ULTIMO

Advancing Sustainable User-centric
Mobility with Automated Vehicles

DELIVERABLE

D4.1 – MaaS passengers & LaaS Services - First version

Co-funded by the European Union

Project co-funded by
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Confederation
Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

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This work has received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI).

Document Information

Grant Agreement	**101077587**
Full Title	Advancing Sustainable User-centric Mobility with Automated Vehicles
Acronym	ULTIMO
Deliverable	D4.1 – MaaS passengers & LaaS Services - First version
Deliverable Due Date	30.09.2023
Work Package	WP4 – T4.1
Lead Partner	PADAM MOBILITY
Leading Author	Atziri Sanchez Contreras
Dissemination Level	Public

Document History

Version	**Date**	**Author**	**Description of change**
1.0	27.09.2023	Atziri Sanchez	First version MaaS passengers & LaaS Services
1.1	28.09.2023	Evangelos Antypas (CERTH/ITI), Alexandros Papadopoulos (CERTH/ITI), Georgios Nikoletos (CERTH/ITI), Georgios Chondrogiannis (CERTH/ITI), Konstantinos Giapantzis (CERTH/ITI), Meropi Pavlidou (CERTH/ITI), Theoktisti Marinopoulou (CERTH/ITI), Dimitrios Tsiktsiris (CERTH/ITI),	Contribution regarding proposed passenger services

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1.2	29.09.2023	Atziri Sanchez Javier Guimera	Cleaning and finalising the first version

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Acronyms

ADAS	Advanced Driver Assistance Systems
AST	Anruf-Sammel-Taxi
AV	Automated Vehicles
B2B	Business to Business
CCAM	Cooperative, Connected and Automated Mobility
CINEA	European Climate, Infrastructure and Environment Executive Agency
D4.1	Deliverable 4.1
DB	Deutsche Bahn
DO	Drop-off
DRT	Demand Responsive Transport
ETA	Estimated Time of Arrival
GE	Canton of Geneva
ITS	Intelligent Transportation Systems
LaaS	Logistics as a Service
MaaS	Mobility as a Service
OCSTAT	Office cantonal de la statistique
ODD	Operational Domain Design
PTO	Public Transportation Operator
PU	Pick-up
SAE Level	Society of Automotive Engineers Level (Vehicle Autonomy Level)
SBB	Swiss Federal Railways
SERI	Swiss State Secretariat for Education, Research, and Innovation
SoA	State of the Art
SNCF	French National Railway Company
TPG	Transport Publics Genevois
T4.1	Task 4.1
T4.2	Task 4.2
VRU	Vulnerable Road Users
V2X	Vehicle to Everything
WP	Work Package

Executive Summary

This deliverable's mission is to demonstrate a consolidation of currently offered services per site in order to highlight both the starting place and the obstacles that must be overcome in order to meet the ULTIMO project goals. The present document opens with an overview of the fully automated on-demand service, the project's goals, and the WP4 content. The consolidation of the MaaS services now provided at the 3 demonstration sites is the main topic of Chapter 2. In chapter 3, a similar strategy is used, but it focuses on LaaS services. Chapter 4 examines the use cases, location, and present state of these new on-demand automated mobility services within the project demonstration sited. The requirements that must be addressed in the future are then explained in Chapter 5 using the outcomes from D2.1. The applications that were available and were seen during the creation of Chapter 2 are evaluated in Chapter 6 in accordance with the criteria established in Chapter 5. A preliminary proposal of the passenger services, which takes into consideration the project engagements and demands indicated in WP2, is shown in Chapter 7.

In collaboration with the other tasks of WP4 that deal with the vehicle, infrastructure and operator technical requirements and needs, it will be possible to deliver value-added services to all involved stakeholders. The role of D4.1 within WP4 is to provide an overview of the entire existing offer at each ULTIMO site from the perspective of the users.

1. Introduction

During the past few years, many projects and initiatives were undertaken deploying and testing Automated Vehicles (AVs) for public transportation and logistics. However, in spite of their ambition, all these projects stayed on the level of elaborated experimentation and never reached the level of a large-scale commercial deployment of transport services. The reasons for this are many, the most important being the lack of economically viable and commercially realistic models, the lack of scalability of the business and operating models, and the lack of user-oriented services required for large end-user adoption of the solutions.

The ULTIMO project will create the very first economically feasible and sustainable integration of AVs for MaaS public transportation and LaaS urban goods transportation. ULTIMO aims to deploy in three sites in Europe 15 or more multi-vendor SAE L4 AVs per site. A user centric holistic approach, applied throughout the project, will ensure that all elements in a cross-sector business environment are incorporated to deliver large-scale on-demand, door-to-door, well-accepted, shared, seamless-integrated and economically viable CCAM services. We target the operation without safety driver on-board, in a fully automated and mission management mode with the support of innovative user centric passenger services.

ULTIMO's innovative transportation models are designed for a long-term sustainable impact on automated transportation in Europe, around the globe and on society. The composition of the consortium ensures the interoperability between multiple stakeholders by making adoption of new technology at minimum costs and maximum safety. The integration of the ongoing experiments of previous AV-demonstrator projects ensures highest possible technical and societal impacts from the very beginning of the project, as well as during the project lifetime and even long after its completion.

1.1. On-demand Mobility

Public transportation is a key element of a region's economic development and the quality of life of its citizens. Governments around the world are defining strategies for the development of efficient public transport based on different criteria of importance to their regions, such as topography, citizens' needs, social and economic barriers, environmental concerns, and historical development. However, new technologies, modes of transport and services are appearing, which seem very promising to the support of regional strategies for the development of public transport.

On-demand transport is a public transport service that only works when a reservation has been recorded and will be a relevant solution where the demand for transport is diffuse and regular transport is inefficient.

On-demand transport differs from other public transport services in that vehicles do not follow a fixed route and do not use a predefined timetable. Unlike taxis, on-demand public transport is usually also not individual. An operator or an automated system takes care of the booking, planning and organization.

It is recognized that the use and integration of on-demand Automated vehicles has the potential to significantly improve services and provide solutions to many of the problems encountered today in the development of sustainable and efficient public transport.

1.1.1. Fully Automated Vehicles

A self-driving car, referred in the ULTIMO project as a **Fully Automated Vehicle** (**AV**), is a vehicle that can sense its environment and moving safely with no human input.

The terms *automated vehicles* and *autonomous vehicles* are often used together. The Regulation 2019/2144 of the European Parliament and of the Council of 27 November 2019 on type-approval requirements for motor vehicles defines "automated vehicle" and "fully automated vehicle" based on their autonomous capacity:

An "automated vehicle" means a motor vehicle designed and constructed to move autonomously for certain periods of time without continuous driver supervision but in respect of which driver intervention is still expected or required.

"Fully automated vehicle" means a motor vehicle that has been designed and constructed to move autonomously without any driver supervision.

In ULTIMO we operate ***Fully Automated mini and micro shuttles for shared public transportation***. In relation to the SAE levels, the ULTIMO project will operate SAE Level 4 vehicles.

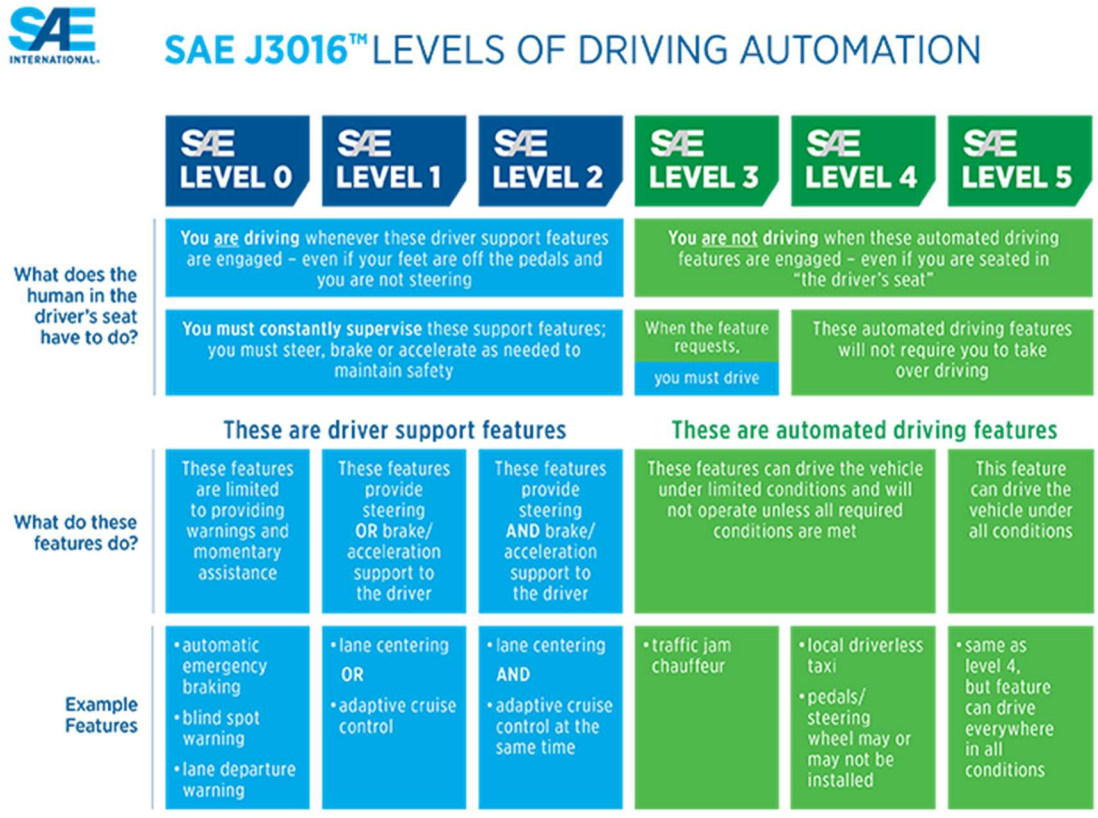

Table 1: SAE Driving Automation levels (©2020 SAE International)

1.2. The ULTIMO dream for public transportation

Our city has a population of 700.000, and the local PTO (Public Transport Operator) deploys 3.000 Km of public transportation services' routes, with 4 backbone tram lines, 8 backbone large bus/trolley lines, and 340 fully automated multi-manufacturer mini and micro-shuttles in an on-demand, door-to-door shared public transport service. The fleet of the 340 automated minibuses is composed of different vehicle generations and models from different manufacturers, as it was purchased in different batches during the last 12 years (it all started with the first 15 bought by a European project in 2023/24). It is today composed of the first 15 twelve-years old vehicles from manufacturer A, 160 eight-years old vehicles from manufacturer B and 160 two-years old vehicles from manufacturer A, which are the new generation of manufacturer's A vehicles. These last 160 vehicles re-placed the last 70 old, driver based, thermic busses that reached the end of their life after 18 years in operation. The change from driver large busses to automated mini-buses and from fixed line service to on-demand, door-to-door, for the last area of the city, was decided 6 years ago, and was based to the great success of the already deployed AV-based services in the other parts of the city.

The integration of new vehicles in the PTO fleet was done within just a few days, thanks to the now standardised APIs of the automate vehicles' connection with the AV fleet management and orchestration service, that allows a plug-and-operate functionality, but also enables the combination of AVs with all other means of transport, offering a seamless citizen centric journey to the users. Similarly, the now standardized High Definition (HD) maps between the vehicle manufacturers, allowed us to reuse the maps created in the past for the 3.000 Kms of routes of the city, with small adaptations for the new vehicle capabilities. At the same time of the purchase of the last 160 AVs, we also switched to a new AV fleet management and orchestration service, from another provider, which offers more precise trip time estimations, considering also traffic jams in the city and weather conditions (that affect traffic in the city). The replacement was made within just two weeks, thanks to the new standardised interfaces between AV fleet management and PTO MaaS services.

Passengers are now able to reserve, via their mobile phone app, on the fly or with pre-reservation trips from one side of the city to another, using the optimal transport mode available for them, with a combination of different transport modes, and having the automated vehicle arriving next (or almost) to their door entrance and bringing them to their final destination or to a backbone transport connection. All trips are offered with highly reliable and accurate transport and arrival times, based on real time, dynamic route changes of the vehicles, responding to the passenger needs. Many passenger services are available in the AVs via a mobile phone app, adapted to all passengers' needs, from special needs passengers (visually impaired, wheel-chair users, pregnant women, elderly, children), to persons transporting suitcases or a baby-stroller, providing adapted information of their trip (where to get-off, PTO general information, and even infotainment, like city related information and historical facts and anecdotes, related to their current position).

With the full suppression of on-board operators, automated in-vehicle monitoring provides a multitude of passenger services, which were, and are developed with a continuous collaboration and innovation between users and the PTO. An on-board unit identifies locally

(that is, in the bus) incidents and events, like aggressions, vandalism, forgot-ten objects, littering, accidents, etc., and raises incident alarms to the PTO back-office. The PTO officer at the back-office evaluates the incident and decides, based on the operator policies, what action to take: dismiss the incident, or stop the vehicle and call one of the intervention teams to go the vehicle and take the required action. The back-office operator, based on the number of incidents and intervention time legal obligations, can deploy any of the 15 intervention teams available in the city, ready to reach within a few minutes any AV. At the back-office, service operators are able, with one set of screens linked to the fleet management, to follow the vehicle status, trip reservations, routes chosen, open and closed road segments (due to works, accidents, etc. thus adapting dynamically the trip routings), while in a second set of screens, the back-office operators can follow the passenger services' incidents and the status and location of the intervention teams. The two systems, although independent, are linked so that the back-office operator can transfer incidents to intervention teams and turn-on, when possible and under the local legal restrictions, video connection to inspect the incident.

The public transport services are operating 24/7 with different active vehicles, de-pending on passenger transport demands. The PTO, being eco-sensible, has defined that the vehicle must have an average occupancy of at least 3 passengers. This of course has implications, especially in off-peak hours, in the transport delays, but it is fully justified for an optimal and eco-responsible operation. Exceptions are made for people with special needs or when the passenger is ready to pay an additional price.

While at peak-hours the full 340 strong fleet of AVs is in service for public transportation, in the off-peak and night hours, due to the reduced transportation needs, part of the fleet is not serving passenger transportation. However, because having a vehicle waiting idly is a waste of resources, the PTO has signed an agreement with Logistics as a Service (LaaS) Service providers. During the off-peak hours the unused vehicles are dynamically chartered by the different LaaS providers to be used for other types of incidental transport of goods or even non-public transportation of passengers. Local shops and enterprises use the service, on demand with dynamic reservation, to offer home delivery of on-line purchases, or B2B delivery of goods from an urban consolidation center to the distribution center (hub, many to one or one to many [7], or even transport their VIP customers directly to their offices or exposition centers. This way they can deliver the goods to their customers in the city, with a delay of just 60 minutes with affordable prices, as the last mile is the most inefficient part of the goods delivery chain. The goods send can include books from local bookshops or libraries, supermarket bags or even documents exchanged between companies or waste. The local shops are even using the service in the early hours (5 o'clock in the morning) for re-provisioning their shops for the day. The so chartered AVs are "returned" to the PTO for public transport at the peak-hours automatically, at the end of the chartered period.

1.3. Preamble – AI leveraged Services for ULTIMO ITS/CCAM ecosystem.

WP4 develops innovative MaaS services for travellers and LaaS services to increase delivery efficiency. In order to contribute to adoption of new mobility paradigms, it also develops technology to enable vehicle and infrastructure services, considering VRUs among others, to offer secure and reliable ITS management services.

In this WP an iterative methodology is used for the development of MaaS and LaaS services, these services will be tested in the different demo sites. Among the objectives of this WP are to demonstrate that the user experience must be seamless and secure, to get people to adopt new technologies (MaaS) and to maximize the efficiency of delivery (LaaS). In addition, it is proposed to enable vehicle and infrastructure services, along with ITS management services.

Deliverable D4.*1 - MaaS passengers & LaaS Services – First version* presents the consolidated demo sites' MaaS services, providing the fundamental MaaS services while also identifying the alternatives and problems that need additional technological development and improvements. In summary, D4.1 focuses on a SoA of existing mobility applications, evaluating them to know what will be needed for the implementation stage considering the identified user needs.

2. Consolidation of current MaaS offer per ULTIMO site

2.1. Geneva, Switzerland

The Swiss demonstration site is in the canton of Geneva (GE), one of the 26 cantons that constitute the Swiss Confederation. In 2022, there were approximately 517,800 inhabitants distributed among the 45 municipalities that conform the GE (OCSTAT, 2022). Before starting the analysis of available mobility services, it is important to understand the mobility behaviour within the canton. For this, we will take as a reference the most recent mobility survey found, which dates from 2021 and was published in 2023 (OCSTAT, 2023). For analysis purposes, 45 municipalities of the GE canton were divided into 4 categories considering, the characteristics of the territory such as density. The names of the categories are: Centre (City of Geneva), 1st crown (7 municipalities), 2nd crown (11 municipalities), and peri-urban (26 municipalities).

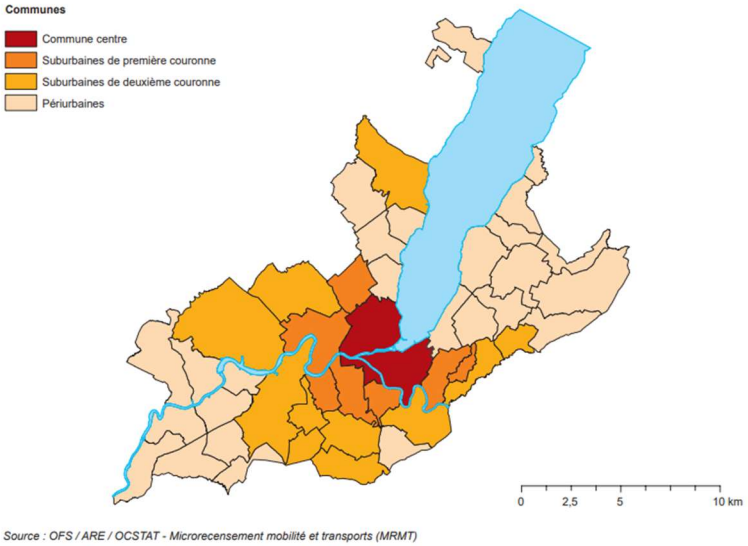

Figure 1. The 45 communes of the canton of Geneva according to typological division

Firstly, the new survey data show a decrease in the number of daily trips of the canton's inhabitants, from 3.6 in 2015 (OCSTAT, 2019) to 2.9 by 2021. It is believed that this phenomenon may be due to the COVID-19 pandemic that hit the world a few years ago, affecting their mobility behavior. Naturally, this figure is an average, there are days of the week with more activity (weekdays) compared to others (weekends).

