



The Essence of Multimodal Travel and Key Standards for Data Exchange in Public Transport

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Abstract: The concept of multimodal transport has recently attracted much interest. It is user-oriented, i.e. the passenger planning his trip. To properly plan and prepare a mobility offer, it is necessary to know the mobile behaviour of travellers or their changes. Both the travel history and communication preferences of passengers can contribute to the design of a mobility distribution model in which various modes of transport offered by different operators are integrated into one service provided within one digital platform. The study aims to present the concept of multimodal travel and show the added value for the traveller: the synergy of combining ticket purchase and payment channels and a wide range of transport options. The authors highlight two key public transport data exchange standards: Open Journey Planner (OJP) and General Transit Feed Specification (GTFS). Their goal is to improve the quality of public transport services and provide travellers with better access to information. The article was developed as part of the Network Management Planning and Control & Mobility Management in a Multimodal Environment and Digital Enablers project – an acronym of the MOTIONAL project – implemented by the Research and Development Ecosystem created at PKP S.A. The article's content is part of the WP20 work package Development: Integration of Railways with other means of transport. In particular, it refers to Task 20.1, Improving railway integration using B2B intermodal services, which includes Subtask 20.1.1, Providing MaaS platforms for B2B intermodal services.

Keywords: multimodal transport, passengers, means of transport, shared mobility services, standards for data exchange, public transport

1. Introduction

Recent years have brought rapid development of rail transport systems (Chen et al. 2022). The increase in the number of passengers and the reconstruction of the passenger transport market to a level similar to the pre-pandemic period resulted in the need to take care of the travelling public and offer high-quality services. Additionally, rising energy costs and the need to reduce emissions will cause rail traffic to continue to increase as transportation shifts from road to rail (Stenström et al. 2012). This will increase the demand for railway capacity.

Undeniably, in such a situation, it is necessary to ensure the quality of the transport services provided but understood in a broader sense – including the availability of information about possible transport, shared mobility services, electric vehicle charging points, and information about delays and faults.

On the one hand, identifying and understanding the traveller's needs is crucial to ensuring the highest level of services, and on the other hand, the ability to effectively plan a trip using appropriate data exchange standards in public transport.

The article aims to present the most important issues related to travel, multimodal transport, and key data exchange standards that improve the quality of public transport services and provide travellers with better access to information.



The paper is organised as follows. Firstly, we discussed the essence of transport and multimodal transport (Chapter II). Chapter III presents broadly understood shared mobility, particularly emphasising the MaaS service (Dyczkowska et al. 2023) and its parameters. Chapter IV discusses multimodal travel's importance for "Łódzka Kolej Aglomeracyjna" Sp. z o.o. (Lodz Agglomeration Railway Ltd. – LAR Ltd.). Characteristics of travel platforms are presented in Chapter V, and data exchange standards and their implementation in Chapter VI.

2. The Essence of Travelling

The modern travel model has changed significantly due to the climate crisis. Changes in travellers' thinking resulted in a change in their value system. Issues of transport accessibility have become more important than ownership and property rights. This attitude influenced the change in mobility patterns (Chamier-Gliszczyński 2012), especially in cities and their functional areas, where multimodal travel began to take on new forms (Standing et al. 2018, Ejdyś 2021). Of course, these forms of travel are subject to constant phenomena and processes and are constantly changing. The ongoing changes in travel methods result primarily from the practical way of moving, based on the idea of sharing goods.

Practice proves that new travel concepts based on shared mobility systems complement the public transport system's offer, reaching areas not served by public transport. However, means of transport intended for independent and individual use – bicycles, scooters, or electric scooters – effectively solve transport availability problems at the journey's first and last stages.

Regardless of the opinions presented, it should be noted that to use the advantages of new forms of travel effectively, it is first necessary to create conditions for their development. This seems like a complex task. It should involve promoting knowledge about the social benefits of sharing means of transport, raising awareness of their availability and showing the advantages for users, and striving for regulations that will keep up with innovations and the times.

