban traveller has to adapt to the daily changing situations during his journey. Technological possibilities allow travellers to adapt to different travel scenarios. This is particularly important for new forms of urban transport, such as the multimodal travel concept. Through the use of advanced information and communication technologies, it is possible to achieve a high degree of autonomy and individualisation [19].

The concept of multimodal travel is one of the potential solutions to mitigate the negative impact of transport on the environment. The approach is not new, but it is gaining new characteristics and possibilities especially due to the fast-growing digitalisation, new mobility models and business models ("sharing culture" - car sharing, bike sharing). In the literature, the concept is defined as a door-to-door journey that provides continuous connectivity throughout the journey and uses a combination of transport modes (walking, tram, bus, e-scooter, etc.), Figure 1. Due to its complexity, such a travel concept must ensure easy switching between modes and flexibility in combining modes. Only in this way it can compete with the personal vehicle [20-22].

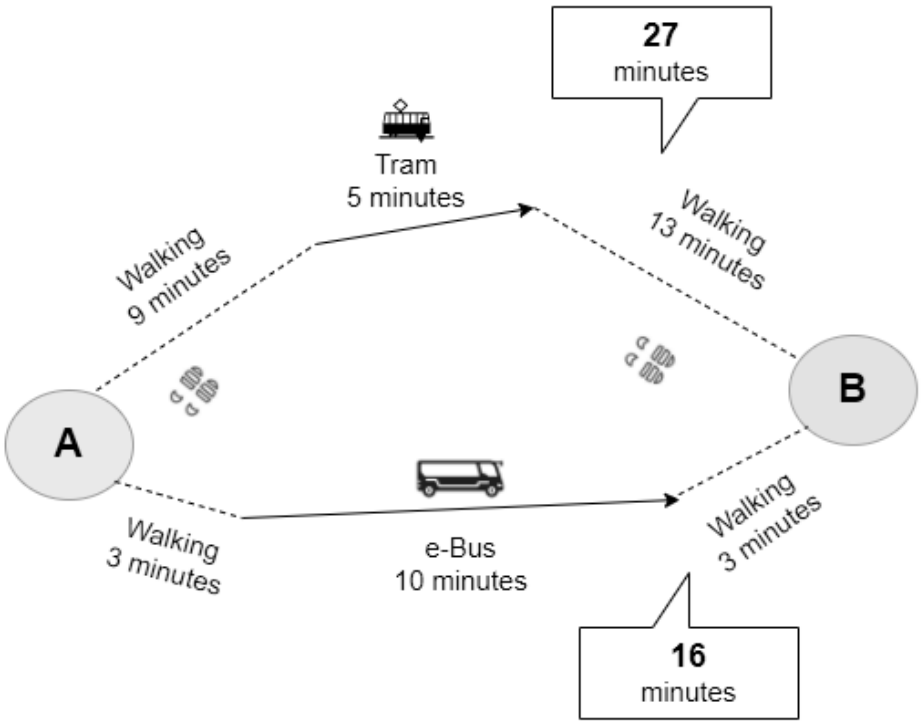

Figure 1. Example of Multimodal Journey Routes (edited by authors) [23].

According to the authors [19], one of the main advantages of the multimodal travel concept is the possibility of individualisation and autonomy compared to unimodal travel (by personal vehicle), where one chooses one mode of transport to get from point A to point B. This hybrid concept can also partially cover the need to adapt to the travel scenario and thus compete with the personal vehicle (in terms of flexibility and autonomy).

To optimise the operations of urban areas, the paradigm of "smart cities" requires sustainable solutions to ensure economic prosperity and social well-being. In this context, the concept of "Mobility-as-a-Service" (MaaS) is a new way of thinking and a smart solution for implementing effective and sustainable urban mobility. It provides a transport solution based on user preferences. The platform combines different types of mobility (public transport, car-sharing, car and bike rental, taxi and a combination of the above) on one platform. This concept offers a number of opportunities that are beneficial to the urban mobility ecosystem. In addition to the

ticketless model, MaaS generates vast amount of traffic data that can help transport planners eliminate bottlenecks and determine the actual needs of passengers. In other words, it is possible to identify and understand passenger behaviour, which will ultimately help to implement transport services that meet passengers' needs. Open data is the basis for establishing user-centric services such as MaaS. This is the only way to empower travellers to change their travel behaviour and improve the overall travel experience and quality of life in general [24-26].