In terms of distance traveled, the inhabitants of the canton travel an average of 23 km per day. The number of kilometers traveled varies strongly depending on the place of residence, with the inhabitants of the center or 1st crown traveling fewer kilometers per day compared to the least dense zones (2nd crown and peri-urban). With a total of 19 km for the city of Geneva and 34.7 km per resident of a peri-urban municipality, the distance between the center and the peri-urban area is almost two times greater.

Moving into the modal split, it is possible to observe that according to the number of trips by mode of transport, walking is the preferred mode of travel in the GE with 39%. The second most used means of transportation is the private vehicle, with 36%, despite the fact that this percentage varies greatly depending on the trip purpose. This is true for business travel, as 62% of journeys are made by cars.

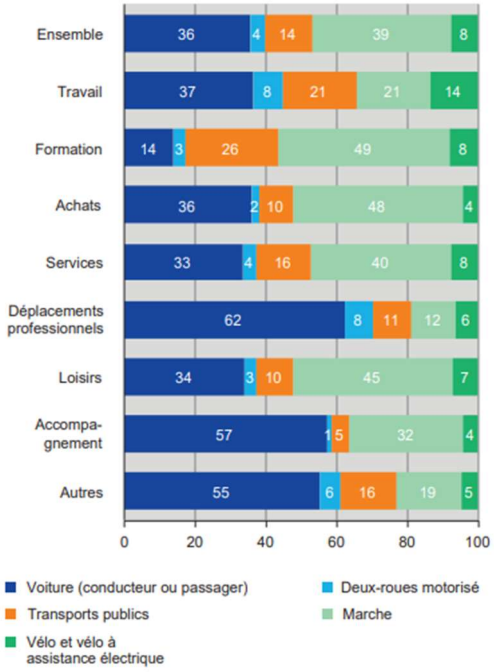

Figure 2. Breakdown of trips by means of transport and reason for the trip in GE.

In third place is for public transport, which ranges between 5% and 26% of trips, depending on the trip purpose, the majority of public transportation journeys are made for educational purposes. It is important to mention that the modal split can vary not only by reason, as seen above, but also by duration or distance traveled.

Taking into account the objectives towards sustainable mobility, the goal will be to focus on further reducing the number of trips made by private vehicles, potentially leading to greater use of public transport for certain reasons, distances and travel times. Currently, the system is mostly managed by the local operator, TPG. The following sections will show the information found in the operator's mobile application, also called *"tpgpreview"*. The goal is to create a

SoA that will enable evaluation of not just the means of transportation available but also of how well the application complies with user requirements and where TPG fits AV on-demand into a MaaS offer.

2.1.1. Mobility offer: Modes and providers of mobility services

The evaluation of the available modes of transport begins with a list, from the classic mass transit modes to micromobility (personal or shared). When an user logged into the application *"tpgpreview",* its evident that the available offer is reduced to 4 modes of mass transit: **bus, train, tram and boat.** While Lémanis (a subsidiary of SBB and SNCF) is in charge of running regional trains, TPG is in charge of running bus and tram routes. In the case of boats, they have historically been managed by a public Swiss company *called "Lake Geneva General Navigation Company."*

All these means of transport have integrated ticketing within the application, with the condition of having a personal account or a guest account. User will be asked for information such as their name, date of birth, and email in case they want to use a guest account to access the ticketing area. Without supplying the aforementioned information, access to the ticketing information is almost impossible.

The **DRT is a means of transport that is only partially integrated** into the current version of the application; it provides information that sends us to a page where we can download an external booking application. The provider of this digital solution is Padam Mobility, however, the service is still operated by TPG. The following figure shows an example of this redirection to the external reservation application for the so-called *tpgflex service*.

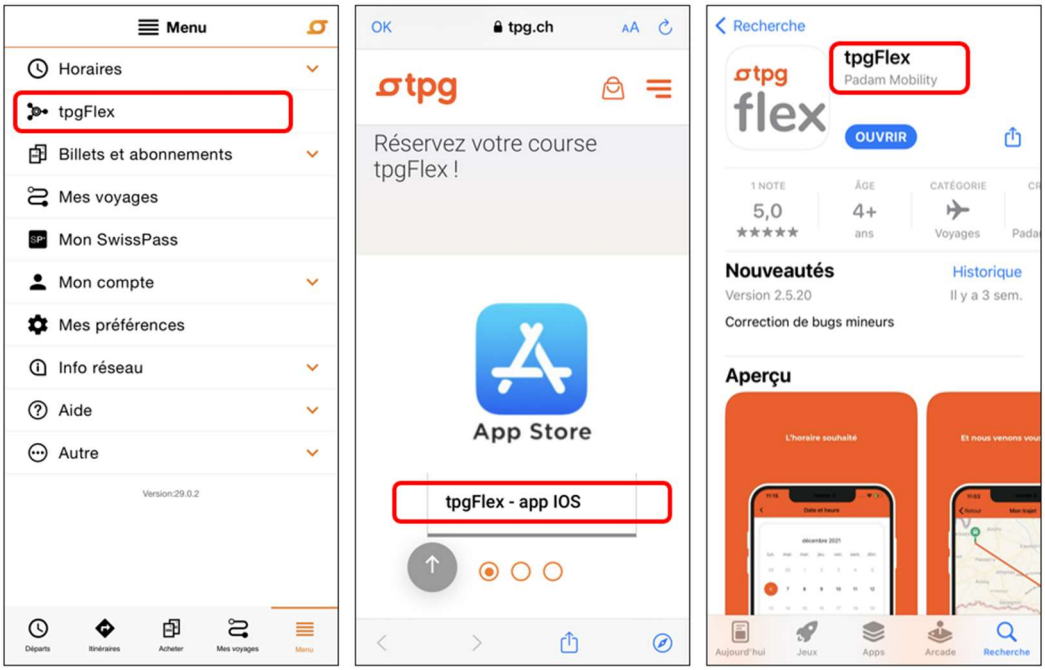

Figure 3. Partial integration of DRT in the tpgpreview application.

The service area is currently located in the western part of the canton, with stops in about nine municipalities, not including some outside the Swiss territory. This cross-border transport has about 95 stops and a total of 2 vehicles available from Monday to Friday between 8:50 am and 4:30 pm and from 7:45 pm to 10:30 pm (*tpgflex | tpg*, s. d.). The service offers connections to mass transit systems such as the train station and tram station, as well as having the same pricing as the rest of the area except for a special ticket called "flea jump".

In keeping with the theme of shared transportation, it should be mentioned that **GE offers carpooling and carsharing services**. However, none of these services are accessible through the *"tpgpreview"* application; instead, information can be found by conducting a search on external websites. Along with having a variety of suppliers in the GE, both services offer ticketing on their individual websites and applications. In the case of carsharing, we can find local providers such as Mobility[1] and 2EM[2], or cross-border providers such as Citiz[3]. In the case of carpooling, it is possible to observe the major players in the market such as Blabladaily, Karos and Klaxit, which are grouped in a regional search platform[4].

The **absence of shared scooters** in GE is the first thing to notice when discussing micro-mobility. This is a result of the government's decision to prioritize the creation of a **network for bike sharing** (Fontannaz, 2019), with Donkey Republic[5] serving as the only provider for the entire region at the moment. Currently, they have their own application and their own ticketing system which is not integrated with the *"tpgpreview"* application. Following active mobility, the application favors public transportation over any suggestions to use this mode of transportation. After multiple experiments, it proved impossible to find route options that prioritized walking or using personal bicycles. The platform does not provide any options for private cars, cabs, or ride-hailing when it comes to individual transportation.

In conclusion, the application tends to give priority to mobility solutions proposed by local operators, leaving micro-mobility in the background and completely excluding individual motorized transport.

2.1.2. Pricing: Payment methods and description of rates

Firstly, pricing is not fully available directly from the mobile application. Access to the information is restricted to users who log in with a personal or guest account, with the possibility of viewing individual ticket information by clicking on the information icon. It was essential to conduct a short search on the operator's website in order to acquire comprehensive information about the tariffs in the service region, where it was able to find a map and the various categories of current rates.

The territory is separated into zones, some of which include French territory, and there are first and second class tickets available in both full and reduced fare, according to what we can see on their website. Within the ticketing section of the application, the available options are: all Geneva, multi-zone, complementary and cross-border.

[1] https://www.mobility.ch/fr/clients-prives
[2] https://www.2em.ch/
[3] https://citiz.coop/
[4] https://www.covoiturage-leman.org/
[5] https://www.donkey.bike/fr/villes/location-velo-geneve

Individual tickets, daily tickets, annual, monthly, and weekly subscriptions are also available through the site. Regarding subscriptions, prices may also vary according to the age of the user, with three different classifications: adult, junior (6–24 years old), and senior (64 years old and older). Other offers available for subscriptions on the site are:

- Duo offers: allows the owner of a valid full-fare All-Geneva adult subscription to offer a second reduced-price All-Geneva subscription to a partner living in the same household.
- Family offers: allows a parent in possession of a valid All-Geneva subscription to purchase an All-Geneva Young Family subscription for their children
- Transferable offers

The *"tpgPay"* rechargeable card, which enables the purchase of one-day tickets at the distribution machines, is also displayed in the website. The *"tpgpreview"* app also enables to store the so-called Swiss pass, a form of card that permits unrestricted travel by train, bus, and boat throughout the full area of Switzerland.

There are four existing payment methods with two distinct currencies in the current TPG application; the application has the advantage of letting the user choose whether to use Euros or Swiss Francs (CHF). The traditional credit cards like Visa, MasterCard, and American Express as well as smaller regional banks like PostFinance are included in the list of payment choices above. Apple Pay, Google Pay, and the Swiss payment software Twint[6] are other options too. An example of how the ticketing system integrated in the TPG application looks is shown in the following figure, where it's also possible to observe whether tickets can be purchased with a certain itinerary in mind.

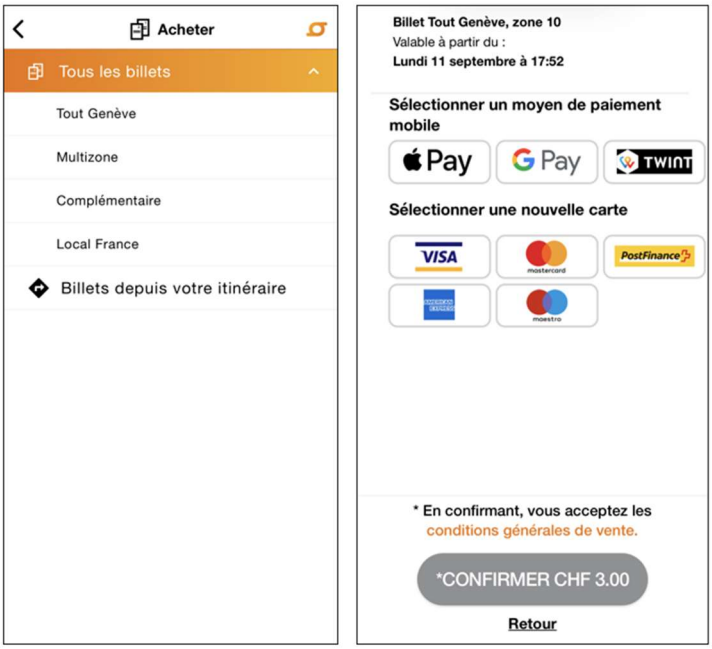

Figure 4. Ticketing integrated into the current operator's application.

[6] https://www.twint.ch/fr/

In conclusion, if we consider a future integration for a MaaS offer, we will need to evaluate the type of ticketing offered by the other mobility providers in the area. Future integrations may benefit from the app's range of payment options, which take into account local requirements, regional providers as well as more global options. The app is a suitable alternative for frequent travels (locals) and infrequent passengers (tourists, business travelers, etc.) due to the wide payment option, the languages offered, and the openness to the preferred currencies.

2.1.3. Current app status: tpgpreview

Several volunteers were requested to support a series of tests in order to assess the users' perceptions of the *"tpgpreview"* app's current status. Within the group of volunteers, there is a great variety of profiles of different genders, ages, and adoptions of technology. The goal of the tests is to identify the areas of the application that consumers find valuable, need to be improved, or are simply missing altogether. Since T2.4 is actively addressing accessibility concerns, they are not the focus of these tests. The 4 volunteers who participated in the test sessions were given several tasks such as make a reservation from the search bar, from the map, from the favourites list, etc. During the searches, participants were asked questions related to previously selected scenarios from D2.1 (Annex A) concerning the information, reservation, or disembarkation of a trip. Not all scenarios could be treated in this part, the method used was in semi-directive interview mode, so it was not possible to cover the more than 200 scenarios proposed in D2.1.

The first task for the users was to give their first impressions by quickly manipulating the application. Some of the first positive impressions from users were regarding the display of real-time data, as well as the ease of identifying stops and schedules. However, some users feel that there is too much unnecessary information on the home page and that the itinerary section should be the default page in the app instead of the departures section. One user also made the comment that, having a real-time view of the departures in that section, he is confused as to exactly which stop the system is referring to. Finally, among the missing points in their first impressions, we find the mutualization of the itinerary and departure sections, as well as more intuitive icons for the users (mostly related to the different means of transport).

The second task performed was to make a search from the search bar. In this test, questions were asked referring to scenarios 2, 3 and 35 that treat the categories of information and reservation in WP2. Here are the users' comments:

Table 2. Results of bar search test (tpgpreview app)

Scenario ID	Brief description	Positive points	Points to improve	Missing points
2	Complete and accessible information about the service.	*"**Accessible** location information and what's available"*	*"Information about my specific **route could be clearer**"* *"The **drop-down list is too space-consuming** and inconvenient"*	*"Feeling that I am being asked too many **unnecessary questions** during my search"* *"**No ticketing or pricing** information without registration"*

3	Accessible information about the vehicle.	*"It is appreciated that the lines are **distinguished by number and color**" "A favorable point is to be able to see the **precise place where my vehicle will leave from**"*		
35	Suggestions for trips with the estimated journey time and specified price			*"**No price information**" "**No specific order** (from the cheapest to the most expensive) or any recommended routes"*

From this first test, we can highlight the importance that users give to real-time data, the clarity of the information to identify the vehicle corresponding to their trip, as well as the value of providing accurate information on the cost of their trips. Unofficially, a user with a highly tech-friendly profile mentions that he is interested in doing a search with no more than three clicks.

Users were invited to repeat the exercise, this time blocking an ETA as indicated in scenario 7. Afterward, the opportunity was taken to ask questions regarding the modes of transport available and their opinion on the complexity of multimodality using the app. Participants mentioned that there should be an improvement in the icons representing the modes of transport, as they are too small and have quite similar colors and shapes. In addition, some of them remarked on the lack of other modes of transport within the suggestions, such as micro mobility or DRT.

After that, participants were instructed to conduct a direct search on the map. Users had to turn on/off the available filters and attempt to make a purchase in order to finish the exercise. The findings are displayed below:

Table 3. Map search test (with and without filters) and purchase attempt (tpgpreview app)

Scenario ID	Brief description	Positive points	Points to improve	Missing points
21	Information about the location of the PUDOs and be able to view the chosen PUDOs		*"When I move the map my **selected stop moves**"* *"It does **not allow me to select directly** by tapping on the map"*	

24	Select pick up and drop off points with criteria important to them.		*"**Difficult to find** the parameters section"* *"**Improve filters** (can only filter by mode of transport)"*	
28	Classic PT tickets shall be valid for this service as well.			*"**No information** at all about pricing"*
31	The user shall be able to register a payment card or others.		*"**Difficult to access** without registration"*	
47	Multiple languages	*"Available in **English and French**"*		

From this test, it can be concluded that there are significant improvements to be made in terms of the map as well as in the filter to obtain itinerary proposals closer to the needs of each user. An important point was that during the purchase intention tests, two of the users did not want to continue with the process until the end because they considered the registration questions invasive. In the case of the third user, he entered his data, but the system had an error, so he could not even see the payment options. Only one user who made it to the end was able to see the different payment methods available. A favourable point is that the application is available in two languages, although considering that Switzerland has at least four official languages, it is possible to assure that there are still more languages to be added to ensure that a larger number of users can use the service.

In a final test, participants were invited to choose a route based on their preferred stops. Regarding the search, 3 out of 4 users had problems understanding the method of selecting the stops added to favourites. With a grid system, the app proposes a more interactive way of selection, however users mentioned that although the method is interesting, there is a lack of explanation on how to use it. Using this trip as a reference, users were asked their opinion on various scenarios, specifically 50, 51, 190 and 120. These scenarios address information on travel cost, carbon footprint, vehicle occupancy, cross-overs and service disruptions. The participants point out a complete lack of information on pricing, CO2 and how crowded the vehicle is, however, the majority of them do not consider the last two points to be essential. Regarding the cross-overs, all participants agreed that the information is available in one way or another, but one user mentioned that he thinks it is unnecessary to show the distance in meters since he mostly uses the time reference. And when it comes to service interruptions, users are satisfied knowing that they have messages explaining the problems or simply information about the delays.

2.2. Herford, Germany

The location of the German demonstration site is in the town of Herford, which is located in the same-named district of the state of North Rhine-Westphalia. There are 253,551 people living in the district, which is made up of nine municipalities (*Landkreis Herford - Einwohnerzahl Bis 2022*, s. d.). Focusing on the city of Herford, a total of 66,551 inhabitants were registered in the year 2021, where 51% of the inhabitants were women and 14.2% were people reported as non-German (IT NRW, 2021). According to the territory's demographics, 60% of people are between the ages of 18 and 65, and over a quarter of the population is over 65 years old. Given that a big portion of the population is elderly, the adoption of mobility systems supported by digitization and automation can be a challenge.

In October 2022, more than 4,000 households in the city of Herford were invited to participate in the mobility survey organized by the city but at the moment there is no information published with the results (Meistes, 2022). Currently, the only source of information found regarding the mobility behavior of the city's inhabitants is the survey conducted in 2011 (Helmert Engineering Office, 2011). It will not be used as an absolute reference to the territory's situation because it is an older source of information.

Assuming that the modal split has potentially not changed radically in recent years, it can be deduced that there is still a strong dependence on the use of motorized vehicles in the area (65% of trips in 2011). The mode of transport with the lowest percentage of trips in 2011 was public transport, both bus and train. The results of the 2011 survey vary by age group and trip purpose, with young adults (18 to 29) utilizing public transportation the most frequently. The results show that it is precisely the educational purpose that presents the highest number of trips by public transport.

As in the case of Geneva, the following section aims to focus on the transport offer available in the territory. The objective is again to evaluate the existing application of the operator OWL Verkehr GmbH, called *"OWLmobil"*. As in the previous chapter, the objective is to evaluate the offer, the conformity of the application with the users' needs and the vision of the operator in position of the future AV-on demand service in the area's MaaS offer.