Without a doubt, these types of activities are not easy, but when properly carried out, they pave the way for multimodal travel, creating a chain of movements by various means of transport (Zhou et al. 2012). This allows one to travel, for example, by taxi from the airport to the city centre, then take a train or metro to the suburbs, and then use a rented bike or scooter to reach a specific destination. This approach to travelling allows us to claim that the future of transport is multimodal. Still, to make it possible, it is necessary to integrate all transport systems at various levels of their organisation and functioning (Krizek et al. 2010). Agreeing with this view requires only adding that the awareness of integration in transport translates into the optimal use of both means of transport and the existing urban infrastructure, which connects urbanised areas with other territorial units. It is also reasonable to expect a reduction in transport congestion, improvement of environmental relations, and the general quality of transport services while increasing the possibilities of social mobility and influencing the choices of travellers (Pawłowska et al. 2014). This is extremely important in times of striving to reduce CO₂ emissions and improve air quality.

The literature proves that the special importance of integration processes in transport was initially observed only in Western European countries (Martens 2007, Kager et al. 2016). However, in Poland and other parts of the world, the deteriorating quality of services offered and an increasingly ecologically conscious society resulted in the potential of this solution being noticed and used in practice (Tsenkova et al. 2007, Mohanty et al. 2017, Radzimski et al. 2019).

Reflection in this area has led to a change in priorities in developing multimodal transport chains worldwide (Kłodawski et al. 2024, Wozniak et al. 2016). The European Union encourages its citizens to use such solutions. Its activities aimed at ensuring travellers have a certain minimum of rights related to their travel have served and continue to serve the same purpose (Dąbrowski et al. 2023). When reviewing the new EU strategy for sustainable and intelligent mobility, one can conclude that it creates a vision of the future transport system – sustainable, intelligent, and resilient (Ejdyś 2017, Chamier-Gliszczyński 2012a). It defines a clear action plan aimed first at reducing the demand for transport, then at reducing distances thanks to spatial planning, then at finding ways to change means of travel and, finally, at increasing the efficiency of travelling by private car (Chamier-Gliszczyński & Bohdal 2016). The EU also highlights the need to adapt the legislative framework on passenger rights to address disruptions at transfer points when travelling by different modes (Komisja Europejska 2011). The 2011 Communication is also referred to in the European Parliament resolution of 2012, which strongly emphasises issues related to intermodality, including strongly calling on the Commission to "continue efforts to create a European multimodal journey planning mechanism, considered an essential element for the creation of intelligent transport systems". The communication and resolution mentioned the need to promote the so-called direct and integrated tickets. Importantly, another Commission document entitled 'Action plan for the EU-wide provision of multimodal travel information,

planning and ticketing services' (Parlament Europejski 2012) was also entirely devoted to this issue. This document focuses on the role of information and planning services that allow the passenger to choose the method of travel that best suits his needs (in terms of mode of transport, route, costs, travel time, and environmental impact) and return to the idea of multimodal integrated ticketing systems (Kauf 2022).

3. Shared Mobility

In the transport dimension, broadly understood shared mobility should be based on a balance between the public interest and the transport solutions that meet travellers' needs. The quintessence of such sharing is the MaaS service (Dyczkowska et al. 2023), which, on the one hand, connects and, on the other hand, facilitates the use of multimodal transport and shared mobility services (Fig. 1) (Matysam et al. 2016, Evangelatos 2016, Koźlak 2020). The literature on the subject allows it to be defined as a user-focused model of mobility distribution, in which all means of transport offered by various operators are integrated into one service provided within one digital platform and available on demand (European Commission 2014, Łukasiewicz et al. 2018). This solution means that the user is not obliged to have his means of transport and, at the same time, has a wide range of transport services at his disposal to help him navigate the designated route. The added value for the traveller here is the synergy of combining ticket purchase and payment channels and a wide range of transport options, including public transport, taxis, car rental, and sharing options (e.g. carpooling, car-sharing, bike-sharing, e-scooters).

