Trip Planner Challenges in the Era of Fast Changing Requirements

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Abstract. Trip planner’s solutions main goal is to provide travelers with the multi-modal trip plan, time estimation, routes choice options and some advisory suggestions. Trip planner solutions operate mainly with publicly open data sources, such as public transportation schedules and routes. Research question: How to identify what other real-time information is needed for the trip planner’s system to be resilient and easily adaptive to the changing requirements. Considering the changes and challenges that will bring post-pandemic transportation requirements, the research goal is to analyze trip planners from the provided services quality view, like comfort, availability for different passenger groups, ecology and investigate possible approaches to address new requirements for social distancing, transport load, life quality and crystallize other vital requirements. The particular result was the analysis of trip planners available for Riga municipality and validation of their compliance against current requirements, clear vision of what passengers will consider as useful features and suggestions for complementary services, besides basic information about the journey, map and schedule.

Keywords: Mobility · Trip planner · Transport service quality · Individual preferences · Big data · Riga case analysis

1 Introduction

Mobility is essential for society and economy and in [1] highlighted that responding to increasing demand for urban mobility and users’ needs for seamless, multimodal urban mobility requires cities to adapt their public transport offering from “delivering transport” to “delivering solution”. Such transformation can be achieved throw public transport quality improvement and users experience via service offering extension and significant application of the information communication technologies (ICTs) in the transport sector. It includes technological aspect such as the share of real-time data about the multimodal alternatives; data format unification; ticketing and payment systems etc.

Data should be shared to promote the benefits of active mobility and be as a service for better mobility planning, monitoring and organization. For the users the focus is no longer on the transport mode, but rather on mobility [2]. Mobility as a Service (MaaS) seeks to transform the way in which travelers choose how he/she travels from origin to...
destination and the core elements of MaaS are ticketing and journey planning. Trip (journey) planner’s solution’s main goal is to provide travelers with the multi-modal trip plan, time estimation routes choices options and some advisory suggestions. Trip planner solutions operate mainly with publicly open data sources, such as public transportation schedules and routes. But considering the changes and challenges that will bring post-pandemic transportation requirements, it is very important to keep society healthy and running throw seamless, safe, reliable and sustainable mobility.

The crisis has shown the importance of acceleration, the digitalization of real-time travel information [3], ticketing and payment, etc. and the task to plan safe, resilience and the sustainable trip from the first mile to last one is the task for MaaS platform. Trip planning should include not only standard attributes of the trip – mode and duration but also a lot of characteristics such as transport current occupancy, frequency of delay and other defined individual preferences.

Data quality is one of the limiting factors of a routing service and the completeness, consistency, accuracy and integrity of the data sets determines the reliability of trip planner. It is critical now to accelerate the new approach to sustainable trip planning based on a variety of Big Data and give the possibility to passengers to make smart and safe decisions and plan routes to minimize their risk of exposure.

The research methodology consisted of following steps. The first step included a thorough state-of-the-art review regarding mobility as a service, different trip planner types and service quality that can be demanded by travelers in the usual time and the era of post-COVID-19 pandemics. Then the sustainable approach to trip planner development suggested.

The main research question was “what other real-time (or predicted) information is needed for the trip planner’s system to be resilient and easily adaptive to the changing requirements”. But the scope of the question is wider than only challenges of the post-COVID-19 world and we want to analyze the requirements to a holistic set of information for trip planners from the provided services quality view, like comfort, availability for different passenger groups, ecology and as well as investigate possible approaches to address new requirements for social distancing, transport load, life quality and crystallize other vital requirements.

The secondary goal was to provide analysis of trip planners available for Riga city and validation of their compliance against current updated requirements, clear vision of what passengers will consider as useful features and suggestions for complementary services, besides basic information about the journey, map and schedule. Lastly, a series of recommendations were formulated, for the Riga trip planners to improve based on Big Data.

2 Related Works

To identify relevant researches, we used the academic search engine Science Direct. The search pattern included next keywords: trip/journey planners; MaaS; traveler (passenger) behavior & change and Big Data. The number of papers with key words “Big data” and “traveler (passenger) behavior & change” continue to increase from 2015 till now and have a strong growing tendency. That shows the actuality of the
research theme. The “trip/journey planners” and “MaaS” represent a stable growth tendency in the research field (see Fig. 1).