2.2.1. Mobility offer: Modes and providers of mobility services

The analysis starts with the mass transport available in the area, and especially in the application. Various mass transit choices are available from the application filters, but since this is a regional system, not all options apply to the city of Herford. Some of the visible options in Herford are: **train and bus.** According to information found in unofficial sources, the use of **the tramway was discontinued** in the city of Herford more than 50 years ago. This information can be partially confirmed by the 2011 mobility survey, where the only two modes of public transport available were those mentioned above. One of DB's subsidiaries runs the local bus service, and the company itself runs the local trains and both services have integrated ticketing in the *OWLmobil* application.

Moving on to shared mobility, it is possible to observe a means of transport known in Germany as **AST or "collective cabs".** An on-demand service, following the DRT principle, but using cabs

as the vehicles responsible for moving users from one point to another. The service found under the name *"On demand TeutoOWL",* operated by OWL Verkehr, has a telephone number and a web site[7] from where users can request the reservation of their services in real time and in advance. Below is an image of the service area:

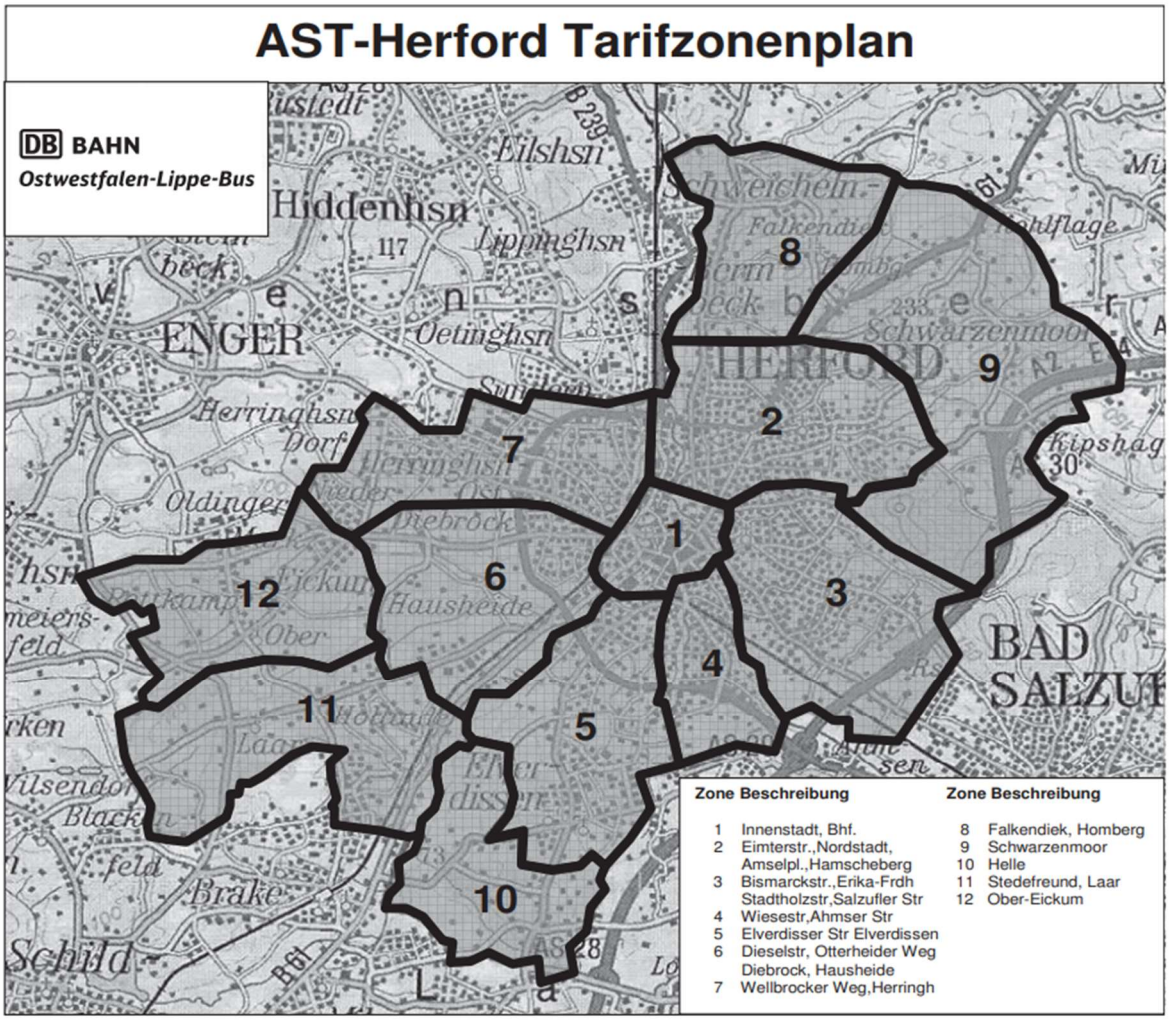

Figure 5. AST or "collective cab" service in Herford (source: City of Herford)

This service is also offered, according to the operator's application's filters, but despite extensive searching, we were unable to get a proposal directly from the app. Without creating an account, it was still possible to complete a reservation straight from the service website with the condition that payment would be made in cash to the driver. It is impossible to say if there are other payment options accessible or their integration with the app because neither the operator's app nor the official website of the service have offered any other proposals.

Continuing with shared mobility, both **carsharing and carpooling** services are available in the area. **The first type of service is partially integrated** in the application, since it redirects the user directly to the supplier's website when offering proposals. This service, called LEC, is a fleet of electric vehicles available to users who simply have to book them from the redirected

[7] https://ondemandonline.teutoowl.de/

website as shown in the app's website information[8]. Another available provider is Flinkster[9], which is a subsidiary of DB, that allows users to pick up vehicles directly from train stations, although this provider is not integrated into the app. Regarding carpooling, a wide variety of mainly local players appear in the area, although there is also the presence of the big players in the market for long-distance trips such as Blablacar.

Continuing with shared micromobility, the first thing that can be observed is the presence of **various bike sharing providers** within the area, from regular to cargo. Some bike sharing services are directly available from the city's official website, as is the case of Herford Bike[10] and Milla Bike[11]. None of the providers mentioned above are integrated to the application, possibly, each of them has an own ticketing system, but verification was impossible because registration is required. Regarding **shared scooters, these are available in the area** with two of the major suppliers in the market, Bolt and Tiers. Each has its own ticketing system and neither is integrated with the operator's current application.

Concluding the topic of micro-mobility, there are parameters in the system to obtain suggestions by personal bicycle or by walking. After several searches, it was not possible to obtain results with the use of personal bicycles, but some proposals for walking routes were correctly indicated, including map.

The current application did not display any suggested routes for individual motorized mobility by car, cab, or ride-hailing. Although there are several different taxi companies in the area, ride-hailing services like Uber were not available.

In conclusion, the application provides a greater range of transportation options, but regrettably we were unable to get results for all of them. Being a complex territory and a regional application, potentially some options do not appear because we do not know how the area works.

2.2.2. Pricing: Payment methods and description of rates

Firstly, the application contains information on the zone's pricing. However, because there is no accompanying graphic and all of the material is exclusively in German, it is impossible for people who do not know German to understand. The lack of translated information makes it impossible to understand how the rates in the area operate when looking up tariffs directly from the websites too.

Access to the payment section is available exclusively to users who have an account on the site, it is impossible to register as a guest, and the registration is completely in German. When attempting to create an account, it is imperative that users enter a debit card into the system. For personal data protection reasons, it was not possible to continue with the registration until other payment methods were available because no team member wished to enter their card details.

[8] https://www.owlmobil.info/linien-e-carsharing/
[9] https://www.flinkster.de/kundenbuchung/process.php?proc=station&f=3
[10] https://herford-bike.evemo.app/login
[11] https://milla.evemo.app/login

Because of the language barrier and the desire to preserve its personal data, it is impossible to understand how the pricing or payment methods actually work. The single online payment option for this initial version of the deliverable is determined to be a credit card. In the next steps, the relevant local authorities will be contacted for more details about this chapter.

2.2.3. Current app status: OWLmobil

An introduction of the methodology used was given in the section concerning the Geneva demonstration site, based on this principle, the same tests were carried out with the same volunteers but this time for the "*OWLmobil application".*

The first test was again a quick manipulation of the app, and the following impressions were obtained. According to participants, one positive aspect is having all the information regarding pricing directly in the application, and some users appreciated the functionality to move their trip forward or backward without the need to redo their search. However, users comment that there are significant improvements to be made in the design. They consider it rigid, with too many repeated options, too many paths to the same information, a saturation of data and no possibility to distinguish the difference between means of transport or points of interest. Among the points they found really negative was the need to zoom in too much to see the available stops, and even 2 out of 4 participants found the map unpleasant.

Moving on to the second test, we asked users to search directly from the search bar, here are some of the comments made by the participants:

Table 4. Results of bar search test (OWLmobil app)

Scenario ID	Brief description	Positive points	Points to improve	Missing points
2	Complete and accessible information about the service.		*"It is relatively **slow to propose** options during the search"* *"It is **difficult to read** the options in list format"*	*"I get **no suggestions** in the **mobility alternatives** section"*
3	Accessible information about the vehicle.		*"Same color, could be changed (**no clear difference** between bus/train)"* *"**All are in the same color**, I know the nomenclature but not all"*	
35	Suggestions for trips with the estimated journey time and specified price		*"Some routes **do not have prices**"*	

This test has made clear how crucial it is for users to recognize different types of vehicles and modes of transportation. One of the participants had some knowledge of the names of the German buses and trains, but for those users who did not, it was nearly impossible to tell the difference because there were no distinctive icons or colors to distinguish them. In addition, there was a lack of consistency in the results as some functionalities never showed proposals, or some proposals did not include trip prices. The system took a while to offer route proposals, according to 3 of the 4 participants, and 1 of them didn't like the preset list format used to display the proposals.

Users were invited to repeat the exercise, this time blocking an ETA. In terms of multimodality, users once again remarked on the absence of an iconography/color scheme for the different modes of transport, making it confusing to know which mode they were using. 2 of the 4 participants mention that there is a lack of micro mobility alternatives, such as bike sharing services. Participants believe that the capability to specify the ETA is slightly hidden; one participant even said that she was hesitant to click because she assumed it was just text on the screen.

The next test is the selection of stops directly on the map, both with and without filters, trying to get to a purchase attempt. Here are the comments made by the participants:

Table 5. Map search test (with and without filters) and purchase attempt (OWLmobil app)

Scenario ID	Brief description	Positive points	Points to improve	Missing points
21	Information about the location of the PUDOs and be able to view the chosen PUDOs		*"It is **not very easy to find the stops** (at first I thought there were none)"* *"The map of the itinerary should be on top"*	*"I cannot complete the search from the map"* *"I **cannot visualize from where to where** I am going on the map"*
24	Select pick up and drop off points with criteria important to them.	*"**More complete filters** - route without stairs/without elevators"* *"**Variety of filters** (such as Maximum cycling time)"*	*"**Too many filters** available with different forms of interaction"*	*"Not easily accessible"* *"Not very clear **where to click for filters**"*
28	Classic PT tickets shall be valid for this service as well.	*"Option **Eezy ticket**"*	*"It is not very easy to understand (when I go to ticketing I get the **complete list and not directly my ticket**)."*	*"**Complex pricing** due to the composition of the territory"*

			"German only"	
31	The user shall be able to register a payment card or others.		*"**Two ticket windows** (no apparent difference)"*	*"Access to the ticket **only by registering**"*
47	Multiple languages		*"Not everything is translated"*	

This test has shown that the stops and map layout are crucial for the app to be truly helpful to users, additionally, the variety of filters may be both a strength and a weakness for some of them. In any case, it's crucial to provide obvious and straightforward access so that users may utilize this feature. One participant's remarks of the pricing was the existence of the eezy ticket, which determines the fare based on the route. However, due to linguistic difficulties, the complex nature of the region composition, or the way the application displayed the price list, the remaining participants regarded the pricing process to be confusing. Following the ticketing issue, the application had multiple access channels for the same function, which created confusion among participants. Since the system required a register with personal data they were not ready to offer, none of them wanted to attempt a purchase. Finally, in terms of language, non-German speakers were unable to use the service due to the absence of translations in several areas.

Participants in the final test were asked to select a route based on their favorite stops. For this test there were divided comments about the icons, some saying they were clear and others saying they should be improved. As this is a purely subjective choice, no further mention will be made of it. All participants agreed that although if knowing their carbon footprint was not critically crucial information for them, it was nevertheless pleasant to know about it and even share it. The participants noted that the availability of information regarding the cost and capacity of the vehicle varied, with some routes including it and others not. The information corresponding to the cross-overs time is available, which was appreciated by the participants. However, although there is information about service problems in real time, it is only available in German, making it impossible for non-German speakers to understand.

2.3. Oslo, Norway

The last demonstration site is the Grorud Valley, in the north-east of Oslo, capital city of Norway located in the district of Ostlandet. Besides being the capital, it is the most populated city in the country and an important economic pole in the Scandinavian region being the hub

of Norwegian trade, banking, industry and shipping. It is an important centre for maritime industries and maritime trade in Europe.

Focusing on the city of Oslo, there are about 709,037 inhabitants in the municipality, while the greater urban area has 1,064,235 in 2022, and the metropolitan about 1,5 million. Its population was increasing at record rates during the early 2000s, making it the fastest growing major city in Europe at the time thanks to international immigration and high birth rates, but also from intra-national migration.

Figure 6. Oslo's boroughs

As in the case of the 2 previous sites, the following section will be focused on the transport offer available in the territory. This includes an evaluation of the existing trip planning application, by Ruter, the local PTA. As in the previous chapter, the objective is to understand the offer, the conformity of the application with the users' needs and the vision of the operator in position of the future AV-on demand service in the area's MaaS offer.

2.3.1. Mobility offer: Modes and providers of mobility services

We started looking at the local mass transit options using the process used at the prior sites. The following mass transit services are displayed by the Ruter application's filters: **Metro, Tram, Bus, Train, and Ferry**. Additionally, there are specific transportation options (bus and train) for getting to the airport, which will be taken into account with the traditional bus and train offer. The vast majority of the system is operated by subsidiaries of the local operator Sporveien Oslo AS, an example are the subway and tramway services run by the local operator's subsidiaries Sporveien T-banen and Sporveien Trikken, respectively. There are several bus operators in the area, some of which are subsidiaries of the local operator's company (e.g. Unibuss AS), and others of which are external (e.g. Nobina AS or Connect Bus AS). For the ferry, two companies are responsible for the operation: Boreal and Norled AS. Additionally, the operator Vy, formerly known as Norwegian State Railways or NSB, is in charge of running the passenger train services and some bus services too.

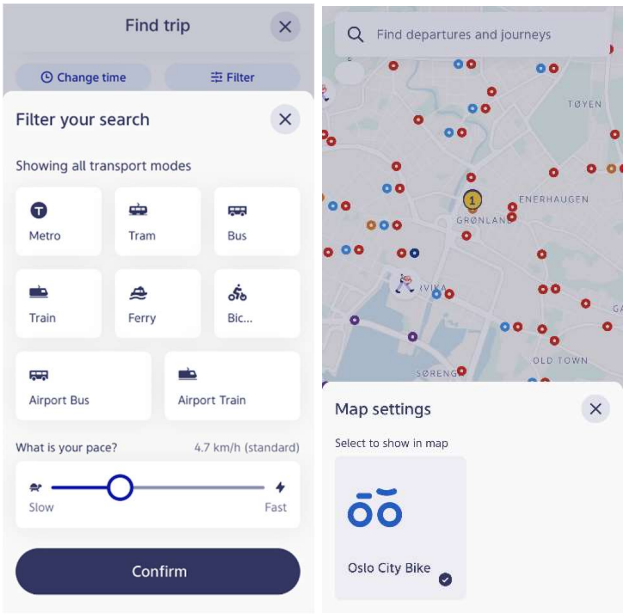

Figure 7. Examples of transport mode filters (Ruter app)

Moving on to shared services, we can appreciate the existence of **carsharing and carpooling services on the site**, nevertheless, none of them are right now accessible through the Ruter application. In the case of Carsharing, there is a wide variety of providers on the site, from the classic car rental services at the airport[12], to free service with only electric vehicles[13] or not[14]. Checking the corresponding websites reveals that each one has a unique ticketing system. A similar phenomenon could be seen in the case of carpooling services, where two platforms—Carpoolworld[15] and Same-way[16]—have been identified, each with a separate application and ticketing system. Regarding **DRT, no services were currently** found in the territory.

Keeping with the shared mobility topic but on the scale of micromobility, we notice that the **bike sharing service is currently only partially integrated** into the Ruter application. The service is provided by Oslo City Bike, and users can view the availability of bikes and parking spots right from the app. However, in order to make a reservation, users must be forwarded to an external application created by Urban Sharing. Continuing with the theme of shared micromobility, we found two providers in the area for **shared scooters:** Voi and Ryde. These suppliers, who won the most recent bidding procedure, replaced two other ones that were previously in the area, notably Tier and Bolt, according to information that was obtained in some journals (Hubbard, 2023).

Regarding micromobility, the app is currently offering details on the trip by **bicycle and by walking**, as well as details on the day's weather and the travel time. Although no functionality to indicate that users are riding their own bicycles was visible, no multimodal trips including a bicycle portion were seen during testing.

[12] https://www.drivenow.com.au/norway/car-hire-oslo-airport.jspc
[13] https://www.greenmobility.com/fi/en/greenmobilitys-cities/
[14] https://bilkollektivet.no/
[15] https://www.carpoolworld.com/carpool_ride.html
[16] https://same-way.com/

There were no suggested routes for individual motorized transportation via car, taxi, or ride-hailing in the existing application. After searching the area, we discovered that there are both **taxi services and major ride-hailing** companies like Uber or Bolt, and both services have their own ticketing system.

In conclusion, the app provides data on all forms of local mass transit, as well as giving micro mobility its rightful place as a means of transportation. The territory appears to have shared micro mobility regulations, as demonstrated by the fact that scooters had to compete for permission to circulate in the area.

2.3.2. Pricing: Payment methods and description of rates

First of all, the application provides information on the prices per trip, but there is no information on the overall pricing of the system. We had to access the Ruter website in order to find this information, and there we discovered a broad selection of tickets. Tickets range from singles to 24-hour, 7-day, monthly, and annual passes. Additionally, there is the option of including extra zones, each with a different charge based on the user's category (adult, child or senior). The price varies according on the service zones, and there is special pricing like the Rufus Ticket, which is for groups of students up to the 10th grade. The purchase of credits, where you pay expressly for the ride, is another choice. This card is offered at the points of sale.