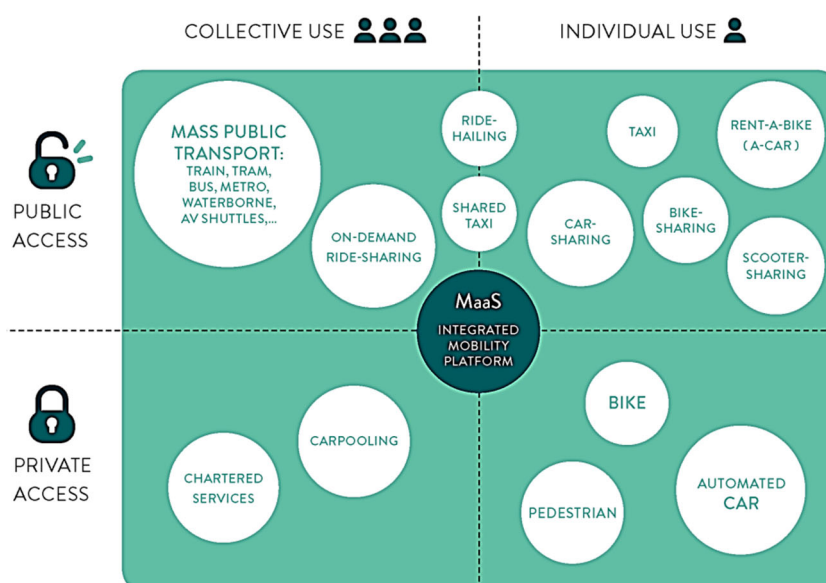


Fig. 1. Urban mobility services (UITP 2019)

Undoubtedly, one of the key challenges of the MaaS service is breaking habits and changing the mobility behaviour of travellers based on the analysis of data regarding previous travel history and communication preferences. In addition, the basic parameters of the MaaS service include (SWD 2014):

- fast, efficient, and effective flow of people and the accompanying flow of data,
- global scaling of transport services, including the first and last mile (door-to-door),
- higher travel comfort compared to those made by their own means of transport,
- openness to information and cooperation with intelligent transport systems.

According to the new mobility paradigm, for travel to a destination to be achieved by combining different means of transport and services, the entire package should be booked and paid for using one application (Schaller 2018). Therefore, the new concept should not only include the physical integration of existing means of transport but also offer better travel conditions, e.g. a higher level of service or lower costs (Fig. 2). Furthermore, there should be an increase in the coordination of services, which means that mobility is treated as a single, coherent service rather than as a series of different, loosely related services (Yaraghi et al. 2017).

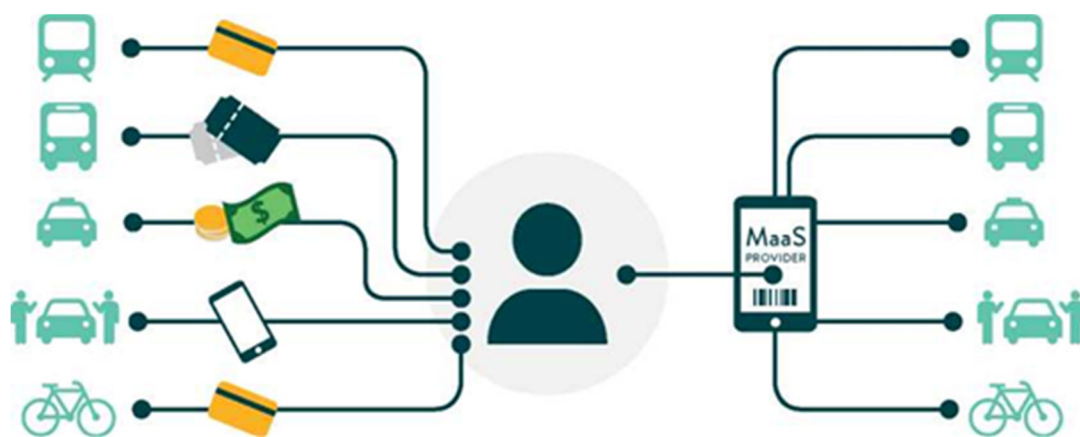


Fig. 2. Mobility as a Service (UITP 2019)

In 2018, Transport for Greater Manchester (TfGM) and Atkins/SNC-Lavalin tested the hypothesis that MaaS could shift commuters out of their cars onto public transport or towards active travel options such as walking and cycling to work. This work took a very customer-centric and human-centred approach from the outset. 39 participants from across the city, all working in Salford, took part in the live trial. Immersive research captured rich participant data, including in-depth interviews and ride-alongs with passengers, which provided insights into the key day-to-day issues affecting commuters. The personalised journey plans offered seven modes of travel: buses, trams, carshare, taxis, bike share, on-demand shared mini-bus and walking. Extensive analysis showed that MaaS could be a significant tool in achieving TfGM's objectives, as 26% of participants were more willing to use public transport, and 21% were more willing to cycle and walk. This indicates that MaaS has the potential to create more sustainable travel behaviours (active travel modes and ride-sharing), which can help address the challenges local authorities face in urban areas. Six months following the trial, 82% of participants interviewed wanted MaaS back. One-third of car owners wanted to give up their vehicle following the research, and most participants were willing to pay an increase in their monthly travel expenses for MaaS.