MULTIMODAL JOURNEY PLANNERS

In specific scenarios of multimodal travel, there are some obstacles, such as lack of information for certain modes of transport (transfers, waiting times), lack of personalisation etc. To achieve the quality and efficient functioning of such systems, it is necessary to use advanced ITS services. This area includes static and dynamic information about the transport network, pre-trip and on-trip information services, and support for services that collect, store and manage data for planning transport activities. Pre-trip information services are of great importance to users as they allow them to plan a journey from home or any other location where internet access is available. In addition to pre-trip information, access to information during the trip is crucial for users to make a timely decision about their trip [7]. Specifically, the Advanced Traveller Information System (ATIS), as an integral part of the above-mentioned functional area, aims to support the traveller in multimodal travel planning. Because of the increasingly complex requirements of modern users, ATIS plays a significant role in intelligent mobility [27-29].

On-trip information includes real-time travel information, estimated travel time depending on existing traffic conditions, parking availability, traffic accidents, etc. MJPs represent the integration of these services and, as such, are a key component of implementing ITS in cities today. They offer a comprehensive range of relevant information to assist the user in planning a door-to-door journey [7].

MJPs are defined as guidance and navigation services by the ITS architecture and the ISO 14813-1 specification [7]. MJPs enable travel planning for end-users based on the collected and processed traffic/transport data. The user can combine different (available) travel options depending on the current state of the transport network and his own needs. MJPs provide better modal integration and more sustainability by allowing travellers to choose the most appropriate combination of transport modes. This could lead to increased use of public transport, cycling or walking in urban areas [30]. Figure 2 shows an example of a multimodal journey planner for a selected destination, suggesting four routes with different combinations of travel modes.

The basic task of the multimodal planning service is to answer the user's question: "How do I get from point A to point B at a certain departure/arrival time and under what conditions?" [31]. Today, MJPs are mainly based on algorithms generating the shortest route/travel time. The complexity of creating a model that generates options tailored to passengers is reflected in the diversity of their preferences.

In urban areas, multimodal information is of great importance as it increases the use of public transport and other 'healthy' ways such as walking and cycling. Multimodal travel information promotes mobility for all user groups, especially users with disabilities or reduced mobility, by providing information about facilities and assistance at transport interchanges. A special type of user of MJPs are tourists. They may be guided by additional criteria when choosing a travel route, e.g., choosing a route that includes different Points of Interests (POIs) [30, 31, 33].

Citymapper is one of London's best public transport planning tools [34] and is generally applicable to many European and American cities. The service offers multimodal travel planning

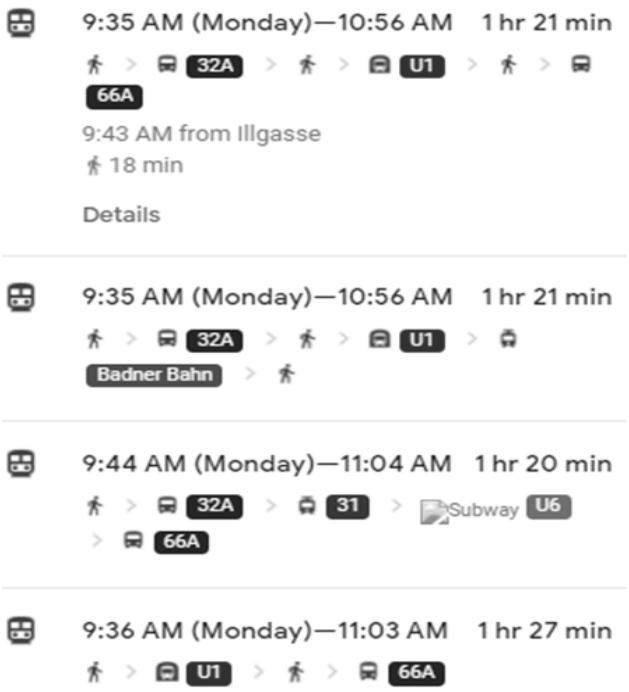

Figure 2. Example of multimodal routes generated by MJP [32].