The following illustration shows the several zones into which the area is divided:

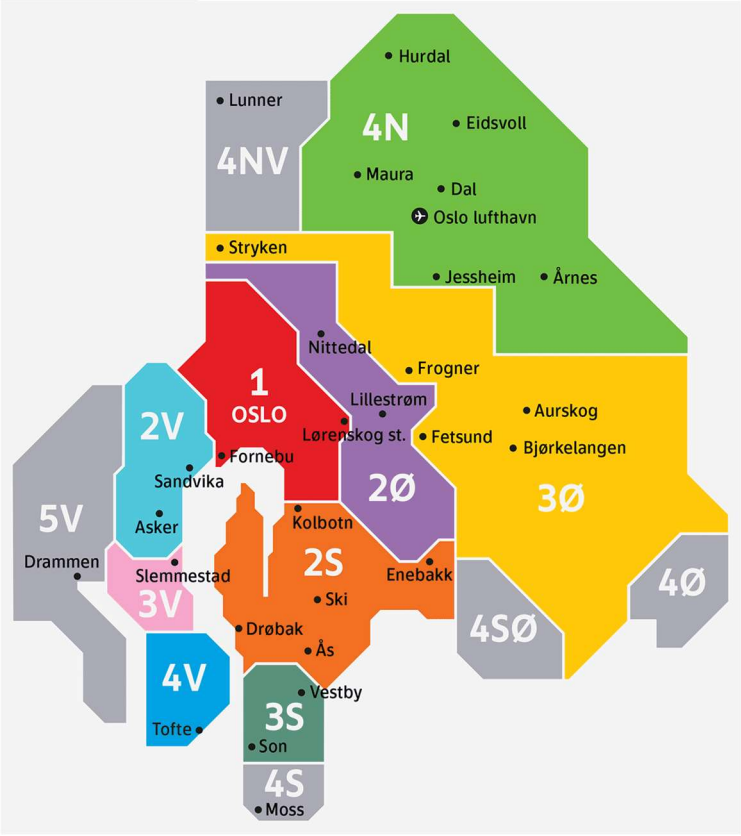

Figure 8. Zoning of public transport in Oslo

The only available currency for payment methods is the local currency NOK. To pay for rides using the app, there are presently 3 alternatives available. The first option is the conventional card method, followed by Apple Pay and a local service named Vipps[17]. It's crucial to note that both occasional and frequent users can access the app and complete the purchasing procedure without creating an account.

2.3.3. Current app status: Ruter

The same process employed in the other two territories was applied once more for this case, beginning with an exploration phase during which the volunteers recorded their initial impressions. Users note that the interface is beautiful, with attractive colours, and aesthetically better structured and user friendly among the favourable impressions we can see in UX/UI comments. One of the participants highlights access to the list of stops she will make while using a specific mode of transportation before reaching her destination as a positive aspect, something that is present in other applications but is first highlighted here. The space-consuming about whether the proposal is suitable or not, as well as refining the explanation of the information about the space where the vehicles leave from, are some of the things that the participants stated that should be improved. Only one user brought up a negative or missing point, namely that the drop-down list takes up a lot of screen space.

After the first phase is complete, users are prompted to proceed immediately to the first search test from the bar, the following are the participants' comments:

Table 6. Results of bar search test (Ruter app)

Scenario ID	Brief description	Positive points	Points to improve	Missing points
2	Complete and accessible information about the service.	*"**Easy to access** pricing and tariffs"* *"I have access to pricing and to **select my user profile**"* *"Best route as first option"*	*"The search bar is **a bit hidden**"*	
3	Accessible information about the vehicle.	*"Identification with **number, color and nomenclature**"* *"Information about the wagon/line number"*		

[17] https://vipps.no/

35	Suggestions for trips with the estimated journey time and specified price	*"**Both information** are available"*		

The first thing we can note from this review is that the majority of user comments were fairly positive, with only one improvement comment given by a user with a profile that was quite tech-savvy. The ability to add a user profile and receive customized rates (e.g., an adult rate, a student rate, etc.) is seen positively by participants. They also appreciate the ability to acquire price information straight from their searches. One participant added that it is important for him to have the list of proposals sorted out, with a suggested route as the best option. Regarding the identification of the lines, users seemed quite satisfied with the fact of having not only number or colour, but also information about the place where the vehicle will depart from (platform). Finally, information regarding the time and cost of the route suggestions offered by the application was pleasantly noted by every user.

The test is run again by blocking the ETA, just like in the previous territories. The participants utilized this activity to respond to questions about the application's multimodal approach. The users noted that having accurate information on micro mobility (walking and cycling) and the option of hiding the layer if they do not want to view it was a plus. However, some users remarked on the lack of deep integration of the bike sharing service, something that can be improved in the future. Another participant stated that various modes of transportation were absent, and that several icons were regrettably duplicated and would be confusing. The lack of connectivity between cycling and mass transit in the route suggestions provided by the app was only highlighted by one participant.

The following test asks participants to perform a directly search from the map, play with the filters, and attempt to make a purchase. Some of the participants' comments are listed below:

Table 7. Map search test (with and without filters) and purchase attempt (Ruter app)

Scenario ID	Brief description	Positive points	Points to improve	Missing points
21	Information about the location of the PUDOs and be able to view the chosen PUDOs		*"I can **partially do my search** (from one of the stops), but the second one cannot be selected on the map"*	
24	Select pick up and drop off points with criteria important to them.	*"They are clear"* *"Transport mode and **walking speed filters** (interesting)"*	*"I **can't customize my filter** by saying that I have a bicycle to take into account in my trip"*	

			*"Differentiate between **personal bicycle and free service** bicycle trips"*	
28	Classic PT tickets shall be valid for this service as well.	*"Zoning (with information)"* *"It tells **me which ticket** I have to buy"* *"Information about zoning and **profile type**"*	*"I don't get the **price until after I click** on the proposal."*	*"Lack of information on pricing in the area"*
31	The user shall be able to register a payment card or others.	*"**Three methods available** in the app"*	*"Some routes did **not offer a ticket** for purchase"*	
47	Multiple languages	*"**Correct translations** throughout the app"*		

This experiment demonstrates the value consumers place on having accurate pricing information, with users complimenting the availability of trip tickets that take into consideration both their individual profiles and local pricing. However, it is evident that each user's interpretation of "clarity" in pricing information will vary. Another aspect valued by the participants was the variety of payment options, along with the ability to filter by mode of transportation and speed. Users ask that both PU and DO be available in select from the map so they can finish their search without using the bar, according to comments on areas for improvement. Users again ask for the distinction between personal and free service bicycle use when it comes to filters, as well as their consideration when getting route suggestions. During the route proposal phase, information like where to park the free service bicycle and the proximity of available bikes are important for some users One participant found trip suggestions with only two out of three modes of transportation having ticketing, and no payment options for the full journey. The fact that the application was available in English was not criticized by any of the participants, despite the fact that they were all French speakers.

In the last test, participants were required to choose a route based on their preferred stops. In this sense, 2 out of 4 participants think the favourites functionality is a little hidden, and they also think the icons are not sufficiently illustrative and leave room for interpretation (e.g., others icon). They were questioned during the test about their opinions of the information provided in real time, such as disruptions, as well as the information per trip (cost, time, CO2, correspondence time, and flow). All users first expressed that there was no information on carbon footprints, although two of them added that they found it to be interesting but not essential. Opinions on how full the vehicle is varied; some think the information can be valuable, others think it can be useful if it suggests alternative routes, and yet others don't

even think it's significant. It is evident that the application does not currently have access to this information. There weren't many comments on the cross-over time other than to say that it was available and that it was even feasible to receive further details from the website. 2 of the 4 participants indicated that they found it fascinating to be able to view the position of their vehicle in real time when discussing real-time data. All users also valued having access to timely, accurately translated information about delays and interruptions.

3. Consolidation of current LaaS offer per ULTIMO site

This first draft of the deliverable attempts to demonstrate a consolidation of already offered services, and currently no demonstration site has a LaaS service that is live. Having in mind that one of the 3 sites, Geneva, is committed to testing them within the AV possibilities and ecosystem, in the second edition of this document we will try to demonstrate the outcomes of the first version of this kind of services.

4. The place of AV on-demand on ULTIMO sites

4.1. Belle-Idée (Geneva site)

Within the framework of the ULTIMO project, the first stage of the demo site will be carried out in the Belle-Idée domain, which is located between two communes: Chêne-Bourg and Thônex. These municipalities are located in the first and second crown of the canton's suburbs, respectively, so their inhabitants do not have exactly the same mobility behaviour as discussed in chapter 2.1.

The Belle-Idée estate covers an area of approximately 38 hectares, where 24 buildings are located (TPG, 2022). Within the site we can find different medical establishments, conference centres, schools and even a farm. The area also has 6 parking spaces and an ODD complex with small roads and one roundabout.

Figure 9. Demonstration site Belle-Idée's domain.

The area is accessible by public transport, with 3 fixed lines *(1, 34 and 31)* operated by TPG that cross the domain to connect with municipalities such as Geneva or Puplinge. It is also accessible by private transportation, bicycle, or walking, with a wide variety of user profiles ranging from students and staff to hospital patients.

The service has 3 shuttles available for the initial stage, with more than 70 stops distributed throughout the territory and with a completely free-floating system from point to point. The service begins its first stage of reopening to the public on Thursday 28/09/2023 as the service has some experience with other providers. Due to permit concerns, the public opening will only be available until November 30, 2023, on Thursdays from 10 am to 2 pm, and there will be 3 vehicles available throughout the area. The service is currently operated by TPG, with the shuttles of the manufacturer Gaussin Macnica Mobility, using the DRT system of Padam Mobility and with Padam also as responsible for the fleet orchestrator.

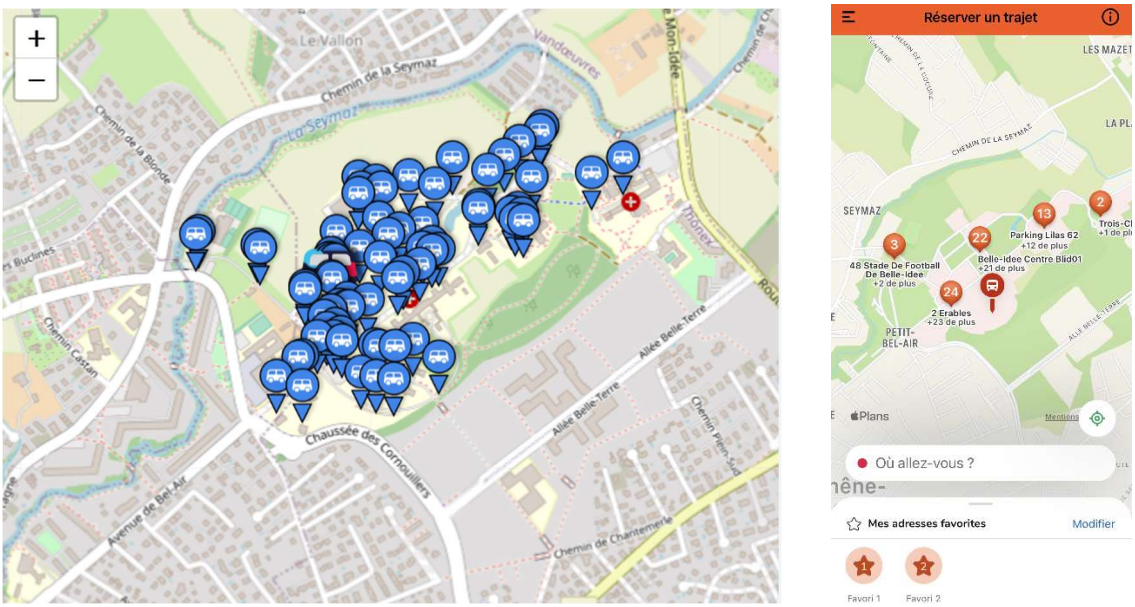

Figure 10. Display of available stops for the operator (left) and the user (right) - Padam Mobility

The Belle-Idée service is provided using the same application as the current DRT service in Geneva as part of efforts to integrate AV services into public transportation. As a result, customers of the *tpgflex* service will be able to access both areas from a single interface and, depending on their location, make reservations there as well.

Figure 11. Mutualization of AV-DRT and DRT services in tpgflex service (Padam Mobility app)

A comparable strategy is suggested to the operator, who now manages its *tpgflex* service using the management interfaces provided by Padam Mobility. By switching territories, operators may now monitor the service both with and without a driver in real time from the same interface. A parallel interface that is capable of tracking AVs and missions sent by the Padam Mobility orchestrator is also provided. There are currently no ticketing settings activated for the Belle-Idée zone, but since it uses the same interface as *tpgflex* service, integrating payment methods across the two areas shouldn't be an issue.

Finally, the Belle-Idée territory is envisioned as expanding in terms of both coverage and vehicle availability. A group of consortium partners are actively working to accomplish the goals established, collaborating hand in hand with the operator and taking into consideration his vision and demands. Although there is currently no LaaS service in the area, this territory is committed to testing both MaaS and LaaS service in the future years.

4.2. Herford (Herford site)

Unlike the Geneva and Oslo sites, the Herford demonstration site does not yet have a designated service area. The leaders of this site, however, have specified where the AV on-demand will be place in the mobility ecosystem in the area.

One of the goals of this kind of services is to provide a connection for the first/last miles leading to the train and bus stations. Another possible application would be to connect rural areas, giving residents a real substitute for using their private vehicles. Visitors and residents of the city of Herford are among the primary customers for this new mobility service.

Currently, the area does not have an open service, thus further information on this is anticipated on the second iteration of this deliverable.

4.3. Grorud Valley (Oslo site)

The so-called Grorud Valley, which includes the districts of Bjerke (west), Alna (south), Grorud (north) and Stovner (east), is where the Oslo demonstration site is situated. Within the grouping of districts that make up the Grorud Valley, a total of 140,000 people were counted in 2016 (Eriksson, 2023). The residential area within the demonstration site was created as a "satellite city," which refers to localities that are near to the major city and act as the hub for the metropolitan area (Ranjan, 2023).

Currently, the area has 19 bus routes, 3 metro lines, and train lines operating, making it accessible by public transportation. However, an analysis of a route from Oslo to the demonstration site[18] reveals that private vehicles, such as cabs, take only 16 minutes, as opposed to the 20 to 40 minutes required by public transportation. This effect is particularly evident while traveling within the demonstration area, where parking is conveniently available and trip times make public transportation less competitive than driving a private vehicle.

Ruter believes that a first/last mile use case to feed the metro is the best first stage for an AV on-demand service in the area. They also foresee a free-floating service in complex ODD without a safety operator that can operate under adverse weather conditions. Additionally, an equivalent trial using AVs will be run in the area between January 2023 and December 2025, some of the stakeholders are: Ruter, Mobileye (an ADAS provider), and Holo (an operator). The goal of the project is to have 15 NIO cars servicing about 21.75 km2, and the route, vehicle, and application preparation stages are now being completed (*Autonomous Mobility in Grorud Valley - Holo, Mobileye and Ruter*, s. d.).

In conclusion, MaaS-based initiatives will be deployed in the area in the future under various use cases, although no service is currently available to the general public. Ruter also made the decision to focus only on passenger services with flexible and on-demand modes of operation, both for shared and private use.

5. Identified requirements for ULTIMO's MaaS/LaaS offer

5.1. Methodology

The **results on passenger and PTO needs from D2.1 were utilized as a reference** for this section. For LaaS services, as there isn't yet an operating service in any demonstration site, it won't be included in this initial version of D4.1.

In the case of MaaS passenger services, we exclusively consider the user needs, which are divided into the following categories: informing/deciding, book, getting to PUDO, wait, connect Pax-Vehicle, boarding AV, onboard, incident, disembark and review. D2.1 demonstrates how certain requirements in each category are more dependent on the

[18] https://www.rome2rio.com/es/map/Oslo/Grorud-Valley

capabilities of the vehicle, while others must be met by using websites, apps, or other communication channels.

The first step in the methodology is to choose which of the 205 user-centered scenarios can be satisfied by the use of applications. Four main categories were taken into consideration for this, as will be mentioned below:

- **App:** refers to any scenario where a mobile application serves as the main form of satisfying user's needs.
- **Vehicle/OBU:** refers to any scenario that relies primarily on the capabilities of the vehicle or on-board unit to fulfill the user's needs.
- **Both:** refers to any scenario where both of the aspects listed above are necessary to satisfy the user's requirements.
- **Beyond this assessment:** refers to scenarios that are concerned about evaluating accessibility issues for vulnerable users.

After analyzing the 205 scenarios suggested by D2.1, we discovered that around 43% of them primarily depend on the capabilities of the vehicles or on-board unite to satisfy the needs. Around 4.4% of scenarios were about users with special needs or accessibility-focused evaluations that were not included in this deliverable. In total, 53.4% of the scenarios require the use of applications or websites, both partially and completely, to meet user needs. In this first version of D4.1 users only have access to these last two tools, therefore future evaluations will not currently take into account requirements that depend on an on-board device or vehicle capabilities.

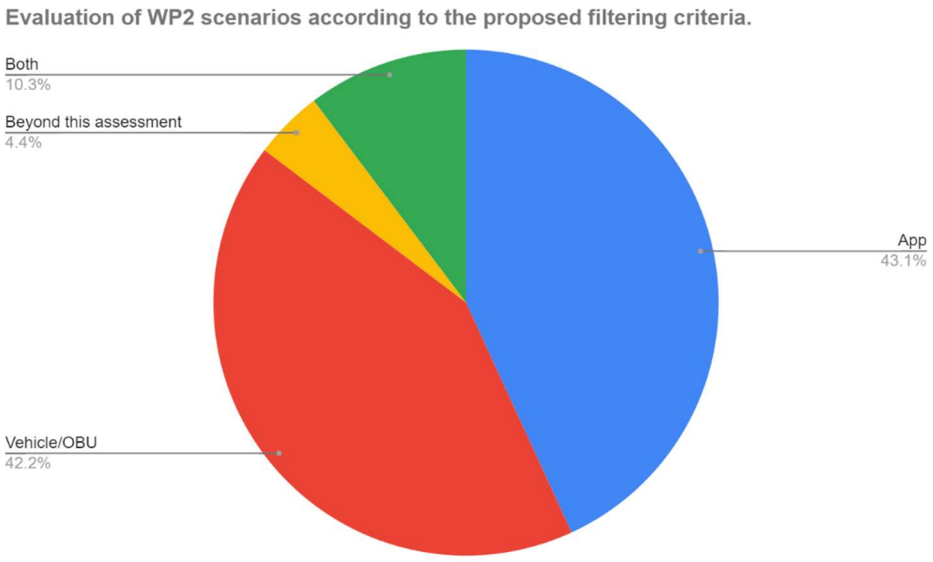

Figure 12. Evaluation of WP2 scenarios according to the proposed filtering criteria

We proceed to the second step of the methodology once we have selected the 109 scenarios that match the goals of this initial version of D4.1. This step consists of determining which of

the requirements are focused on a global mobility offer (MaaS apps) or are specific needs of an on-demand shared systems (DRT apps). The subcategories used are described below:

- **All modes:** refers to requirements that apply to all forms of transportation, not only DRT services.
- **Mostly DRT:** refers to the scenarios that are most relevant to a DRT service (with driver or not).