4. The Importance of Multimodal Travel for LAR Ltd.

The city of Łódź is one of the leading urban centres in Poland. It is an important academic centre on the country's map, with a rich industry, economic zone, and extensive cultural offer. The main communication axes are east-west and north-south. The city's characteristic buildings and street layout of industrial centres from the beginning of the 19th century and the lack of river crossings generate specific communication problems. What is also worth emphasising is that there is no main railway station in Łódź, and Łódź Fabryczna and Łódź Kaliska serve travellers from different directions, which is to change when the cross-town tunnel is put into operation.

Public transport in Łódź is based on a tram and bus network, supplemented by a public bicycle and scooter system. Since 2016, LAR Ltd. introduced, together with the Road and Transport Authority in Łódź, mutual acceptance of tickets. Since then, LAR has been an important public transport branch in the city and neighbouring centres. Due to the city's high intensity of renovation and construction work, travelling by train is an excellent alternative to travelling from the city's outskirts.

From the passenger's point of view, what matters are the possibility of a convenient transfer, travelling on one ticket, travel time, and comfort. The LAR network does not reach everywhere, so integrating various means of transport is important. Cooperation with the City of Łódź and other smaller centres in the agglomeration allows us to create an offer tailored to the passenger's needs. In addition to tariff integration and mutual receipt of timetables, it is important to introduce feeder transport in areas without public transport. In 2023, the first buses (Kolejowa Komunikacja Autobusowa – Railway Bus Transport) were put on the roads of the Łódź Voivodeship, which are to complement the offer of LAR. Departure/arrival times are adjusted to the train timetable, and tickets are sold according to the same principles as in rail connections. LAR Ltd. understands the importance of multimodal travel; therefore, it consistently introduces activities and solutions to facilitate functional travel for passengers.

5. Characteristics of Travel Platforms

Analysis of various concepts of MaaS platforms showed that they use advanced algorithms for trip planning. Their optimisation takes place through the prism of parameters selected by the user: price, time, means of transport, driving license, number of transfers, access for disabled people, or very specific requirements, such as avoiding cycling in the rain or the desire to make longer journeys by pedestrians. In this way, the traveller chooses his or her priority – e.g. the speed of reaching the destination regardless of the cost of travel or the use of a direct connection (Parker et al. 2016).

The multimodal trip planning process should be as follows, considering the above. The traveller plans a trip using a mobile application or online portal with the option of using all available means of transport. It indicates the first destination – "Point A" – and considers priorities (time, cost, travel comfort, weather conditions, carbon footprint, etc.) – Fig. 3.