![Graph showing dynamics of related publications to keywords in https://www.sciencedirect.com/ by year and subject.](image)

**Fig. 1.** Dynamics of related publications to keywords in https://www.sciencedirect.com/ by year and subject.

### 2.1 Mobility as a Service

MaaS can be described as an integration of different types of transport services into the united mobility service, which is available on demand. Reduction of car dependence and providing more customized user-oriented transport system accessibility to the general public are key objectives for MaaS implementation. MaaS core enabler is a combination of public transport, private transport, ride-sharing, car-sharing, bike-sharing, taxi, car or scooter rentals providers though the user-friendly single application interface, that provides access to mobility and helps to create and manage trips, for which users/passengers can pay from a single application account [4]. MaaS users are provided with a list of travel options, including public and private, traditional and new transport modes, based on multiple needs, preferences and budget, and it is a service which allows them to pursue more activities within the same timeline [5]. Global interest in MaaS is growing and the concept is gaining more attention, as an example in the UK public and private sectors [6], where MaaS has the opportunity to improve people and goods movement. In Polis study [7] concluded that further research is necessary to gain greater insight into the potential impact of new mobility services, especially in terms of travel behavior change, and an understanding of those situations in which MaaS services can deliver the greatest and quickest benefits. Thus, it is important to specify what kind of mobility services should be included and to what extent these services should be offered [8].
MaaS became a trend and demand for more personalized transport services [2] and it created momentum for new mobility service providers solutions development, as it is clear that mobility systems also were affected by the pandemic and post-pandemic differentiated hygiene and distancing requirements. The number of new solutions and mobility services provided is growing fast worldwide, and it is becoming challenging for users to choose the best option that can suit their needs the best. Mobility will increasingly be seen as an information service with physical transportation products, rather than a transportation product with additional services.

In 2019 European Commission published study results about challenges for EU-wide integrated ticketing and payment systems and one of the critical points was mentioned that a large number of different local and regional transport operators, each one developing their own program, leads to higher transaction costs for integrated ticketing providers [9].

One of the reasons for the diversity of MaaS platforms is different geographic footprints of each region and/or country. Besides that the majority of MaaS initiatives are built on a local level, there is a clear need to have a unified global platform. Good examples of integrated services platforms are Google Maps or Free2Move. These two players currently mostly address non-frequent customers, but they should not be underestimated because they still represent a huge market segment and continue to work on the development of new features and services.

From sustainability point of view [10], MaaS should provide citizens with access to more mobility options and reduce the volume of traffic, and fulfil their mobility needs without owning a private car. It was proved by Ubigo pilot in Gothenburg in 2014 [11] and Atkins/SNC-Lavalin [12] hypothesis test in Transport for Greater Manchester 2018 (TfGM). Ubigo pilot results showed [10] that private car usage can be reduced by 50% and TfGM, that 47% of participants were willing to use public transport, cycle and walk. It can be effective tool for sustainable journey planning because it changing citizens’ mobility habits and shows the shift to more sustainable transports modes usage.

2.2 Trip Planner

Trip or journey planner is the core element of MaaS. First research paper about the trip planner concept was published in 2011 as a solution for a tourist expert system, called the City Trip Planner [13], which would allow planning routes for five cities in Belgium. It was implemented as a web application that takes into account the interests and trip constraints of the user and matches these to a database of locations in order to predict personal interests. A trip or journey or route planner is a specialized search engine that is used to find an optimal means of travelling between two or more given locations, sometimes using more than one transport mode [14, 15]. Searches may be optimized on different criteria, for example, fastest, shortest, fewest changes, cheapest [16]. They may be constrained, for example, to leave or arrive at a certain time, to avoid certain waypoints, etc. A single journey may use a sequence of several modes of transport [17]. The decision on potential routes and modes of transport is an important aspect associated with journey planning and as well journey time and cost are the key factors in choosing routes. Integration of different transport modes as a way to improve
the door to door transport chain. The main aim of it is to provide a passenger with a seamless journey using different modes of transport: the user must choose public over private transport and to make this he must appreciate the quality, speed, ease and comfort of the public transport.