The requirements that will be assessed in the following chapter in relation to the applications described in chapter 2 of this document are obtained from this second step. The requirements that will be taken into account for each subcategory are summarized below.

5.2. Regarding global mobility offer

Of the 109 scenarios evaluated in the second step of the methodology, 48 are considered as requirements that can be applied to the variety of mobility services offered by a MaaS offer. With a total of 18 scenarios that explore topics such as informing users or exploring the existence of a ticketing system, *booking* is one of the categories with the most requirements in this subcategory. Other categories are *Onboard*, which is primarily concerned with passenger communication and information procedures, and the *Getting to PUDO* category, which is also mainly concerned with information-related issues. The requirements that will be utilized to assess the MaaS apps described in Chapter 2 are broken down into the following chart per category:

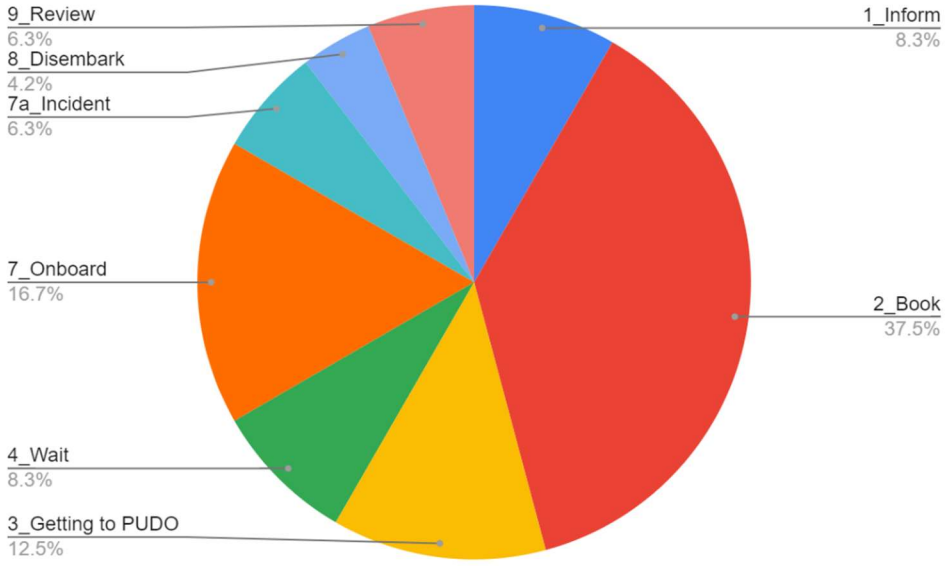

Figure 13. Distribution of needs (D2.1) related to the global offer of transportation by category.

Two categories that are strongly focused on the AV component of the services are absent from this graph, and they are: *Connect Pax-vehicle* and *Boarding AV*. This outcome is predictable given that the entire mobility offer also includes components that don't involve the use of AVs, like shared micro-mobility services.

Appendix A has an extensive list of the requirements that will be used to *assess tpgpreview, OWLmobil*, and *Ruter* app.

5.3. Specificities of on-demand transport

The remaining 61 requirements are mostly related to the specific situation of DRT services. Again, the needs of the *booking* category are most frequent, which is quite natural given that it serves as the foundation for this kind of service. All the information required to make a reservation, the information sent to the user, and even a portion of the specific needs that can be taken into account during a reservation are among the issues addressed in this category.

The *onboard* category is the second one that takes into account the most scenarios specifically for the case of DRT services. The information and communication with the user, as well as anything associated to route adjustments, are the key issues covered. The requirements that will be considered for future evaluations of DRT applications are summarized down in a chart by category:

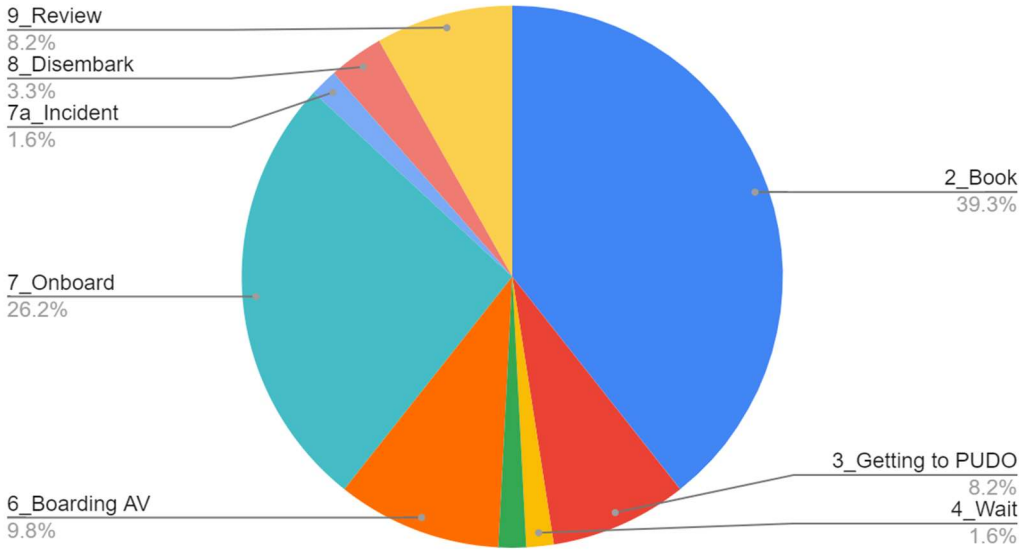

Figure 14. Distribution of needs (D2.1) related to DRT services by category.

The absence of the *informing/deciding* category from the graph indicates that it was mostly covered by the subcategory related to the global mobility offer displayed in section 5.1.1. In the case of the category *Connect Pax-Vehicle*, which mostly depends on the capabilities of the vehicle, represents just 1.6% of the total number of scenarios that applied to DRT services.

This chapter covers the range of scenarios that have an impact on a DRT service (with and without a driver), with the aim of continuing the approach to a seamless adoption of DRT services with AV fleets. The single DRT application currently in use at one of the demonstration sites, which is offered by *Padam Mobility* under the name *tpgflex* as shown in chapter 2, will be evaluated in accordance with all the requirements in this section. The Annex B contains full details on the scenarios used to assess this app.

The requirements for on-demand services that could be considered as new because they are centered on the use of AV fleets will be properly addressed in the next section to deepen the

reflection. However, as was already stated, these requirements will be given the same weight as those that apply to on-demand services with drivers.

5.4. New requirements for on-demand automated transport

In terms of a traditional DRT service with drivers, 10 of the 61 scenarios outlined in the previous section are considered as new requirements for on-demand automated services. Although there are several scenarios where the word *AV* is used to describe the vehicle, identical circumstances might also apply to the case of a DRT service involving a driver (e.g. vehicle identification), so were not considered as new requirements. We have identified the following categories among those that fulfil brand-new needs for AV on-demand services: *book, connect Pax-Vehicle, boarding AV, onboard* and *disembark*.

The requirements for *booking* category are concentrated on the so-called safety operator. One of them discusses informing the user of the presence or absence of an operator on board, while the other one emphasizes the necessity of a reservation that includes a safety operator for a user with special needs. The only need in the category *connect Pax-Vehicle* is the match between the user and the vehicle, so that the user is aware that he or she is boarding the proper vehicle for his or her travel now that it's not the driver doing it. Monitoring and informing are the two main topics of category *boarding AV.* Innovative ways of determining if users are violating the terms of service in the absence of a driver are required, and in the case of a new mobility service, it is also vital to make the regulations on board explicit. In terms of category *onboard,* it prioritizes user communication and information sharing. We can find the notification when the PUDO is reached, the way to interact with customer service, and the means to interact with the remote control center among these new requirements.

The category *disembark* has a requirement that places more emphasis on the vehicle's capabilities than it does on the application, since it’s one of the scenarios that was catalogued as *both* during the first step of the methodology. The scenario is divided into two parts: the first part discusses the necessity for the door to open automatically, which depends on the vehicle, and the second section discusses announcing the stops reached. The second part of this scenario has already been covered in category *onboard* above.

Finally, as the first service deployments take place over the coming months, potential additional requirements may emerge. The second iteration of the deliverable will cover them.

6. Assessment: current user needs compliance in ULTIMO's sites

6.1. Geneva site

We now proceed to analyse the MaaS and DRT application found in section 2.1.1 of this document based on the requirements presented in the previous chapter. The goal is to determine the current applications' degree of compliance with the requirements proposed by WP2 while taking into account three different standards: **available, to be improved, and not available.**

6.1.1. Regarding the global mobility offer: tpgpreview app

Overall findings indicate that the application satisfies 41.7% of user needs for partial or full use of the application *tpgpreview* regarding the global mobility offer. 29.2% of the scenarios are only partially satisfied, this suggests that there is work to be done to enhance some of the app's present functionalities. Currently, 29.2% of customers' needs for the global mobility offer are not being met by the Geneva MaaS application.

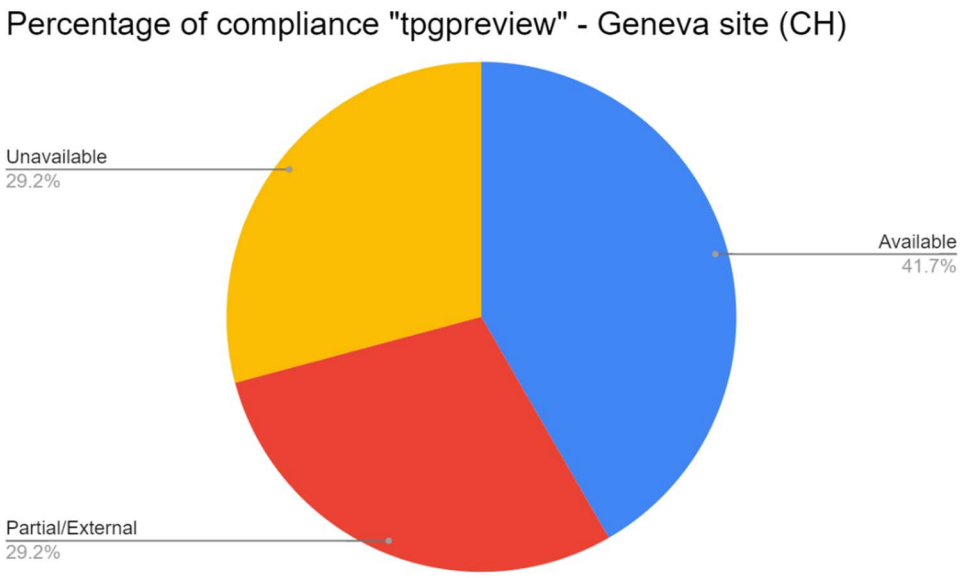

Figure 15. Percentage of compliance "tpgpreview app" regarding WP2 needs

The full evaluation using the before mentioned standards is available in this document's Annex C. We will concentrate on the requirements that are currently partially available or completely missing for analysis purposes. During testing with volunteers, some of these scenarios were already covered in section 2.1.3. The results of compliance are displayed in the following table by category:

Table 8. Compliance of the "tpgpreview app" by category

Category	**Available**	**Partial/External**	**Unavailable**
1_Inform	1	3	
2_Book	7	6	5
3_Getting to PUDO	2	2	2
4_Wait	1	1	2
7_Onboard	4		4
7a_Incident	2	1	
8_Disembark	1		1
9_Review	2	1	

The *inform* category presents a total of three partially completed requirements, which correspond to scenarios 2, 3, and 4 illustrated in Annexes A and C. The main issue with scenario 2 is brought up by the participants in section 2.1.3, who state that only registered users can see the price information. The fact that the website is the only source for information on prices in the zone was also highlighted in section 2.1.2. Despite the favorable remarks provided by users in chapter 2.1.3 about scenario 3, a missing element within the requirement is the implementation of security measures. Concerning scenario 4, the main issue is that FAQs section can only be seen on the website, as can be verified while trying the *tpgpreview* app.

From category *book*, we can observe that there are a total of 6 needs that are partially satisfied and 5 that are fully unsatisfied because the application is missing some components. There are four partially satisfied cases that have already been covered in section 2.1.3: 6, 35, 47, and 50. The other two scenarios deal with informing the user of the possibility of video surveillance (ID 29), which is now only available via the website, and with automatic payment for the journey (ID 32), however all payment methods today need registration. Two of the five unmet requirements—numbers 24 and 51—have been addressed in section 2.1.3. The other 3 requirements are about receiving updates when modifying an itinerary (ID 40), being informed about the risks and rewards of ridesharing (ID 20), and using specified criteria to have the system suggest PUDOs (ID 44). The issue with scenario 40 is that there is no method to notify changes because doing so would require starting a completely new search as the application lacks a button to start the itinerary. The app does not have any information for scenario 20 and for scenario 44, it was noted in section 2.1.3 that the only filters accessible are those depending on the mode of transportation.

Two requirements in category *Getting to PUDO* have been partially met, while two others have not been met at all. Scenario 54, which deals with the position of the user but not the vehicles, and scenario 61, which deals with the simplicity of identifying the PUDO on the map, are two examples of partially satisfied needs. It's crucial to make clear that scenario 61 is open to interpretation because how easy it is to recognize the stops varies from user to user so it’s completely subjective. Unsatisfactory scenarios include scenario 53, in which the app does not

currently display a description of the PU point, and scenario 55, in which the inability to launch an itinerary block us from receiving a confirmation that we are at the right location.

In category *wait*, scenario 67 is partially answered since it is possible to know in time how far away the vehicle is. Examples of unmet needs include scenarios 68, which shares the same issue as scenario 55, and 69, which lacks the vehicle position in real time.

When it comes to category *Onboard*, the 4 missing components include the absence of options when there are disruptions or issues with the connection as well as lack of alerts as the vehicle approaches its destination. The last missing element is exactly the same as in scenario 20.

In the last 3 categories, we have 2 partially satisfied and 1 unsatisfied scenario. Scenario 170 is only partially satisfied because the consumer is alerted of unforeseen events but is not necessary asked to resume the trip, and scenario 204 has an issue because only stops, not favorite trips, are currently registered. Due to the application's inability to notify the user when they arrive at their desired destination, scenario 182 is now unsatisfactory.

6.1.2. Regarding specificities of on-demand transport: tpgflex app

The findings indicate that 50.8% of the 61 requirements that correspond to DRT services are met by the Padam Mobility application. About 28% of the highlighted demands will need improvement because they are only partially met. Additionally, the app's current state leaves 21.3% of the scenarios unresolved.

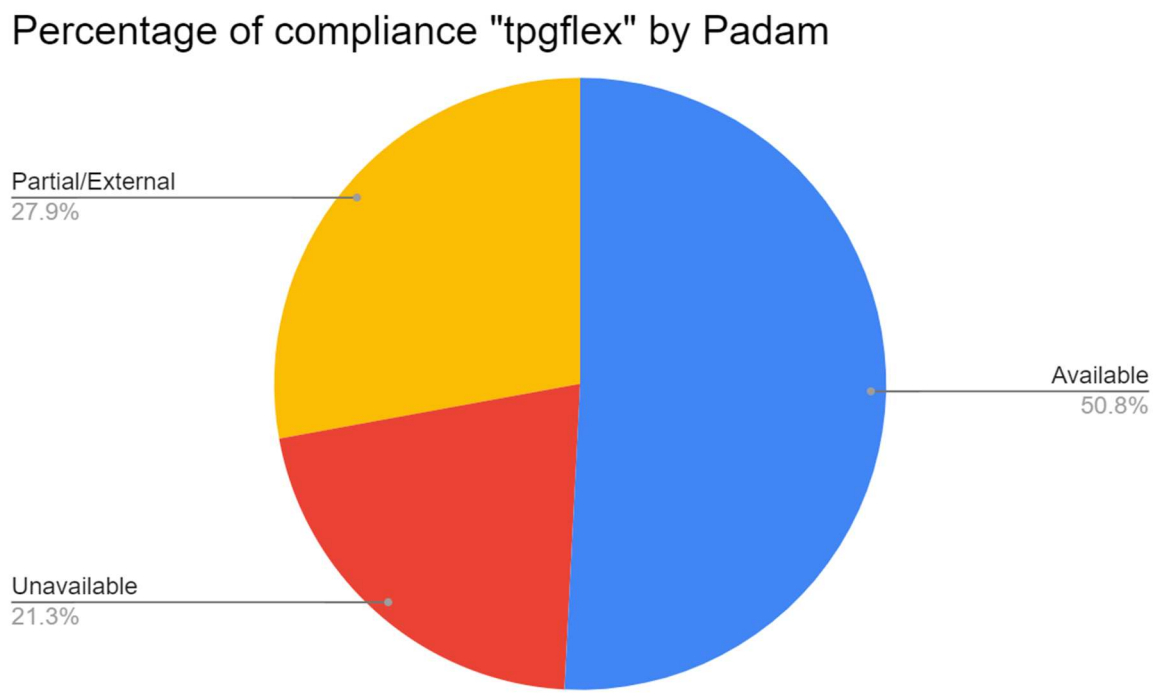

Figure 16. Percentage of compliance "tpgflex app" regarding WP2 needs

The complete needs assessment is available in Annex D of this document, although only the partially resolved and unresolved scenarios will be discussed in this section. The results of compliance are displayed in the following table by category:

Table 9. Compliance of the "tpgflex app" by category

Category	**Available**	**Partial/External**	**Unavailable**
2_Book	16	3	5
3_Getting to PUDO	2	1	2
4_Wait		1	
5_Connecting pax and vehicle	1		
6_Boarding AV	2	3	1
7_Onboard	5	7	4
7a_Incident	1		
8_Disembark	1		1

In the first category, the Padam Mobility app has three partially satisfactory scenarios. The issue is that even if the current app asks for confirmation when making changes to the reservation, it doesn't provide explicit information on the consequences in the process. Additionally, users today do not have access to the profile section to modify information if they are users with special needs; only operators have access to it. This leads to the fact that Padam Mobility only offers additional boarding and disembarking times to customers with special needs, meaning that no customer may request it prior to making a reservation. Among the five unmet requirements, two relate to brand-new criteria for the AV fleets, one to solo ride, and the final two needs talk about group reservations involving multiple PUDOs.

The only partially satisfied scenario of category *Getting to PUDO* is that the specific amount of time the vehicle will wait in each PUDO is not currently published; just the maximum waiting time is. A system that may anticipate a delay and prolong or modify a user's reservation is mentioned as one of the unmet requirements that is currently not available on the market.

The only partially satisfied need of the Category *Wait* situation is that, in the current app, Padam Mobility transfers no-show responsibility to the vehicle rather than the passenger.

In the case of Category *Boarding AV*, the application has three partially satisfied scenarios. The main issues focus on communication's channels for onboard rules, app-based user-to-remote center communication, and information about the match passenger-vehicle while making reservations from third parties. The only scenario that cannot be satisfied is a new AV case need, where new tools are required to make sure that no user violates the service agreements.