with a variety of features that enhance the user's experience and satisfaction. The service provides step-by-step instructions during the trips, which is especially important for multimodal trips due to the complexity of the system (switching to another transport mode, waiting, etc.). The travel planning service displays tariffs for available modes of transportation, and includes platforms such as Uber, Lyft, City Bike, GREENBike, and others. In addition, the application allows users to personalise their profiles by storing favourite routes, stops, and other information. The user can subscribe to a specific mode to receive information for selected modes. The location can be shared via social networks and selected profiles/contacts.

TripGo is a travel planning service developed under the MaaS concept. The planner has been highly rated by experts and it is widely used in the EU. As an additional, partially personalised feature, the service offers the possibility to plan a daily schedule of activities including trips for the day. The system suggests the most convenient routes for the user based on that plan [35].

Personalised MJPs are a step forward in the field of travel information. In a dynamic urban context, such a multifunctional system integrates a variety of functions required for planning journeys that meet travellers' needs. The end-user is at the centre of such an advanced information system. There are a number of active multimodal planners in the EU with different functionalities. Most include basic functions/criteria for selecting a multimodal route, and only a few offer some degree of personalisation [35-37].

Travel data is also personal data because it reveals much more than just the user's movement [17]. In recent years, various technologies have provided efficient and cost-effective sources of data collection. The number of smartphone users in the world has been on the rise, resulting in the largest source of data on human mobility. MJPs, which help users plan their trips, are also sources for collecting large amounts of travel data. For each user and travel scenario, such a system tracks mobility patterns based on preferences. Additionally, it contains data that is entered into the system when setting up a user profile (if the platform offers this option). These are usually some of the basic preferences of end-users.

THE IMPORTANCE OF OPEN DATA IN THE IMPLEMENTATION OF ADVANCED ICT SERVICES

Open data (OD) could be described as data being available with no financial and legal restrictions [38]. OD represents available resources that can be integrated into innovative digital solutions [39]. The resources provided at the national level need to comply with the OD principles (e.g., G8 Open Data Charter) and to satisfy the principles of maturity [40]. Furthermore, the OD ecosystem is a broader concept including many interrelated perspectives with closely connected interdependencies and reflecting on different aspects of open data [41].

The concept of OD is strongly associated with innovative capacity and transformative power [42]. It is increasingly recognized that proactively opening public data can create considerable benefits for several stakeholders, such as firms and individuals interested in the development of value-added e-services or mobile applications, by combining various types of OGD, and possibly other private data, or scientists, journalists and active citizens who want to understand better various public problems and policies through advanced data processing and production of analytics [43].

The benefits of OD are common in all initiatives considering a socio-economic focus for both, private and public sector, and, according to [44] four different types of values can be distinguished: (1) efficiency values, related to the higher efficiency of public sector bodies as a direct result of the availability of data coming from other public organisations, (2) innovation values, where the use of OGD (Open Government Data) can create new economic profit for the public sector, (3) transparency values, which contribute to the growth of public trust in government and reduction of corruption, and (4) participation values, where private sector gains social benefits through cooperation with the public sector. Pfenniger et al. [45] derived with OD benefits for science: (1) Improved quality of science in order to meet fundamental scientific principles like traceability, reproducibility and transparency, (2) More effective collaboration across the science-policy boundary in terms of better and more transparent results through data quality and data validation processes and (3) Increased productivity through collaborative burden-sharing avoiding unnecessary duplication and learning from each other.

The above benefits are almost impossible to implement without ensuring availability and then proper accessibility to the data. Only providing data will not necessarily lead to a generation of new value [46]. To achieve this, some efforts must be made in data quality, a rise of awareness among users about the benefits of open data and development of mechanisms to exploit data potential. At last, OGD success does not depend only on data itself but on a functioning ecosystem where two sides, data availability and data demand, are building on each other [38]. During the past 10 years, several OD assessment methods have been created. However, the outcome of such assessments is no guarantee whatsoever that a simple question a citizen may have can be answered by the open data. By checking the availability and proper accessibility of data for a specific domain is the first step towards the realisation of innovative services.