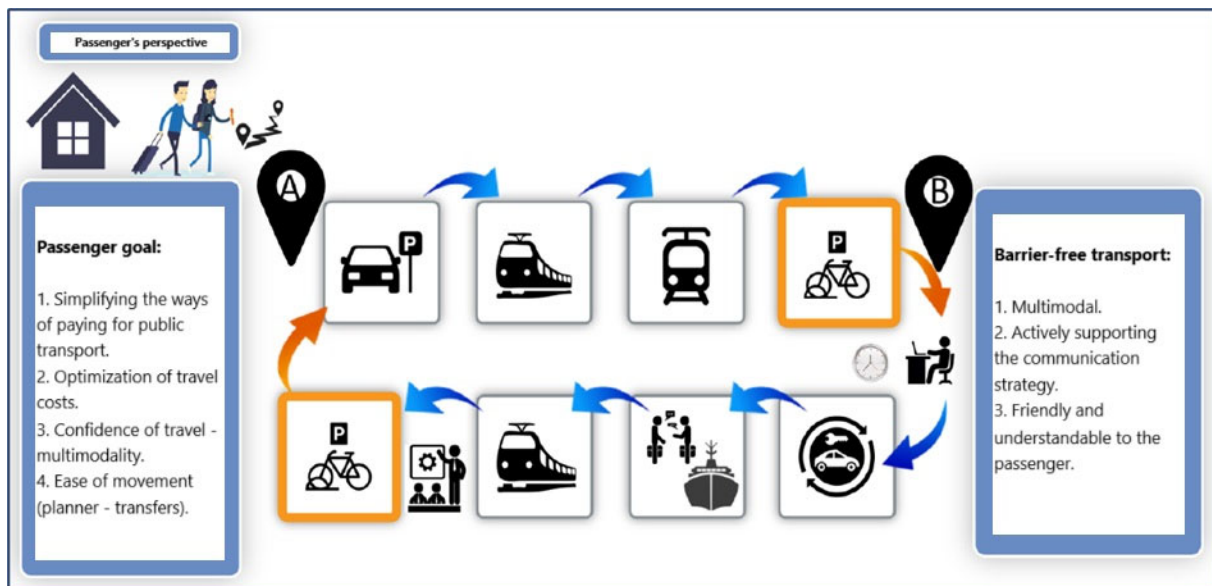


Fig. 3. Travel diagram from the passenger's perspective (Ejdys 2020)

Additionally, the traveller should be able to reserve a bike in the Public Bike System (PBS) to ride from the nearest PBS parking lot to the railway station and leave the bike at the RM parking lot. At the station, the passenger, without the need to log in to the website or use the ticket counter, checks in on the platform (identification in the validation device at the beginning of the train journey), then boards the Przewozy Regionalne (Local Railways) or LAR train and goes to the destination station by train, where he checks out (identification in the validating device at the end of the train journey) and changes to the tram (by verifying the current timetable in the mobile application). After checking in using the QR code or NFC, the traveller should ride until the application notifies him about the upcoming destination stop and then confirms the bike reservation in SRM. After checking out in the vehicle, using the application installed on the mobile device, the traveller gets out and follows the navigation instructions showing the current route to the nearest bicycle parking lot next to "Point A" and then reaches his/her destination on foot. The passenger completes the next stage of the journey later in the day. For example, you go to a business partner and then to one of your customers with him. For this purpose, he uses the tram organiser's public transport. The tram fare is included in the ticket price for travellers returning home by regional train and bicycle. At the end of the day, the system should optimise the fees by selecting the best tariff from all available ones.

During the above scenario, the traveller:

- makes payments for the journey in a uniform manner regardless of the transport organiser carrier, as well as regardless of the selected means of transport,
- can use various identification media, e.g. a telephone with a mobile application communicating with a validating device,
- he can provide his data (he has a personalised account in the system) or remain anonymous (for QR tickets).

From the point of view of the transport organiser (or transport operator or carrier), the system should perform other tasks. First, it should allow for the settlement of the transport service provided – Fig. 4.