Seven partially satisfied scenarios are presented in category *Onboard*. The existing limits are observed around topics like communication of rules, customer service communication, interaction with the remote center, booking change repercussions, or information in the case

of third party booking. The system does not let changes to be made from the application during the trip once the journey has been started, which results in the scenarios that are currently not satisfied.

Since it is currently impossible to determine with certainty if a user is in the proper DO when it comes to a reservation made by a third party, the last category only has one unmet requirement.

6.2. Herford site

Following the methodology outlined in Section 6.1, the evaluation is repeated, but this time using OWLmobil application.

6.2.1. Regarding the global mobility offer: OWLmobil app

In general, the findings show that 52.1% of user requirements that rely on the use of the OWLmobil application for the MaaS offer are satisfied. One fourth of the scenarios are only partially satisfied, indicating that some of the app's current functionalities need to be improved. Currently, 22.9% of customers' expectations for the global mobility offer cannot be met by the Herford MaaS application that is now available.

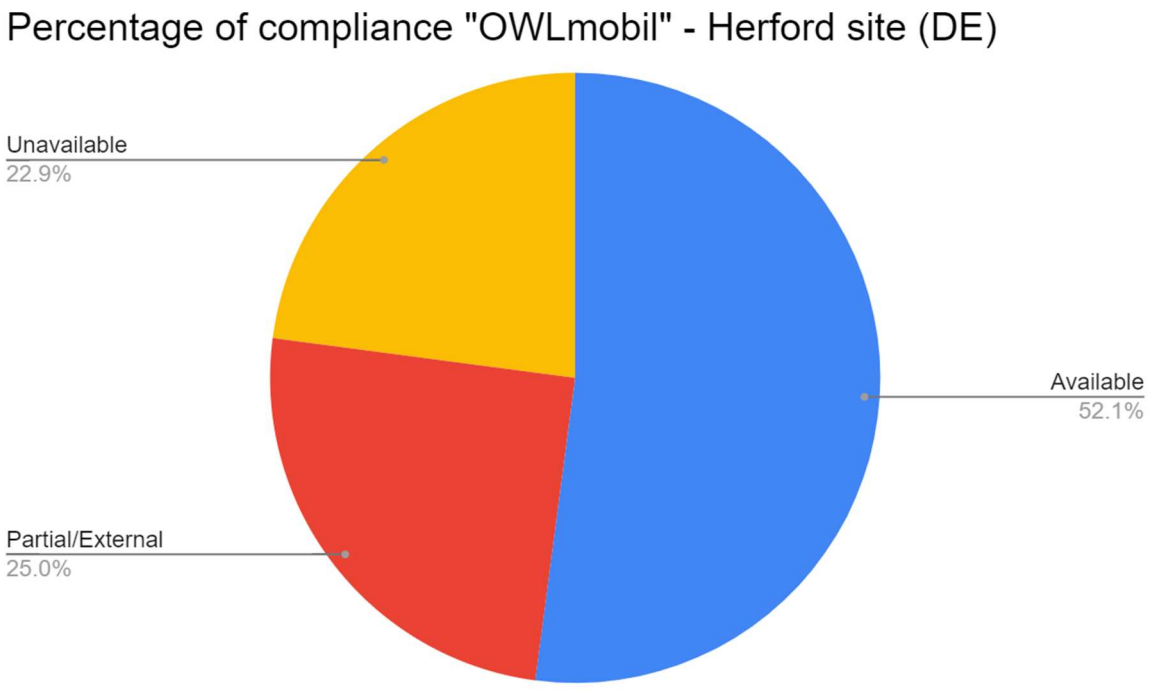

Figure 17. Percentage of compliance "OWLmobil app" regarding WP2 needs

The complete evaluation table is in Annex C, and as in section 6.1.1. only partial or unsatisfied requirements will be discussed. Also keep in mind that the findings from section 2.2.3 will be cited to support some of the statements made in the requirement's assessment. The following table lists the outcomes of compliance by category:

Table 10. Compliance of the "OWLmobil app" by category

Category	**Available**	**Partial/External**	**Unavailable**
1_Inform	1	3	
2_Book	12	4	2
3_Getting to PUDO	2	2	2
4_Wait	1	1	2
7_Onboard	4		4
7a_Incident	2	1	
8_Disembark	1		1
9_Review	2	1	

The same partially satisfied scenarios from section 6.1.1 are replicated here for category *Inform.* Among the missing components are prices for some routes, proposals for some modes of transportation, issues with the icons used to distinguish between the train/bus and the redirection to the website's FAQ section.

In terms of category *book*, we can see a decrease in the number of requirements that are partially or completely unmet. Among the partially satisfied scenarios are 47 and 51, mentioned in section 2.2.3, scenario 6 due to the lack of clear icons and some modes of transportation, and 32 because we do not have access to the ticketing service without registration. The application does not display information on the consequences/benefits of ride sharing, nor does it provide updates for changes in itinerary, resulting in the two unmet scenarios which are 20 and 40.

The requirements for the category *Getting to PUDO* are the same as those for the section 6.1.1, and we realized that the problems are shared by both apps. Similar phenomena can be seen in the following categories, where the same issues and weak points appear in both *tpgpreview* and OWLmobil application. This indicates that some of the elements to develop and improve may be shared between the three sites as they are not currently offered by any applications.

6.3. Oslo site

The evaluation is conducted again this time using Ruter application, adhering to the methodology specified in Section 6.1.

6.3.1. Regarding the global mobility offer: Ruter app

Results indicate that 56.3% of user requirements for the MaaS offer that rely on the use of the Ruter application are met. Around 17% of the scenarios are only partially satisfied and currently, the Oslo MaaS application is unable to satisfy 27.1% of customers' expectations for the global mobility offer.

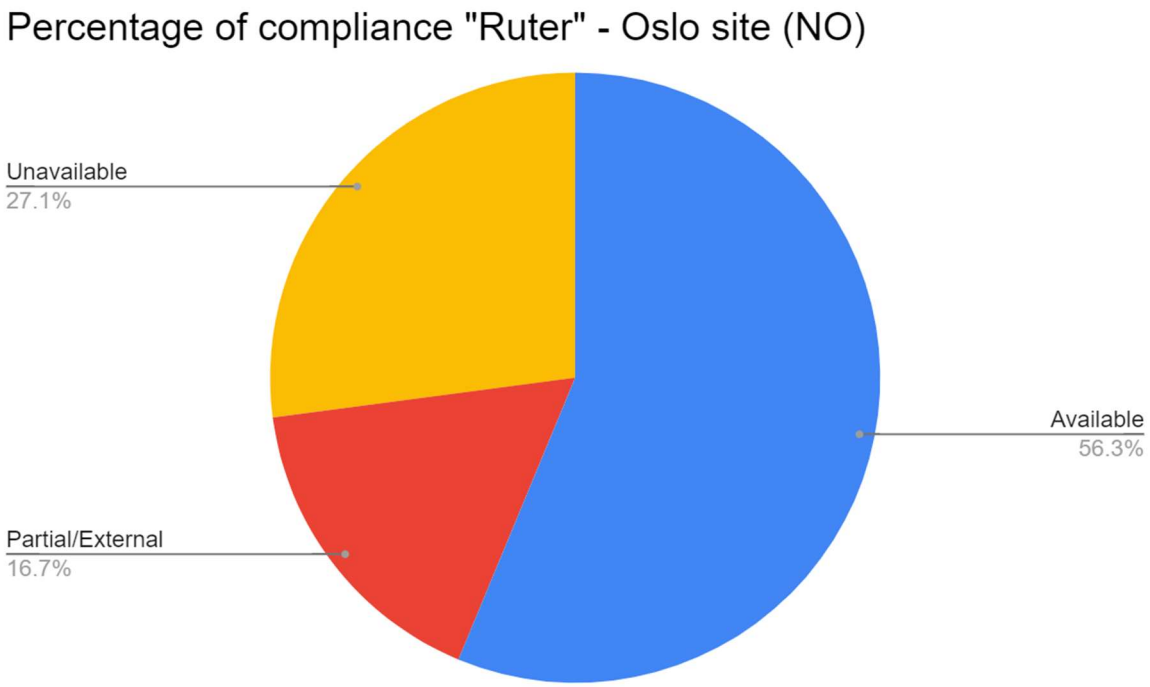

Figure 18. Percentage of compliance "Ruter app" regarding WP2 needs.

As in the previous sections, the complete information is available in Annex C, and none of the satisfied needs will be addressed here. The following table lists the outcomes of compliance by category:

Table 11. Compliance of the "Ruter app" by category

Category	**Available**	**Partial/External**	**Unavailable**
1_Inform	2	2	
2_Book	9	4	5
3_Getting to PUDO	4		2
4_Wait	3		1
7_Onboard	4		4
7a_Incident	2	1	
8_Disembark	1		1
9_Review	2	1	

For the *inform* category, Ruter application has only two partially met requirements as opposed to three, which was the case of other two apps. The problems lie mainly in scenario 2, due to the lack of deep integration with shared micro mobility or other modes of transport, and in scenario 3 due to the fact that security measures are only available at external sites.

In the case of category *Book*, we can observe a new rise in the number of partial or unfulfilled requests; this is mostly attributable to the topic of filtering criteria, where OWLmobil has more sophisticated functionalities. The addition of more modes of transportation to the MaaS offering, the translation into more languages, as well as the information on the carbon footprint discussed in section 2.3.3, are among the elements that might be improved. All information related to advanced filtering criteria, updates to itinerary changes, vehicle inflow, and the consequences/benefits of ridesharing are among the elements that are missing.

None of the apps on the ULTIMO sites have yet met requirements 53 and 55 for category *Getting to PUDO*. The causes are identical; none include a description of the PU or details about whether the user is in the right location. The second situation is the same as the one that blocks category *Wait* scenario 68 from being satisfied.

The final categories share the same aspects that need to be improved and are absent from the other apps, demonstrating the generalizability of the issue and the need to give it priority in how sites move forward with it.

7. Provisional Proposed Passenger Services

The provisional passenger services proposed in the following subsections are either derived from similar EU-funded projects, or are outlined in the Grant Agreement, or suggested by partners of WP2. The primary goal of Task 4.1 is to design and implement the MaaS offering, considering the specific requirements and preferences of each project site. This involves the development of user-friendly interfaces, robust communication protocols, and integration with local transportation networks. In addition to technical considerations, Task 4.1 collaborates closely with WP4's other tasks to ensure that the technological underpinnings align seamlessly with the co-creative and citizen-centric approach advocated by WP2.

Task 4.1 plays a pivotal role in realizing the project's objectives by focusing on the seamless interaction between vehicles and passengers, thereby facilitating the delivery of Mobility as a Service (MaaS) to various project sites. Along with Task 4.3, which implements the technologies related to the vehicle itself and the overall infrastructure, will assist the ULTIMO dream for public transportation.

Lastly, the services proposed in the following subsections encompass a comprehensive approach that also takes into account the accessibility and inclusiveness features necessary to address user needs identified in WP2 and fall within the scope of Task 4.1.

7.1. Convoy Service

Convoy Service represents an urban transportation solution, meticulously designed to offer an efficient and sophisticated mode of multimodal transportation for groups of individuals within urban areas.

Key Features of this service include online reservation, by providing a range of booking alternatives, enabling commuters to secure their convoy. The booking process will be

facilitated through a user-friendly application, a dedicated call center, or conveniently accessible public transport kiosks. By providing diverse vehicle options, passengers will be able to select from several AVs. Moreover, Convoy Service provides pickup point facilitation, by identifying a suitable point of embarkation, considering the commuters' origin and destination, ensuring that the convoy of vehicles will be reachable by the end-users.

From the operators' side, the key features of this service include efficient route planning, by leveraging state-of-the-art routing algorithms, optimizing the convoy itineraries, curbing travel time and mitigating traffic bottlenecks, thereby guaranteeing a swift and efficient traversal of the urban landscape. Moreover, real-time monitoring helps operators to locate the convoy in real time through an operator dashboard. Safety and Reliability are two more key features, as safety ranks as this service's paramount importance. Environmental responsibility is also a very important issue, where fleet of autonomous vehicles adheres to eco-friendly standards, promoting a cleaner and more sustainable urban environment.

The operational overview of the convoy service includes features, such as reservation, where the commuters can commence their journey by booking their convoy through the mobile application, the call centre, or the public transport kiosk. The end user needs to specify the number of tickets to be booked and any other specialized requirements. Pickup coordination will guide the commuters in identifying the most convenient pickup location, factoring in the origin and the planned route. Real-time tracking ensures that passengers remain informed of the convoy's progress with real-time updates delivered via a user-friendly application. This procedure facilitates the arrival to the desired destination seamlessly and conveniently.

7.2. In-Vehicle Infotainment

This proposed "In-Vehicle Infotainment" service is targeted towards the passenger's need to be both entertained and educated or informed about city-related information and historical facts during their transportation inside the autonomous vehicle. The overall purpose of this service is to enhance passenger quality of life during transportation, which is what today's customers expect. Enjoying movies, surfing the internet on a reliable connection, watching TV, listening to music, and hearing crystal-clear tour guide announcements will now be made possible with this in-vehicle service.

As mentioned above, this infotainment service is designed to be used in a two-fold way. First and foremost, it is designed as an additional passenger trust service that will remove any passenger uncertainties with the continuous and real-time provision of relevant information regarding each trip. To build trust in public transportation, the passengers need to be assured that they will get where they are going and be constantly prepared about any unexpected deviations (e.g., estimated time of arrival, vehicle occupancy, etc.).

On the other hand, despite the before mentioned trust reasons, this infotainment service was also proposed as a way of passenger on-route entertainment, being proposed as an alternative form of a tour guide without the need for an actual human guide inside the vehicle. For this purpose, the autonomous vehicle will be equipped with the latest multimedia functions, including appropriate screens and speakers inside the shuttle, and will support continuous Wi-Fi connectivity that will allow for video and audio streaming, music, and books combined with respective online information about each historical landmark. This way, passengers will stay entertained even in cases of unexpected delays.

7.3. Estimated Time of Arrival

The proposed "Estimated Time of Arrival" (ETA) service derives from the SHOW H2020 ecosystem, as this was the first iteration of an AI toolbox that touches this subject. This service is needed in order to inform commuters about the punctual arrival of AVs in Public Transport. This enables end-users to calculate their ability to reach their destination, while also enhancing their decision-making ability about the modes of transportation they are using.

For the implementation of this service, the AV needs to transmit information about the scheduled itinerary, outdoor weather, real-time location, speed and acceleration. For the data processing, an algorithm was proposed [15] for distance calculation, which uses the real-time vehicle coordinates. Data processing also involves several time zones (morning, afternoon, no operation) for more precise prediction.

The main algorithms used for this analysis are Gradient Boosting methods, namely eXtreme Gradient Boosting (XGBoost) [16], Categorical Boosting (CatBoost) [17], and Light Gradient Boosting Machines (LightGBM) [18]. These algorithms provide a cutting-edge technology for regression problems, as they are able to provide solutions fast and seamlessly, compared to other traditional approaches (such as Neural Networks, Support Vector Machines, k-Nearest Neighbor etc. [15]), while concurrently demanding less computational power from other approaches, such as Graph Neural Networks, LSTMs etc.

The dataset acquired from the AV can be treated as a time-series dataset. In this scenario, previous time-steps need to be taken into consideration, which is the time needed to cover the distance for previous stops within the itinerary. The equation that describes this approach is:

In this equation, func() is the Gradient Boosting function used, $x_1 \dots x_n$ represent the variables taken into consideration (location, speed, acceleration, time of the day etc.), while $y(t\text{-}s)_{s=1}^{m}$ is the loop of the previous time steps taken into calculation. For the approach within the SHOW ecosystem, six variables were used (location, speed, acceleration, weather, time of the day, day of the week), utilizing four previous time-steps (m=4), as more time-steps did not enhance the acquired results.

Finally, the metrics used for this service are:

- Root Mean Square Error (RMSE): RMSE is an estimator that measures the root of the average squared difference of the estimated values from the actual values, i.e the square root of the average of the squares of errors
- Mean Absolute Error. MAE measures the absolute difference of the estimated values from the actual values.
- Mean Absolute Percentage Error. MAPE measures the difference of the estimated values from the actual values, while expressing the accuracy as a ratio.

It is important to note that ETA is a service that originates in another project. Therefore, specific steps need to be implemented for the specific needs of the ULTIMO ecosystem. First, the Machine Learning toolbox provided, must be incorporated for the AVs used by the ULTIMO

pilot sites. The next phase of this service is to extend to a Mobility-as-a-Service architecture. Therefore, interoperability and extendibility to new AVs need to be enabled, to fit the new ecosystem. Moreover, real-time scenarios should be implemented, in order to facilitate passengers to benefit from Artificial Intelligence. Finally, a UI could be implemented, to enhance the overall passenger experience and upgrade the Quality of Service provided to the end-users.

7.4. Accessible PUDO database

This “Accessible PUDO database” service is proposed in order to empower passengers with the information they need to make informed choices when selecting a PUDO. Passengers should easily access details such as the availability of acoustic speakers, appropriate entrance levels for accessibility, noise levels conducive to acoustic guidance for visually impaired travellers, well-illuminated extended spaces for wheelchair users for safe boarding/deboarding and more, and even PUDOs offering round-the-clock human assistance by volunteers. This service will ensure that passengers can confidently select a PUDO that aligns with their unique requirements, whether it is accommodating individuals with disabilities, enhancing safety for wheelchair users during boarding and deboarding, or providing a supportive environment for all travellers.

The primary goal of this service is to enhance the overall service quality within the realm of autonomous vehicles. This could be achieved by creating a tailored list of PUDOs that cater to passengers' specific needs, creating a seamless and accessible experience for all. With functional requirements focused on enabling passengers to identify and select the ideal PUDO for their journey, and non-functional requirements emphasizing interoperability and scalability, this service should leverage a robust database of PUDO conditions. This database, complemented by user-friendly software, would offer users easy access to vital information, backed by GPS and contextual data, ensuring that passengers can embark on their journeys with confidence, knowing they have chosen the right PUDO for their needs.

7.5. Door Location Service

The Door Location Service (DLS) is a vital initiative designed to cater to the needs of visually impaired passengers using AVs. Its primary aim is to provide a safe and efficient method for these passengers to locate and access the AV doors. This service operates by employing exterior audio cues that guide the visually impaired individual to the AV's doors.

The DLS can be activated manually at the passenger's request, ensuring that they have control over when they receive guidance. Additionally, for added convenience, this service can be set to activate automatically when a visually impaired passenger books a trip, either through user profile preferences or explicit booking selections.

The technical components of the DLS primarily revolve around the generation and placement of audio signals outside the AV. These signals are optimized for clear, high-quality output and positioned strategically for effective door location guidance. A user-friendly interface allows for easy manual activation, while integration with user profiles ensures a personalized and tailored experience.