If we look on every day journey planning [18], then the majority of trip planners have limitations of integrated transportation information, it is mainly private car routes, public transportation routes, and schedule and walking distances, less trip planners can plan expenses, forecast expected latency, influence on ecology and the convenience of provided route options. Travelers gain important information regarding the trip they wish to take by using journey/route planning apps although most of the algorithms underlying in these kinds of apps are deterministic, which means they do not cover in case of delay (i.e. traffic, red lights, etc.).

In [19] provided an analysis of 20 journey planning apps based on different high-level features that journey planners should include: (1) Multimodality; (2) Navigation guidance; (3) Real-time information based on built-in GPS navigation, henceforth users are notified about traffic conditions and re-route to avoid certain unpredicted delays; (4) Crowdsourcing data; and (5) Personalization that allows users to meet their specific needs more efficiently as well as effectively.

Technology enables new opportunities in form of direct access to information anytime and it is perceived by citizens is differently processed depending on various factors, normally according to their socio-economic context and experience, but the goal one – service quality increasing. The quality of transport system service is a key factor regarding mobility and especially for some special groups: the elderly or mother with children. So, trip planners can provide exclusive and important information to all groups of users. Experts point out in [10] that there are two main user groups of urban mobility services: one is collective use services group - like mass public transport and another individual use services group - taxi, bike, car or scooter sharing.

2.3 Good Practices

Transport System Catapult in support of the realization of Intelligent mobility in the UK [20] had developed a study on travelers’ needs and UK capabilities, as a result, they have explored four concurrent transformational themes through to 2030: Access, Demand and Supply, Integration and Automation. Key findings were that 53% of travelers always look for a way to optimize journey, 72% have smartphones and 57% don’t mind sharing their data for better services.

The goal of Denmark’s national trip planner Rejseplanen [13] was to secure seamless transportation all over the country, both in metropolitan and rural areas, but in 2018 the new multimodal MaaS app MinRejseplan was launched with the help of software specialists from HaCon (Siemens). In addition to the regular public transport services, MinRejseplan integrated shared mobility services, demand-responsive transport, road traffic information, bike, ferry and pedestrian routing. Instead of filters sorting search results according to modes of transport, the intelligent algorithm enabled users to filter according to times, prices or the fastest connections. All integrated transport could be booked via the app [10].
Another good example of joint collaboration is OpenTripPlanner (OTP) [21], which is an open-source multi-modal trip planner, mainly focused on travel by scheduled public transportation in combination with bicycling, walking, and mobility services including bike share and ride-hailing. OTP is a collaborative project incorporating code, translation, and documentation from contributors around the world. There is a wide list of known deployments of OTP on a different government- or agency-sponsored production capacities, such as The Helsinki Regional Transport Authority, the Finnish Transport Agency and many others.

As the best practice, we consider an advanced platform for MaaS HAFAS [13] allows intermodal trip planning and integrated ticketing in several countries and major cities and setting new standards in terms of comfort, feature richness and accuracy. HAFAS system has features door-to-door routing including all modes of transportation (buses, trains, trams, ferries, planes, car, bicycle as well as pedestrian routing), real-time information and individual push notifications. An advanced platform for MaaS HAFAS [13] allows intermodal trip planning and integrated ticketing in several countries and major cities and setting new standards in terms of comfort, feature richness and accuracy. HAFAS system has features door-to-door routing including all modes of transportation (buses, trains, trams, ferries, planes, car, bicycle as well as pedestrian routing), real-time information and individual push notifications.

The cities working into developing the trip planners that help to analyze the travelers’ behavior and for example, the CO2 component decreasing using the application for citizens in Lahti city [22] – Urban Innovative Action project by Lahti city. In this example digital data platform to reduce traffic congestion and emissions from transport, collect and make available digital data on mobility is developed for citizens in Lahti and might be used as an example to develop environmentally aware citizen mobility rewarding system (project CitiCAP).