In establishing open data, technical (interoperability, inconsistent open standards, data silos) and social barriers (open data ethics, equity, engagement) are still present [17]. The benefits of open travel data should be seen as a win-win situation. By opening and reusing data, the quality, efficiency and transparency of public transport services increase. It helps operators to organise passenger transport effectively and to offer innovative mobility services that meet the needs of modern users [47]. On the other side, users can be provided with a personalised travel information service. Discovering preferences from large (open) data sets plays a key role in user profiling and in establishing personalisation.

For example, if the discovery of user preferences for the student population were included, then more credible data on their travel behaviour would be obtained (preferred modes of transport to certain locations, POIs, etc.). The analysis can encourage travel planners and other experts to understand better and predict travel demand (e.g., where, when and how to travel) and assess the impact on the transport network and society.

For this reason, it is necessary to act in the direction of raising awareness and highlighting the benefits of open travel data. With open access, it is possible to increase the availability and attractiveness of public transport. It also allows operators to understand better the real needs of users based on their mobility patterns. However, there is still some mistrust in the ethical use of data. When data is shared and used to combine openness and innovation while based on ethical principles, it has significant global potential for society and the economy [17, 47].

NATIONAL ACCESS POINT FOR MULTIMODAL INFORMATION

Without the openness and availability of data, MJPs would not be relevant to end-users (especially when it comes to personalising the service). According to the EU Directive, each Member State will set up its own NAP, which will be a single/unique access point based on open data.

National Access Point for Multimodal Information (NAPMM) is defined as a digital interface where the static travel and historical traffic data, together with the corresponding metadata, are made accessible for reuse or where the sources and metadata of these data are made accessible for reuse [48]. Delegated Regulation 2017/1926 [49] defines that multimodal travel information services are based on both static and dynamic travel and traffic data, where 'dynamic travel and traffic data' stands for data related to different transport modes that often change on a regular basis, and 'static travel and traffic data' stands for data related to different transport modes that do not change at all or change seldom and on a regular basis. The document also recommends that travel information services should use the European Technical Specification entitled 'Intelligent Transport Systems – Public Transport – Open API for distributed journey planning 00278420' currently under finalisation when performing distributed journey planning. When service providers establish handover points for distributed journey planning, such handover points should be listed in the national access point. In technical terms, NAPMM is based on an information-communication system (ICT solution).

NAPMM is intended to be the main open data repository for multimodal travel planning, where relevant stakeholders will deposit their static and dynamic data. NAPMM involves several groups of stakeholders, as presented in Figure 3. Stakeholders either provide data, corresponding metadata information on the quality of the data accessible to users and end users. Stakeholders providing data include transport authorities, transport operators, transport on-demand service providers and infrastructure managers. Users and end-users can use this data as an enabler for transportation-related services and to make travel decisions.

NAPMM covers various modes of transport, including air, rail including high-speed rail, conventional rail, light rail, long-distance coach, maritime including ferry, metro, tram, bus, trolleybus, shuttle bus, shuttle ferry, taxi, car-sharing, car-pooling, car-hire, bike-sharing, bike-hire, and personal modes. The static travel data, among others, include location search data of origins and destinations and access nodes, trip plans, access nodes and trip plan computations for both scheduled modes of transport and for road transport, special fare query for all scheduled modes, information service for all modes, trip plans and trip plans computation.