Safety is paramount, with the DLS continuously monitoring traffic conditions to prevent any inadvertent exposure to danger. The service also emphasizes user education, offering training programs and guidelines to ensure visually impaired passengers can use it safely and confidently. In summary, the Door Location Service is an innovative solution that enhances accessibility and safety for visually impaired passengers, contributing to a more inclusive transportation experience for all.

7.6. Visual Location Service

The proposed "Visual Location Service" is engineered to enhance the user experience in autonomous vehicles (AVs), prioritizing passenger convenience and safety. This innovative service is more than just a technological enhancement. It symbolizes the dedication to making AVs more intuitive and accessible for all. By projecting clear visual signals from the vehicle's exterior, it serves as a guiding visual signal, helping passengers, especially those with hearing impairments, to effortlessly locate their designated AV.

The essence of the "Visual Location Service" lies in its ability to make the boarding process straightforward and safe. The days of wandering aimlessly, trying to distinguish one's vehicle from a multitude of similar AVs, are over. Thanks to this service, passengers can quickly identify their specific vehicle, ensuring a fluid and stress-free boarding. The visual indicators are crafted to be distinct and easy to discern, removing any ambiguity and guaranteeing that passengers always enter the right vehicle.

The "Visual Location Service" is also characterized by its adaptability. Understanding the varied preferences of passengers, it provides the choice of either manual or automatic activation. Some may opt for the autonomy of manually activating the service, while others might favor the ease of its automatic function. This becomes especially handy as either the AV or the passenger nears the specified Pick-Up and Drop-Off (PUDO) point, facilitating a smooth journey from the sidewalk to inside the vehicle. Such versatility reflects the dedication to cater to the unique needs of each passenger.

7.7. Acoustic Location/Identification Service

The proposed “Acoustic Location/Identification” service is designed to cater the navigational needs of passengers, with a particular focus on visually impaired individuals, ensuring they receive assistance regarding the location and identification of the Autonomous Vehicle (AV) they have requested. The fundamental purpose of this service is to elevate the quality of life for passengers with special needs during transportation, fulfilling their expectations of seamless and inclusive mobility solutions. The ability to easily locate and identify their AV through clear acoustic signals and announcements enhances user experience and ensures a stress-free journey.

To achieve this, the service should integrate sophisticated loudspeakers, strategically located both inside and outside the AV, which are capable of broadcasting clear and discernible acoustic signals and announcements. The external placement of the loudspeakers is crucial to effectively guide visually impaired passengers towards the vehicle. These announcements will be structured with appropriate frequencies and sequences of sounds that are easily perceivable, thus creating an auditory environment that directs passengers to their assigned AV, allowing them to distinctly differentiate it from other vehicles in the vicinity.

Simultaneously, the internal loudspeakers will play a vital role in delivering continuous, clear information and updates to all passengers within the vehicle, ensuring they are well-informed about the status of their journey and any impending stops or route alterations. This precisely designed acoustic landscape guarantees that the service is accessible and meets the specific needs of individuals who are blind or have visual impairments.

7.8. Visual Location Service with AR

This service aims to provide passengers with the ability to locate their reserved autonomous vehicle in an effortless way, avoiding stressful search of the vehicle and possible boarding mistakes. The service makes use of the Computer Vision AI methods for Augmented Reality (AR) applications. Via “Visual Location Service with a AR” service, passengers can locate their reserved vehicle by simply using their mobile phone camera. The app identifies the vehicle and provides audio and augmented reality (AR) directions for a seamless and user-friendly experience.

With the proper data provided, the service aims to create audio and AR directions, taking into consideration any kind of danger within the road (e.g., high traffic, high speed of vehicles) and provide a highly reliable tool for enhancing the passengers’ public transport experience and safety feel.

The main feature of the service is visual recognition of users’ booked AV. The users equipped with the service application on their mobile phones can detect the AV by pointing their cameras at the area that the vehicle is scheduled to arrive. The vehicle will be automatically annotated. Furthermore, the service provides AV and audio Guidance, which is, giving specific visual and audio navigation for a secure way to the reserved AV, until boarding has been completed. Those features ensure the enhancement of QoE and QoS for public transport users and allow easy accessibility for users with disabilities.

7.9. Triggered Communication between Pax and Customer Service (CS)

The proposed 'Triggered Communication between Pax and Customer Service (CS)' is aimed at passenger safety by triggering a call to Customer Service whenever it detects an incident, including actions such as pressing the stop or emergency button, vehicle problems or incidents captured by on-board cameras. This ensures quick responses and assistance in critical situations, ultimately enhancing the overall security of passengers. More specifically, these incidents can be categorized as follows:

- **Pressing the stop or emergency Button**: When a passenger presses the stop or emergency button inside the moving vehicle, it indicates an urgent need for assistance. The automated and direct interaction between passengers and CS ensures that the passenger’s needs are at a high-priority in the overall vehicle operation.
- **Vehicle Issues**: If the operating system detects a mechanical or technical problem with the vehicle, it can initiate an automatic process to trigger a CS to resolve the issue. This

ensures that repair and maintenance of the vehicle can be dealt on the spot to prevent a possible accident or a disruption of passenger's safety.

- **Camera/Microphone-Detected Incidents**: AVs are equipped with on-board cameras and microphones to monitor the overall passenger safety. If the surveillance equipment detects any unusual or dangerous situations, such as altercations between passengers or actions that they are threating the passenger's safety and personal stuff, can initiate a CS to de-escalate the situation and inform the relevant authorities.

In all these cases, the triggered communication between passengers and CS can accomplish a rapid response with the automation of the CS call process. By proactively identifying and responding to alarming incidents, this service creates a secure and reassuring travel experience.

7.10. Emergency exit service

The Emergency Exit Service targets the crucial area of passenger safety within vehicles, prioritizing rapid response in the face of potential dangers both inside and outside the vehicle. The main goal of the service is to integrate advanced technological solutions with traditional safety measures, ensuring that passengers are provided with an immediate and effective means of escape during emergencies while also being alerted to external threats in real-time.

The proposed service integrates sensors within the vehicle to detect emergencies such as a fire, rapid temperature changes, or sudden impacts. For example, upon identifying a threat, vehicle doors would automatically unlock and open, allowing passengers to exit quickly. For situations where the vehicle is in motion, the system first activates necessary safety measures like deceleration, ensuring that passengers can evacuate without harm.

Outside the vehicle, the service includes cameras that constantly monitor the surroundings. Using object detection algorithms, these cameras identify potential threats such as moving traffic, obstacles, bicyclists, and pedestrians. When a danger is detected externally, the system rapidly informs the passenger about the risk e.g., issues an audible warning to alert passengers of the impending threat. For example, an audio alert would be supplemented by a visual display indicating the nature of the threat, such as "Moving vehicle on the right". Depending on the situation, the system suggests the safest direction or exit point, guiding passengers away from the detected threat.

The introduction of this Emergency Exit Service offers several significant benefits. Firstly, it substantially enhances passenger safety by facilitating immediate evacuation in emergencies and providing real-time data about external threats, reducing the risk of injury. Additionally, drivers receive significant information that can assist in their decision-making, potentially averting collisions or harm to other road users. Lastly, the incorporation of such a system can boost public confidence in the transportation service, ensuring that passengers feel secure and protected.

8. Conclusion

As indicated previously, this is the first one of a series of three deliverables around the topic of MaaS and LaaS services for passengers, so focusing on what should be provided so that AV passengers can benefit and seamlessly use the on-demand autonomous offer that is being deployed within ULTIMO. Now some conclusions about the current study and next steps.

8.1. Main ideas

We focused these first pages in clearly defining ULTIMO's starting point and scope for the different sites in terms of passenger services. After an understanding of the MaaS service already proposed by the different urban areas where the 3 deployments are taking place, including the different modes, pricing and description of their respective trip planners, we tried to understand the role the new AV services will be playing on the already existing transport ecosystems. Each of the AV sites has been chosen to serve real transport needs for the local population, and it will be important to understand and keep in mind its purposes when the passenger services will be defined and prioritized.

After that, we analysed the list of needs identified by ULTIMO's WP2, being the base for the services we aim to provide in WP4. A first analysis helped us to select the needs that are directly related to the passenger: the passenger needs. Indeed, before defining the exact services, we have to understand which are the passenger needs that our AV offers are expected to answer, as these services/features will be this solutions. We have then evaluated each one of the passenger needs coming from WP2 to determine which ones were already answered by the current MaaS apps and Padam Mobility's DRT user app, so far the only one live in one of the sites, Geneva. Identifying the level of compliance is an interesting exercise as ULTIMO is not starting from scratch but placing its new contributions on an existing basis. We are "not reinventing the wheel" but working on its next version. The results of these evaluations are promising in terms of compliance: 41.7% for tpgpreview (Geneva), 56.3% for Ruter (Oslo) and 52.1% for OWLmobil (Herford). Finally, 50.8% for the DRT app by Padam. So about half of the needs are already answered by existing services and our developments will mainly focus on the other half, where an important share is already partially answered.

Finally, the first proposed passenger services have been added in chapter 7. Those are provisional services and still need to be prioritised and developed but they are already answering some of the previous evaluated needs. When the complete list of service will be generated, each one of those will be also evaluated and potentially included in the prioritization process.

8.2. Missing elements

Some elements that could have make sense within the current analysis and that couldn't be included for different reasons are:

8.2.1. MaaS from the PTO's/PTA point of view

There is a missing piece in the current section about MaaS consolidation by demo site: the operators and authority point of view. We evaluated the MaaS ecosystem from a user perspective but in terms of available data and current challenges, this could have been an interesting subsection to complete the consolidation. A lack of time and the fact that D4.7 is already focusing on the ITS management services, from the operators point of view, where reasons to no develop further on it.

8.2.2. External brainstorming for additional needs

There are many partners that are important technological actors on their respective markets and this is also the case for Padam Mobility within the Demand Responsive Transport sector. An idea appeared to organize an internal brainstorming with colleagues from different profiles, not necessarily related to the automated mobility, but with huge experience in technological solution, to identify some external needs external from people out of the consortium. This wasn't organized due to a lack of time but could still be interesting if additional needs are required or if there is a gap to be filled.

8.3. Next steps

We have a predefined list of the next steps to be followed in the coming months and which conclusions or content will be included in the second deliverable (D4.2). This refers to:

8.3.1. Evaluating user apps by other fleet orchestrators

We have been able to evaluate the MaaS apps for the three sites, defining which are the needs this apps are already answering and its level of compliance. We've been able to do the same for the Padam Mobility user app, as it is already deployed in Geneva. However, there are two other fleet orchestrators that will also provide user-centric apps and passenger services: Trapeze and ZF. This could have been included in the "Missing elements" section but, due to its pertinence for the next steps, we consider that once their apps will be available, this analysis still has to be done, as it directly impacts the list of unserved needs.

8.3.2. Adding services already provided by other partners

Related to the previous step, and to define a list of not answered/to be improved needs that is as accurate as possible, we should also evaluate which of the needs are already being answered by other partners. Some of the needs might not be answered by apps or user-centric interfaces, but by alternative technological solutions provided by other partners. This is what we would need to evaluate. Anyway, this step still needs to be confirmed and it might not be pursuit.

8.3.3. Identifying the specific needs by test site

The evaluated needs come from WP2, where most of the partners where involved, but are defined following a global approach for the AV ecosystem. However, the PTOs and PTA for each of the sides (TPG, DB and Ruter) can have its own needs as AV operators and regarding the specific service they are deploying. On this step, we propose to consolidate their

requirements for on-demand autonomous transport, both in terms of services and associated data. Finally, we'll evaluate together the deployment capabilities within the ULTIMO context to be as much realistic as possible on what should be included in now.

8.3.4. Consolidating non/partially answered needs list

When reaching this step, we will have selected the needs from WP2 related to passenger services, identified the ones that are already served by the three MaaS apps, the fleet orchestrators or other partners (including next steps 8.3.1 and 8.3.2), and defining its level of compliance. We will have also defined if there are specific needs by the and PTO's PTA that still need to be considered. With all this inputs, we will be in capacity **to define the official list of non-answered needs and those that are only partially answered**. This is a very important consolidation step that should be done in the coming few months and that will be the base to define the related services answering these needs.

8.3.5. Defining the final passenger services list

Once the not/partially answered needs listed, we'll start defining the services/features that will answer some of them. This will be based on all the previous work and will be a central element of the next deliverable.

At this stage, the provisional services proposed in chapter 7 of this deliverable D4.1, included in Task 4.1 & Task 4.2 but that have not been fully addressed yet, will be considered and directly included. Duplicities must be avoided and no proposed service, even if not coming from the evaluated needs must be excluded before being evaluated.

When it comes to describing the services, we should follow a similar approach to the one already used in chapters 3.5 to 3.17 of D4.4.

This will be the main outcome of all the previous steps, analysis and evaluations.

8.3.6. Identifying the options and issues

During all this process, but especially after defining the final list of passenger services, we need to be able to identify the options and issues that will require further technical development and improvement on the current systems. This is an important step to prepare the existing for the coming services.

8.3.7. Prioritization and developments roadmap

After all the previous steps, and based on the main final outcome, the list of final passenger services, we'll proceed to its prioritization and the definition of a roadmap of developments at a consortium level.

Annex A - Requirements applicable to all modes of transport (from D2.1)

ID	Category	Topic	Requirement
1	1_Inform	Information	The user shall have access to complete information on the service and the vehicle
2	1_Inform	Information	The PTO/PTA shall provide complete and accessible information about the service e.g., that it exists, where and when it is offered, what price to expect, what can be brought, how to book it, etc.
3	1_Inform	Information	The PTO/PTA shall provide accessible information about the vehicle e.g., what it looks like (outside and inside), how it can be identified, implemented safety measures, etc.
4	1_Inform	Information	The system shall provide FAQs (Website and in-app), plus form to send in other questions
6	2_Book	MaaS integration	The passenger shall be able to use different public transport services seamlessly (including first mile/last mile to and from mobility hub)
20	2_Book	Information	The user shall be informed about the (time) consequences and/or price benefits of ride sharing
21	2_Book	Information	The user shall be informed about the location of the PUDOs and be able to view the chosen PUDOs on a map with the walking distance between their current location/destination and the designated PUDOs
24	2_Book	booking data	The passenger shall be able to select pick up and drop off points with criteria important to them (e.g. shortest walk vs. no road to cross)
28	2_Book	Payment	Classic PT tickets shall be valid for this service as well
29	2_Book	Data protection	The user shall be informed about potential video surveillance
30	2_Book	Information	The specified price shall be reliable
31	2_Book	Payment	The user shall be able to register a payment card or use vipps or the like

32	2_Book	Payment	The user shall be able to pay automatically for the trip
34	2_Book	booking data	The user shall be able to input their start and stop points
35	2_Book	Information	The system shall provide suggestions for trips with the estimated journey time and specified price
39	2_Book	Information	The user shall be informed if the service cancels or changes their trip
40	2_Book	Information	The user shall receive updates on any changes to their itinerary (new prices, route changes, new ETAs)
41	2_Book	booking data	The user shall be able to save favorites (trips, PUDOs) - also **without booking it**
44	2_Book	special needs	The system shall provide suitable PUDOs when user asks for specific criteria (e.g. no road to cross to destination, suited for wheelchair ramp --> gradient)
47	2_Book	special needs	When of another nationality **(language**!), the passenger **shall be able to book** and **use the service**
50	2_Book	Information	The user shall be able to compare costs - travel time - CO2 footprint of different PT options
51	2_Book	Information	The system shall inform the user about the expected demand (how crowded the vehicle might be)
53	3_Getting to PUDO	Information	The user shall be provided with an accurate and accessible description of how to find their pick-up point
54	3_Getting to PUDO	Information	The user shall be provided with a real-time time estimate indicating the distance between their current location and the PUDO/the vehicle
55	3_Getting to PUDO	Information	The user shall receive confirmation when they have arrived at the correct PUDO
57	3_Getting to PUDO	Information	The system shall provide a map with PUDOS and the user position marked
61	3_Getting to PUDO	Information	PUDO shall be marked in such a way that it can be easily recognised
62	3_Getting to PUDO	Communication	The user shall be able to report an issue with a PUDO

63	4_Wait	Information	The user shall be informed about the time when the vehicle will arrive at the pickup point
67	4_Wait	Information	The system shall provide a time estimate of how far away the vehicle is
68	4_Wait	Information	The user shall be able to get a confirmation that this is the correct location
69	4_Wait	Information	The user shall be able to track the vehicle (its position and time to arrive at PUDO)
109	7_Onboard	Information	The user shall be informed about the time when the vehicle will arrive at the drop off point
110	7_Onboard	Information	The system shall provide the information how the passengers will get from the drop off point to the destination
111	7_Onboard	Information	The user shall be informed about the connections at the connecting station
119	7_Onboard	Communication	The passenger shall be able to report littering/damages, etc.
120	7_Onboard	Information	The passenger shall have alternative travel options suggested in the event of a disruption
137	7_Onboard	Information	The user shall be informed about the (time) consequences and/or price benefits of ride sharing
160	7_Onboard	Information	The vehicle shall alert passengers about arriving at their destination at an appropriate time before reaching it
162	7_Onboard	MaaS integration	If vehicle fails to reach the connection, it shall inform the user and offer an alternative.
166	7a_Incident	Communication	The user shall be able to talk directly to customer service in case of an incident or any concerns
170	7a_Incident	Information	The system shall inform the passengers about any unforeseen events and ask if they want to resume the ride
174	7a_Incident		The user shall be able to report an incident

182	8_Disembark	Information	The system (e.g., app, in-vehicle screen) shall inform the passenger that the vehicle has now reached the passenger's destination
190	8_Disembark	MaaS integration	The system shall provide info about changeover time for connecting means of transport
202	9_Review	Payment	The user shall be able to receive a receipt of the trip
204	9_Review	booking data	The user shall be able to save a trip as a favorite
205	9_Review		The user shall be able to report an issue with a PUDO

Annex B - Requirements applicable to DRT services (from D2.1)

ID	Category	Topic	Requirement
7	2_Book	booking data	The user shall be able to book a trip with a fixed ETA (e.g. to doctor's appointment or to a connecting means of transport)
8	2_Book	booking data	The passenger shall be able to book a trip for the current moment
9	2_Book	booking data	The passenger shall be able to schedule a trip in advance
10	2_Book	booking data	The user shall be able to book for other passengers, for example for children that do not use smartphones, grandmother. etc.
11	2_Book	special needs	The user shall be able to book a soloride e.g., at night, for a young child, etc.
12	2_Book	special needs	The user shall be able to book a ride with safety operator on board
13	2_Book	special needs	The user with special needs shall be able to book a ride specifying the needs, e.g. with/without ramp, space for luggage, space for guide dog, low-floor vehicle, group of people, dog-free vehicle, …