3 Sustainable Approach to Trip Planning

In the interpretation of [23], MaaS offers need-based and customized mobility solutions for the users with the goal of achieving a more sustainable transport. In [3] published a 2020 report about mobility in the post-pandemics period noted that safety has always been a central issue for mobility systems, but the choice of mobility modes during the crisis has been heavily affected by health and hygiene concerns. In the aftermath of the lockdown, there has been a deficit of trust towards mass transit and shared mobility, driven by the perceived risk of infection from contaminated surfaces and the challenge of maintaining physical distancing.

As highlighted below, it is important to specify what kind of mobility services should be included in trip planner and to what extent these services should be offered (i.e., hours of car sharing, unlimited use of public transport, etc.). Based on the Sustainability approach and European standard requirements to quality of passenger transportation the Summary of Sustainable Trip Planner features (Table 1) was developed. It consists of the travel information characteristics, on which information is critical and important, for the traveler when he/she makes a decision on which route is most suitable and safe for him/her, what supplementary services or support are
provided, how safe will be the upcoming trip. Majority of the features are rarely or not realized in the trip planners currently available for the public, but those features become critical in the regular and especially in the pandemic world.

| Quality Indicators of Transportation | Realized in TP | Rarely realized in TP | Not realized in TP |
|--------------------------------------|----------------|----------------------|--------------------|
| Time                                 | Timetable journey time | Punctuality | Expected delay |
| Availability                         | Network | Ticketing options | Infrastructure |
| Accessibility                        | Facilities assistance | Ride comfort | |
| Customer care                        | Customer interface | Information during journey | Customer support |
| Comfort                              | Travel information | Weather | Ergonomics physical assistance |
| Security                             | Roads Safe from accidents | Roads safe from crime | |
| Environment                          | | | Pollution |

Table 1. Summary of sustainable trip planner (TP) FEATURES.

So, the new features now are more important that existed ones, and for passengers in order to make a safe and optimal decision on travel route choice, trip planner solution should be able to provide as much useful information for safely and sustainability as possible. The volume and velocity of transportation-related data, available for the decision making, grows and requires Big Data techniques and algorithms for using it in trip planning solutions. Big Data as approach based on technologies continue to introduce a variety of smart devices, which constantly produces different format of data, based on passengers’ usage. Big data gives new opportunities in route planning and the challenging aspect of Big Data fusion using by person is in the extraction of needed information across multiple data sets for route and travel planning.

The main driving question is current status and utilization levels of data. Main sources of transportation and travel data nowadays are GPS and GIS. By data diversity and sources, the travel-related Big data fall into the main three categories: (1) transactional data; (2) generated by devices, and (3) generated by the travelers.

Trading data is transactional data including travelers’ card data, online booking data, online search data etc. Traveler card data could be used to analyze personal travel patterns using specific transportation types, mainly public ones. Based on its historical data the travel start time, end time, and travel direction can be analyzed in order to predict traffic flow and expected delays of schedule.

Data generated by devices consist of GPS, GPS tracked bikes, Roaming, Wifi, traffic sensors, floating car data, street cameras, meteorological stations, mobile phone usage data, infrastructure-free traffic management, connected V2V, V2X. GPS data shows real time travel and traffic changes, for example distance, speed, time, and other travel related information. GPS data is divided into the real-time tracking GPS and the logging GPS. In many cities, on the main highways, there are already installed different types of sensors and detectors, which are collecting vehicle volume data: traffic flow, lane occupancy, average speed.
And data generated by the traveler is data from social sensors (text and photo), different Apps data on citizens mobile phones, low-cost sensors’ data. Mobile phone data can provide detailed information of the travel path, but the volume of personal location data is so big, that cleaning and crystalizing needed information would take more time then value it would add.

In aspect of time dimension trip planner will require input of 2 types of data for the trip plan calculation and enriching it with supplementary information. One is historical and static input data: stations names, districts names, GPS coordinates, distances between consecutive stations, total distance on each route, transportation mode/vehicle type, CO2 emissions, speed per transportation mode, ride fare, arriving time for each station for public transport, total time for each route per transportation type, rush hours calendar, transfer hubs, noise level, special need passengers options availability. And another is real time information: accidents, weather information, traffic, delays, cancelations, schedule change.