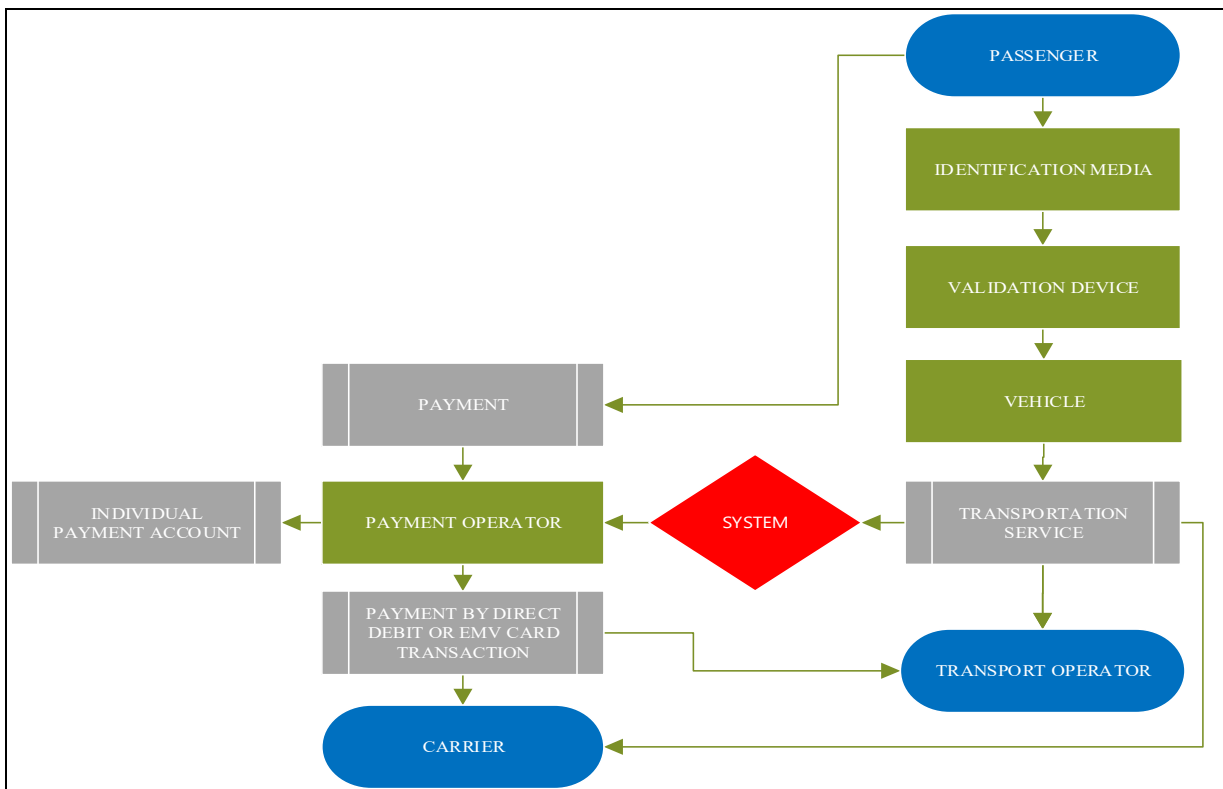


Fig. 4. Travel pattern from the perspective of a transportation organiser

First and foremost, the system should allow for billing the transport service provided. Billing should be based on the association of the transport service (used by the passenger) with a validation device, based on the medium with which the passenger identifies himself by performing check-in (which corresponds to the start of the journey) and check-out (which corresponds to the end of the journey). The validation device should be appropriately associated with a vehicle in the case of local transport or with a station in the case of rail transport. Based on the check-in and check-out, the system will assign the appropriate stops to the passenger's route, which will, in effect, identify the passenger's completed trip in the billing module and settle it by identifying the fare, concessions and costs assigned to the trip. Once the trip costs have been allocated, the system validates the need to collect payment from the traveller using a payment operator.

6. Data Exchange Standards and Their Implementation

Effective trip planning, route tracking, and sharing information with travellers requires appropriate data exchange standards that allow for consistent and interoperable transfer of information between different public transport systems and route planning applications. Two key standards for data exchange in public transport are the Open Journey Planner (OJP) and the General Transit Feed Specification (GTFS). OJP is a standard open brokerage protocol that allows public transport authorities and journey planning applications to access consistent data on routes, timetables, and fares, similar to GTFS, which is a data file format commonly used to share information about public transport timetables, routes, and stops.

1. Open Journey Planner (OJP) Api is an open standard (according to CEN/TS 17118:2017 Intelligent transport systems – Public transport – Open API for distributed journey planning) developed to facilitate travel planning in public transport. It is a protocol that enables the exchange of timetables, routes, fares and other travel-related information between different public transport systems and route planning applications. OJP provides external systems with access to trip planning data by the Open Journey Planner specification (Open Journey Planner 2020).

The OJP standard allows users to access consistent and up-to-date public transport data, making it easier to plan trips and integrate various transport-related systems and applications. The OJP aims to improve the quality of public transport services and ensure better accessibility of information for travellers. The Open Journey Planning API also aims to support distributed journey planning (by the European Technical Specification (CEN) entitled "Intelligent Transport Systems – Public Transport – Open API for Distributed Journey Planning"). It allows systems to exchange information to ensure the planning of cross-border or intermodal journeys or new and innovative information services. The API is based on an extension of the German

TRIAS scheme. The scope of data made available by the OJP Proxy component using the OJP API is defined by Extended system task customer information specification, negotiating with data providers, and the cost of integrating data sources. OJP has already been used to integrate the following data:

- public transport schedules data for all of Switzerland, including real-time information and disruptions for individual carriers,
- OpenStreetMap routes for private transportation,
- elevation data for route calculations,
- shared mobility services (bike rentals, electric scooters, carpooling),
- electric vehicle charging points,
- a large number of points of interest.