14	2_Book	special needs	The system shall confirm that all special needs are considered, e.g. that vehicle with ramp is booked and that space in the vehicle is reserved, and if necessary provide details e.g., how much weight the ramp can support
15	2_Book	special needs	The passenger with special needs shall be able to book their ride spontanously just like any other passenger
17	2_Book	booking data	The user shall be able to book recurring trips
18	2_Book	booking data	The user shall be able to book a shuttle for additional persons (=me plus others)
19	2_Book	Change Trip	The user shall be able to make changes or cancel a trip at short notice.
22	2_Book	booking data	When booking for a group, the user shall have the option to add multiple destinations, accommodating the needs of person(s) accompanying them
23	2_Book	booking data	When booking for a group, the user shall have the option to add multiple pick up points, accommodating the needs of person(s) accompanying them
26	2_Book	Information	The confirmation of the booking shall contain all essential information including location of PUDOS, estimated time of arrival (ETA) at start and destination, properties of vehicle (when indicated), price, wait time of the vehicle and (if applicable) connections at a connecting station
27	2_Book	Information	The user shall have the option to confirm the trip details, including the assigned vehicle
36	2_Book	booking data	The system shall onboard the user easily, requiring only essential information such as name, relevant details, and payment method
37	2_Book	Information	The user shall be provided with information regarding the presence/absence of a safety operator in the AV
38	2_Book	Information	The user shall be promptly notified during the early stages of the booking process if no transportation options are available
42	2_Book	special needs	The user shall be able to request longer boarding and disembarking time during booking process

43	2_Book	Change Trip	The user shall be informed of the consequences of changes to a booking before they confirm the changes or cancellation.
45	2_Book	Information	If booked route is available with conventional service, the system shall inform the user of this fixed line service providing the same route and encourage user to book fixed line
48	2_Book	booking data	The user shall be able to save and edit a user profile including preferences and special needs
49	2_Book	Information	The system shall provide the properties of the booked vehicle (if special requirements are part of the booking)
52	3_Getting to PUDO	Information	The system shall provide the essential boarding information: the estimated arrival time of the AV at the PUDOS and the AV's identifier, such as its name or license plate number
56	3_Getting to PUDO	Information	The user shall get updated with how long the AV will wait for them at the PUDO
58	3_Getting to PUDO	Change Trip	The user shall be able to cancel the trip if they can't make it to pick up point in time
59	3_Getting to PUDO	Information	If system predicts that user will be late and vehicle can wait, the system shall ask user if waiting period shall be extended (and inform about consequences)
60	3_Getting to PUDO	Information	If system predicts that user will be late and vehicle can't wait, the system shall ask user if new trip in next vehicle shall be booked (and inform about consequences)
65	4_Wait		The user shall have the ability to mark the ride as a no-show and contact customer support if the vehicle fails to arrive
74	5_Connecting pax and vehicle		The vehicle shall be able to 'recognize' the user
79	6_Boarding AV	Monitoring	The system shall associate items with passenger
82	6_Boarding AV	special needs	The user shall be able to get heavy luggage into the vehicle

92	6_Boarding AV	Monitoring	When having booked for another person, the user shall be sure the passenger boards the correct vehicle
102	6_Boarding AV	Incident	The user shall be able to report to the PTO if booking can't be fulfilled (vehicle is full, requested space not available, no ramp, etc.)
103	6_Boarding AV	Monitoring	The system shall detect if passenger violates booking agreement (e.g., no. of persons, luggage, ...)
104	6_Boarding AV	Information	Rules in the vehicle shall be obvious (e.g., seat belt or sitting down required etc.)
112	7_Onboard	Information	The user shall be able to access all relevant information via app and via PIS onboard
118	7_Onboard	Monitoring	When having booked for another person, the user shall be sure that the passenger arrives safely
124	7_Onboard	Change Trip	The passenger shall be able to return to their starting point without finishing the booked ride
125	7_Onboard	Change Trip	The passenger shall be able to initiate a halt request to immediately leave the vehicle at the next possible stop
126	7_Onboard	Change Trip	The passenger shall be able to change their trip destination (during the trip)
127	7_Onboard	Information	The user shall be informed how long the AV will wait at the PUDOS (when vehicle is waiting on route for other pax)
132	7_Onboard	Information	The system shall inform users about rules regarding the use of the AV (e.g., "This is a shared service. Remember to respect other passengers")
135	7_Onboard	Information	The user shall be informed if new passengers will boarding their bus
136	7_Onboard	Information	The user shall be informed of changes to their itinerary due to new passengers
140	7_Onboard	Information	The AV shall indicate the name of the PUDO as the vehicle arrives at each location (acoustic, visual, in app)

142	7_Onboard	Communication	The user shall be able to contact the customer service via a button in the AV, via app functionality, via shouting for help, etc.
145	7_Onboard	Change Trip	When user discontinues/cancels trip, the user shall be offered a list of close PUDOs to choose from (closest PUDO = default)
146	7_Onboard	Change Trip	User shall be informed of being dropped off before they confirm the cancellation
151	7_Onboard		As a user, I need to be reminded if I must confirm that my trip is concluded, but I'd rather not have to
152	7_Onboard	Communication	The user shall be able to interact with the control centre in the way that suits them
164	7_Onboard	Change Trip	User shall be informed of the consequences (e.g. re payment) of a change in booking before they confirm the changes or cancellation
173	7a_Incident	Payment	The user shall get a full refund if the reason for discontinuing is the service providers fault
181	8_Disembark		For disembarking, the vehicle shall stop, automatically unlock the doors, and inform pax about destination PUDO (e.g. voice-over announcement or display or app)
196	8_Disembark	Monitoring	When having booked for another person, the user shall be sure the passenger disembarks at the correct location
198	9_Review		The user shall be able to rate the experience
199	9_Review		The user shall be able to share the experience
200	9_Review		The user shall be able to report forgotten items in the vehicle
201	9_Review		The user shall be able to provide feedback on the service
203	9_Review		The service shall provide a process for retrieving/returning lost items (e.g. vehicle could bring item back to PUDO etc.)

Annex C - Current status of MaaS apps of ULTIMO sites according to WP2 requirements

ID	Category	Requirement	Current status (tpgpreview app)	Current status (OWLmobil app)	Current status (Ruter app)
1	1_Inform	The user shall have access to complete information on the service and the vehicle	Available	Available	Available
2	1_Inform	The PTO/PTA shall provide complete and accessible information about the service e.g., that it exists, where and when it is offered, what price to expect, what can be brought, how to book it, etc.	Partial/External	Partial/External	Partial/External
3	1_Inform	The PTO/PTA shall provide accessible information about the vehicle e.g., what it looks like (outside and inside), how it can be identified, implemented safety measures, etc.	Partial/External	Partial/External	Partial/External
4	1_Inform	The system shall provide FAQs (Website and in-app), plus form to send in other questions	Partial/External	Partial/External	Available
6	2_Book	The passenger shall be able to use different public transport services seamlessly (including first mile/last mile to and from mobility hub)	Partial/External	Partial/External	Partial/External

20	2_Book	The user shall be informed about the (time) consequences and/or price benefits of ride sharing	Unavailable	Unavailable	Unavailable
21	2_Book	The user shall be informed about the location of the PUDOs and be able to view the chosen PUDOs on a map with the walking distance between their current location/destination and the designated PUDOs	Available	Available	Available
24	2_Book	The passenger shall be able to select pick up and drop off points with criteria important to them (e.g. shortest walk vs. no road to cross)	Unavailable	Available	Unavailable
28	2_Book	Classic PT tickets shall be valid for this service as well	Available	Available	Available
29	2_Book	The user shall be informed about potential video surveillance	Partial/External	Available	Partial/External
30	2_Book	The specified price shall be reliable	Available	Available	Available
31	2_Book	The user shall be able to register a payment card or use vipps or the like	Available	Available	Available
32	2_Book	The user shall be able to pay automatically for the trip	Partial/External	Partial/External	Available

34	2_Book	The user shall be able to input their start and stop points	Available	Available	Available
35	2_Book	The system shall provide suggestions for trips with the estimated journey time and specified price	Partial/External	Available	Available
39	2_Book	The user shall be informed if the service cancels or changes their trip	Available	Available	Available
40	2_Book	The user shall receive updates on any changes to their itinerary (new prices, route changes, new ETAs)	Unavailable	Unavailable	Unavailable
41	2_Book	The user shall be able to save favorites (trips, PUDOs) - also **without booking it**	Available	Available	Available
44	2_Book	The system shall provide suitable PUDOs when user asks for specific criteria (e.g. no road to cross to destination, suited for wheelchair ramp --> gradient)	Unavailable	Available	Unavailable
47	2_Book	When of another nationality **(language**!), the passenger **shall be able to book** and **use the service**	Partial/External	Partial/External	Partial/External
50	2_Book	The user shall be able to compare costs - travel time - CO2	Partial/External	Available	Partial/External

		footprint of different PT options			
51	2_Book	The system shall inform the user about the expected demand (how crowded the vehicle might be)	Unavailable	Partial/External	Unavailable
53	3_Getting to PUDO	The user shall be provided with an accurate and accessible description of how to find their pick-up point	Unavailable	Unavailable	Unavailable
54	3_Getting to PUDO	The user shall be provided with a real-time time estimate indicating the distance between their current location and the PUDO/the vehicle	Partial/External	Partial/External	Available
55	3_Getting to PUDO	The user shall receive confirmation when they have arrived at the correct PUDO	Unavailable	Unavailable	Unavailable
57	3_Getting to PUDO	The system shall provide a map with PUDOS and the user position marked	Available	Available	Available
61	3_Getting to PUDO	PUDO shall be marked in such a way that it can be easily recognised	Partial/External	Partial/External	Available
62	3_Getting to PUDO	The user shall be able to report an issue with a PUDO	Available	Available	Available
63	4_Wait	The user shall be informed about the time when the vehicle will arrive at the pick up point	Available	Available	Available

67	4_Wait	The system shall provide a time estimate of how far away the vehicle is	Partial/External	Partial/External	Available
68	4_Wait	The user shall be able to get a confirmation that this is the correct location	Unavailable	Unavailable	Unavailable
69	4_Wait	The user shall be able to track the vehicle (its position and time to arrive at PUDO)	Unavailable	Unavailable	Available
109	7_Onboard	The user shall be informed about the time when the vehicle will arrive at the drop off point	Available	Available	Available
110	7_Onboard	The system shall provide the information how the passengers will get from the drop off point to the destination	Available	Available	Available
111	7_Onboard	The user shall be informed about the connections at the connecting station	Available	Available	Available
119	7_Onboard	The passenger shall be able to report littering/damages, etc.	Available	Available	Available
120	7_Onboard	The passenger shall have alternative travel options suggested in the event of a disruption	Unavailable	Unavailable	Unavailable
137	7_Onboard	The user shall be informed about the (time) consequences and/or price benefits of ride sharing	Unavailable	Unavailable	Unavailable

160	7_Onboard	The vehicle shall alert passengers about arriving at their destination at an appropriate time before reaching it	Unavailable	Unavailable	Unavailable
162	7_Onboard	If vehicle fails to reach the connection, it shall inform the user and offer an alternative.	Unavailable	Unavailable	Unavailable
166	7a_Incident	The user shall be able to talk directly to customer service in case of an incident or any concerns	Available	Available	Available
170	7a_Incident	The system shall inform the passengers about any unforeseen events and ask if they want to resume the ride	Partial/External	Partial/External	Partial/External
174	7a_Incident	The user shall be able to report an incident	Available	Available	Available
182	8_Disembark	The system (e.g., app, in-vehicle screen) shall inform the passenger that the vehicle has now reached the passenger's destination	Unavailable	Unavailable	Unavailable
190	8_Disembark	The system shall provide info about changeover time for connecting means of transport	Available	Available	Available
202	9_Review	The user shall be able to receive a receipt of the trip	Available	Available	Available

204	9_Review	The user shall be able to save a trip as a favorite	Partial/External	Partial/External	Partial/External
205	9_Review	The user shall be able to report an issue with a PUDO	Available	Available	Available

Annex D - Current status of DRT apps of ULTIMO sites according to WP2 requirements

ID	Category	Requirement	Current status (*tpgflex app* by Padam Mobility)
7	2_Book	The user shall be able to book a trip with a fixed ETA (e.g. to doctor's appointment or to a connecting means of transport)	Available
8	2_Book	The passenger shall be able to book a trip for the current moment	Available
9	2_Book	The passenger shall be able to schedule a trip in advance	Available
10	2_Book	The user shall be able to book for other passengers, for example for children that do not use smartphones, grandmother. etc.	Available
11	2_Book	The user shall be able to book a soloride e.g., at night, for a young child, etc.	Unavailable
12	2_Book	The user shall be able to book a ride with safety operator on board	Unavailable
13	2_Book	The user with special needs shall be able to book a ride specifying the needs, e.g. with/without ramp, space for luggage, space for guide dog, low-floor vehicle, group of people, dog-free vehicle, …	Available
14	2_Book	The system shall confirm that all special needs are considered, e.g. that vehicle with ramp is	Available

		booked and that space in the vehicle is reserved, and if necessary provide details e.g., how much weight the ramp can support	
15	2_Book	The passenger with special needs shall be able to book their ride spontanously just like any other passenger	Available
17	2_Book	The user shall be able to book recurring trips	Available
18	2_Book	The user shall be able to book a shuttle for additional persons (=me plus others)	Available
19	2_Book	The user shall be able to make changes or cancel a trip at short notice.	Available
22	2_Book	When booking for a group, the user shall have the option to add multiple destinations, accommodating the needs of person(s) accompanying them	Unavailable
23	2_Book	When booking for a group, the user shall have the option to add multiple pick-up points, accommodating the needs of person(s) accompanying them	Unavailable
26	2_Book	The confirmation of the booking shall contain all essential information including location of PUDOS, estimated time of arrival (ETA) at start and destination, properties of vehicle (when indicated), price, wait time of the vehicle and (if applicable) connections at a connecting station	Available
27	2_Book	The user shall have the option to confirm the trip details, including the assigned vehicle	Available
36	2_Book	The system shall onboard the user easily, requiring only essential information such as name, relevant details, and payment method	Available
37	2_Book	The user shall be provided with information regarding the presence/absence of a safety operator in the AV	Unavailable
38	2_Book	The user shall be promptly notified during the early stages of the booking process if no transportation options are available	Available

42	2_Book	The user shall be able to request longer boarding and disembarking time during booking process	Partial/External
43	2_Book	The user shall be informed of the consequences of changes to a booking before they confirm the changes or cancellation.	Partial/External
45	2_Book	If booked route is available with conventional service, the system shall inform the user of this fixed line service providing the same route and encourage user to book fixed line	Available
48	2_Book	The user shall be able to save and edit a user profile including preferences and special needs	Partial/External
49	2_Book	The system shall provide the properties of the booked vehicle (if special requirements are part of the booking)	Available
52	3_Getting to PUDO	The system shall provide the essential boarding information: the estimated arrival time of the AV at the PUDOS and the AV's identifier, such as its name or license plate number	Available
56	3_Getting to PUDO	The user shall get updated with how long the AV will wait for them at the PUDO	Partial/External
58	3_Getting to PUDO	The user shall be able to cancel the trip if they can't make it to pick up point in time	Available
59	3_Getting to PUDO	If system predicts that user will be late and vehicle can wait, the system shall ask user if waiting period shall be extended (and inform about consequences)	Unavailable
60	3_Getting to PUDO	If system predicts that user will be late and vehicle can't wait, the system shall ask user if new trip in next vehicle shall be booked (and inform about consequences)	Unavailable
65	4_Wait	The user shall have the ability to mark the ride as a no-show and contact customer support if the vehicle fails to arrive	Partial/External
74	5_Connecting pax and vehicle	The vehicle shall be able to 'recognize' the user	Available

79	6_Boarding AV	The system shall associate items with passenger	Available
82	6_Boarding AV	The user shall be able to get heavy luggage into the vehicle	Available
92	6_Boarding AV	When having booked for another person, the user shall be sure the passenger boards the correct vehicle	Partial/External
102	6_Boarding AV	The user shall be able to report to the PTO if booking can't be fulfilled (vehicle is full, requested space not available, no ramp, etc.)	Partial/External
103	6_Boarding AV	The system shall detect if passenger violates booking agreement (e.g., no. of persons, luggage, ...)	Unavailable
104	6_Boarding AV	Rules in the vehicle shall be obvious (e.g., seat belt or sitting down required etc.)	Partial/External
112	7_Onboard	The user shall be able to access all relevant information via app and via PIS onboard	Available
118	7_Onboard	When having booked for another person, the user shall be sure that the passenger arrives safely	Partial/External
124	7_Onboard	The passenger shall be able to return to their starting point without finishing the booked ride	Unavailable
125	7_Onboard	The passenger shall be able to initiate a halt request to immediately leave the vehicle at the next possible stop	Partial/External
126	7_Onboard	The passenger shall be able to change their trip destination (during the trip)	Unavailable
127	7_Onboard	The user shall be informed how long the AV will wait at the PUDOS (when vehicle is waiting on route for other pax)	Partial/External
132	7_Onboard	The system shall inform users about rules regarding the use of the AV (e.g., "This is a shared service. Remember to respect other passengers")	Partial/External
135	7_Onboard	The user shall be informed if new passengers will boarding their bus	Available

136	7_Onboard	The user shall be informed of changes to their itinerary due to new passengers	Available
140	7_Onboard	The AV shall indicate the name of the PUDO as the vehicle arrives at each location (acoustic, visual, in app)	Available
142	7_Onboard	The user shall be able to contact the customer service via a button in the AV, via app functionality, via shouting for help, etc.	Partial/External
145	7_Onboard	When user discontinues/cancels trip, the user shall be offered a list of close PUDOs to choose from (closest PUDO = default)	Unavailable
146	7_Onboard	User shall be informed of being dropped off before they confirm the cancellation	Unavailable
151	7_Onboard	As a user, I need to be reminded if I have to confirm that my trip is concluded, but i'd rather not have to	Available
152	7_Onboard	The user shall be able to interact with the control center in the way that suits them	Partial/External
164	7_Onboard	User shall be informed of the consequences (e.g., re payment) of a change in booking before they confirm the changes or cancellation	Partial/External
173	7a_Incident	The user shall get a full refund if the reason for discontinuing is the service providers fault	Available
181	8_Disembark	For disembarking, the vehicle shall stop, automatically unlock the doors, and inform pax about destination PUDO (e.g. voice-over announcement or display or app)	Available
196	8_Disembark	When having booked for another person, the user shall be sure the passenger disembarks at the correct location	Unavailable
198	9_Review	The user shall be able to rate the experience	Available
199	9_Review	The user shall be able to share the experience	Available
200	9_Review	The user shall be able to report forgotten items in the vehicle	Partial/External

201	9_Review	The user shall be able to provide feedback on the service	Available
203	9_Review	The service shall provide a process for retrieving/returning lost items (e.g., vehicle could bring item back to PUDO etc.)	Partial/External

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