The value potential from cross-combining historical data with new sources of data which come from the increased digitization and automation transportation systems is high. Besides mentioned above, it is important to assess all data sources by format, granularity and size, ownership and restrictions, security level and cost. And Big data in transport is not only about collecting and safely storing, it is now refers to extremely large data sets, which should be analyzed and interpreted with the help of modern technologies.

4 Trip Planner in Riga: Current State, Recommendations

Riga is capital of the Republic of Latvia with the urban functional area (FUA) which together covers 1/3 of the Republic territory. The Riga transport system (RTS) is represented by trams (8 routes), trolleybuses (18 routes), buses (54 routes), and minibuses (18 routes). The total length of the Riga public transport (PT) route is 12,012 km. In 2018, almost 150.6 mln passengers were transported (as well as 11.8 mln by minibuses). RTS serves 185,000 passengers travelled on international buses, 796,000 passenger’s turnover in Riga Passenger Port, 18.2 mln passengers used railway services and Riga International Airport – 7 mln passengers in 2018 [24]. Car sharing, bike sharing micromobility (scooters) systems are represented by private providers: car sharing - Car guru, City Bee, Fiqsy, bike-sharing - Next Bike and micro-mobility – Bolt, Altum, Fiqsy and they now close gap of the last and first mile solutions in the city.

The commuter trips make up 40% of all daily trips. The modal shift of these trips is that more than 42% using private cars (data from the household survey conducted in 2019. Despite this result, 18% of FUA residents use coaches and only 3% – trains.

Riga and FUA have approximately 11 PT providers: one for Riga and 10 from the other FUA municipalities (each municipality has the own PT organization). The united PT system planning regulation doesn’t exist in this territory. As was mentioned above, the ticketing system is one of the sustainable transport system components. Worth to mention that there is no integrated ticketing system in Riga yet, that would provide the purchase of a single ticket that allows passengers to travel using different modes of transport provided by more than one operators.
The situation with the trip planners is ambiguous in Riga. From one side city has the number of the trip planner prototype, but from another side, each transport mode provider has the own application and the web page with the possibility to choose the route and mode. Some of them also provide the possibility to pay for the services. Table 2 compiles the 11 most used prototypes of the trip planners in Riga.

Table 2. The prototype of trip planners in Riga (walking – 1, cycling – 2, car – 3, PT – 4, coach – 5, aeroplane – 6, micromobility – 7, train – 8, taxi – 9).

| Transport modes | Schedule | Faring/ticketing | Multimodality | Accessibility | Safety&security | Reliability (delays, congestion) | Environment |
|----------------|----------|------------------|---------------|---------------|----------------|--------------------------------|-------------|
| https://www. 1188.lv/satiksme/marsruta-planotajs* | 1,4,5,6,8,9 | + | + | | | | |
| https://www.google.lv/maps* | 1,2,4,5,6,8,9 | + | – | + | – | + | |
| https://balticmaps.eu* | 1,3 | – | – | – | – | – | |
| https://marsrüts.net* | 3 | – | – | – | – | – | |
| https://iauto.lv/karte/* | 3 | – | – | – | – | – | |
| www.rigassatiksme.lv* | 4 | + | – | – | – | – | |
| https://velokarte.divritesnis.lv/* | 2 | – | – | – | – | – | |
| Waze** | 3 | – | – | – | – | + | |
| Citybee, Atom, Bolt, Fiqsy** | 7 | – | + | – | – | – | |
| Trafii** | 1,2,4 | + | – | + | – | – | |
| Moovit** | 4 | + | – | + | – | – | |