Although various data sources are combined and consolidated by OJP implementations, from a practical point of view, there are currently existing important limitations such as:

- at present, the system supports only Swiss Public Transport Routes,
- some modes are not yet available,
- real-time information is only available where we have received this information,
- fault information is not yet available.

2. General Transit Feed Specification (GTFS) is a data file format that is commonly used to provide information about timetables, routes, and stops on public transport. GTFS is widely used by transportation agencies worldwide and is recognised as the standard data format for public transportation. As a result, trip planning applications can use GTFS data from different transport operators, allowing users to easily plan routes covering different modes of transport (GTFS: Making Public 2024). Many development tools and libraries allow you to create, process, and analyse data in GTFS format, making it easier to develop travel planning applications.

GTFS data is organised in text files containing information about routes, timetables, stops, fares, route shapes, etc. Each file has a specific data structure and format, which makes it easier to process and interpret the information. GTFS is flexible and can be used for different types of public transport, such as buses, trams, metros, trains, ferries, etc. Good practices related to this format are described in the GTFS best practices (GTFS Schedule Best 2024).

Additionally, the GTFS file encompasses recorded stops and communication routes of individual lines, along with their geographic positioning, which can be relatively easily utilised for GIS analyses or assessing transportation accessibility within a specific area. These data originate from carriers and are updated by them based on existing GPS traces from vehicles. Therefore, they serve as quite accurate source data free from any processing errors, and their timeliness is maintained by carriers, who are interested in informing customers and major national route search engines about their offerings, including route changes or the addition of new or updated stops.

3. OpenTripPlanner – one of the applications that use the GTFS standard is the open-source software OpenTripPlanner. It is a group of open-source applications that help individuals and organisations generate and deliver multimodal itineraries based on OpenStreetMap (OSM) and other standard data sources, such as the GTFS mentioned above. From the point of view of travel planning and data exchange, two services provided by OpenTripPlanner are crucial: they are available m.in:

- OTP Routing API is responsible for planning trips and making them available in JSON or XML format. Thanks to this, it is possible to search for travel routes in the standard user interface or with the use of own applications that communicate directly with the API.
- The Transit Index OTP API is a REST web service that provides information from data provided in GTFS files. Examples include routes serving a specific stop, upcoming vehicles at a specific stop, upcoming stops on a particular trip, etc. More complex transport data requests can be made using the GraphQL API.

Trip planning and visualisation are available using maps. It is possible to freely browse the map and viewpoints on the map, including stops saved in timetable data and other points added as map layers. OpenStreetMap is based on the Open Data Commons Open Database License (ODbL 2024).

5. Summary

The increase in the number of passengers and the development of rail transport systems make it necessary to take care of travellers. The increased demand for railway capacity necessitates offering a high, broadly understood quality of services and access to the necessary information, thanks to which the traveller could effectively plan his or her journey. The main conclusions of our study are as follows:

- there are changes in the model of travelling and the choice of means of transport,
- when planning and preparing an offer for travellers, it is important to know passengers' preferences due to changing mobility patterns,
- there has been a development of shared mobility, which complements the offer of the public transport system,
- the MaaS platform is a service that, on the one hand, connects and, on the other hand, facilitates the use of multimodal transport and shared mobility services,
- providing information to travellers requires appropriate data exchange standards,
- the key data exchange standards in public transport are Open Journey Planner (OJP) and General Transit Feed Specification (GTFS).

To sum up, due to the ineffectiveness of the actions undertaken so far focused on road infrastructure development, the concept of multimodal travel brings a new answer to the growing problems related to the increasing dominance and popularity of individual motorisation. It connects different modes of transport into one mobility environment, enabling MaaS operators to offer seamless journeys across IPOs, on-demand, and new mobility.

MaaS is key to changing travel behaviour towards more sustainable mobility options, reducing private car use and providing better mobility.

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