Dynamic travel and traffic data includes passing times, trip plans and auxiliary information. Information service regarding publicly accessible charging stations for electric vehicles and refuelling points, and availability and future predicted road link travel times. The opening of

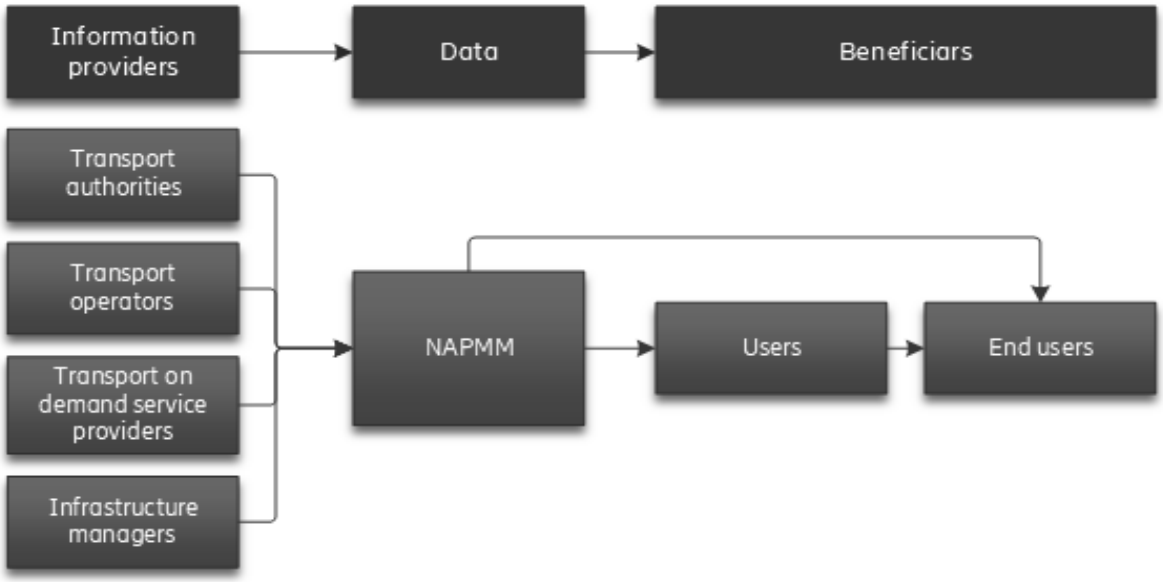

Figure 3. Data flow and stakeholders of NPTMM.

transport data is an ongoing process that has been implemented for the last decade with the goal to enable access to better information that would offer an improved service to users. NAPMM helps mobility players publish their data and make them accessible on a single platform, which facilitates their reuse by travel information services [11].

CONCLUDING REMARKS

Urban mobility, as a leading concept in urban traffic sustainability, is one of the main concerns of the development of modern traffic and transport networks. With the rapid increase of personal vehicles and the growing population in urban areas, the existing traffic network cannot fulfil the user needs for daily migrations within the urban traffic network. A logical alternative should be encouraging the usage of the public transport system and/or other sustainable modes of transport. In order to achieve that, it is necessary to improve the quality of the public transport system, or at least, some specific and crucial parts of it. Traveller information is the best and easiest ITS service that end-users see and use in their daily migration travels.

When choosing a mode of transport, end-users mostly rely on the travel time from origin to a destination, not taking into account the other benefits of the modal transition. Multimodal travel as a concept is the most suitable alternative for personal vehicle replacement because it satisfies all the end-user requirements. In this article, the importance of opening raw traffic data is described, which allows service developers to broaden their offer of products to end-users.

Multimodal journey planners are a complete service that provides all travel information to end-users in one place, so the openness of raw traffic data is essential. The first step is to define the essential traffic data that can be used for multimodal journey planners service development. The second step is to point out the importance of opening those datasets and to provide a platform (both for end-users and other stakeholders) for data collection, analysis, and dissemination/distribution. The final step should be the creation of one complete multimodal journey planner service, which should be developed in real-time according to the present traffic situation and the most suitable mode of travel according to user needs and preferences.

To achieve a better quality of traveller information distributed to users, the implementation of the open data concept is essential. Since the urban traffic system generates a large amount of traffic data (which must be collected, analysed and distributed), the openness of such data is

essential not only for end-users but also for other stakeholders (traffic and transport operators, value-added service operators and distributors, etc.). Currently, multimodal information services across Europe are generally not interoperable and are fragmented in terms of what they offer, including modal and geographical coverage, real-time information, and quality levels. Therefore, a next step and focus on the future period would be on harmonisation of data and exchange of data among NAPMM from various countries and regions.

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