*– online, **– application

The trip planner prototypes are divided into two types: online (google.lv, 1188.lv, etc.) and applications (rigassatiksme.lv, Moovit, etc.). Three trip planners provide information for more than three transport modes (1188.lv, google.lv, Trafii). Two of them provide only information about travelling possibilities by PT (rigassatiksme.lv, Moovit). And three of trip planner’s prototypes give possibilities to choose trips only by car (https://marsrüts.net/, https://iauto.lv/karte/, Waze). Such kind of transport as walking advice to choose: https://balticmaps.eu, 1188.lv, google.lv, Trafii. Only five of planners inform about schedules: 1188.lv, google.lv, rigassatiksme.lv, Moovit, Trafii. Only one tool (1188.lv) gives the possibility to buy the ticket, but not for the multi-modal trip. The micromobility and share transport providers give the possibilities to find and chose the transport mode and after to pay for the services. In Riga case, the existing trip planner prototypes provide only information for possibly to create the route and chose the trip mode.
The Municipality of Riga actively works for this gap solving and created the sustainable planning program until 2027 [25]. The program defined the activities on how to head toward the city into sustainable development. The main goal is to achieve the collaboration between FUA authorities for the integrated ticketing system creation, mobility hub concept development and public transport system optimization. The program highlights fact that the inhabitants of Riga and FUA have opted for private motor vehicles as their main means of mobility, and this has resulted in considerable increases in traffic congestions in most of the traffic routes in Riga, lowering the quality of life of the population and businesses in these routes and the vicinities of the central areas of the municipality, including higher levels of road traffic accident risk, noise and harmful substance (particle) emissions [25]. And in Riga case, exist the possibility to check the air pollution before the trip online https://www.rigaairtext.lv/ [26], but follow about pollution situation during and after the trip is impossible.

As other recommendations, it needs support in the form of a proper legal framework, which can be constructed based on the European Commission's directives and communications that were mentioned and analyzed previously. Moreover, certain soft and hard measures have to be implemented. Individualized marketing and travel awareness campaigns can be utilized to affect travelers’ travelling decisions and steer them towards active travel, while hard measures, especially infrastructure improvement and construction (for example bicycle parking, bike holders, dedicated cycling and walking lanes) can promote active travel in a more direct way.

It is necessary to standardize and digitalized the data, as defined in [27] – the EU directive (COMMISSION DELEGATED REGULATION (EU) 2017/1926 of 31 May 2017 supplementing Directive 2010/40/EU of the European Parliament and the Council with regards to the provision of EU-wide multimodal travel information services). These activities could be the starting point for the united transport system development or MaaS implementation. The Latvian state road (JSC Latvian State Roads) create the National access point and cities need to be ready to achieve these solutions.

5 Conclusions

The European Commission (EC) intends to ensure the EU transport sector is fit for a clear, digital and modern economy and main objectives include: (1) Increasing the uptake of zero-emission vehicles; (2) Making sustainable alternative solutions available to the public and businesses; (3) Supporting digitalization and automation; and (4) Improving connectivity and access. Reliable data, serving as a basis for advanced and up-to-data travel information services, is one of the main prerequisites to MaaS uptake, creating more predictable travel chains and inducing people to leave their cars at home [14]. The pandemic situation represents the importance to change the transport planning paradigm in the cities. The MaaS and trip planner could help to solve the urban mobility problems and these solutions could provide safe and convenient last/first mile trips.
If we look on every day journey planning as core tool in MaaS, the majority of trip planners have limitations of integrated transportation information, it is mainly private car routes, public transportation routes, schedule and walking distances, fewer trip planners can plan expenses, forecast expected latency, influence on ecology, and the convenience of provided route options. But in sustainable approach it should provide not only this information, but also about the environment, safety, security and accessibility for the deferent residence groups.

In paper the trip planners existed in Riga city were analyzed and concluded that they provide only information for possibly to create the route and chose the trip mode. The review of modern approaches and the current Riga PT trip planners showed that it is a lack of information and data integration. As was mentioned above, there is no integrated ticketing system in Riga yet, that would provide the purchase of a single ticket that allows passengers to travel using different modes of transport provided by more than one operators. This system creating could be the motivation for residents to change their travel behavior.

Moreover, exist the number of authorities/stakeholders that has their own data, but would to share and open it. Worth to mention that there is no integrated ticketing system in Riga yet, that would provide the purchase of a single ticket that allows passengers to travel using different modes of transport provided by more than one operators.

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