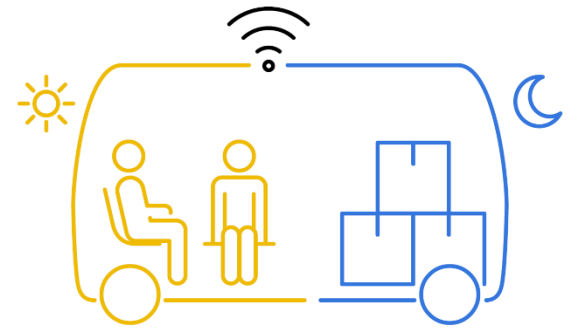

ULTIMO

Advancing Sustainable User-centric
Mobility with Automated Vehicles

DELIVERABLE

D2.3 Inclusion, accessibility and co-creation framework - First version

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Acronyms

ADS	Automated Driving Systems
AI	Artificial Intelligence
AM	Automated Mobility
AMB	Automated Minibus
API	Application Protocol Interface
AV	Automated Vehicle
BMM	Business Modelling Manager
CAV	Connected and Automated Vehicles
CB	Consortium Body
CERN	European Organization for Nuclear Research
D7.1	Deliverable 7.1
DC	Demonstration Coordinator
DI	The department of infrastructure (Swiss Canton of Geneva)
DMP	Data Management Plan
DTU test track	Technical University of Denmark test track
EAB	External Advisory Board
EC	European Commission
ECSEL	Electronic Components and Systems for European Leadership
EM	Exploitation Manager
EU	European Union
EUCAD	European Conference on Connected and Automated Driving
F2F	Face to face meeting
FEDRO	(Swiss) Federal Roads Office
FM	Fleet Management
FOT	(Swiss) Federal Office of Transport
GDPR	General Data Protection Regulation
GIMS	Geneva International Motor Show
GNSS	Global Navigation Satellite System
HARA	Hazard Analysis and Risk Assessment
IPR	Intellectual Property Rights
IT	Information Technology
ITU	International Telecommunications Union
LaaS	Logistics as a Service
LIDAR	Light Detection and Ranging
MaaS	Mobility as a Service
MEM	Monitoring and Evaluation Manager
MT	MobileThinking
OCT	General Transport Directorate of the Canton of Geneva
ODD	Operational Domain Design
OEDR	Object and Event Detection and Response
PC	Project Coordinator
PEB	Project Executive Board
PGA	Project General Assembly
PRM	Persons with Reduced Mobility
PTA	Public Transport Authority
PTO	Public Transportation Operator
PTS	Public Transportation Services
QRM	Quality and Risk Manager
QRMB	Quality and Risk Management Board
RN	Risk Number
SA	Scientific Advisor
SAE Level	Society of Automotive Engineers Level (Vehicle Autonomy Level)
SAN	(Swiss) Cantonal Vehicle Service
SDK	Software Development Kit
SLA	Sales Lentz Autocars
SMB	Site Management Board
SoA	State of the Art
SOTIF	Safety Of The Intended Functionality
SWOT	Strengths, Weaknesses, Opportunities, and Threats.
T7.1	Task 7.1
TM	Technical Manager
TPG	Transport Publics Genevois
UITP	Union Internationale des Transports Publics (International Transport Union)
V2I	Vehicle to Infrastructure communication
WP	Work Package
WPL	Work Package Leader

Executive Summary

The project's ultimate goal is to create a large-scale, well-accepted, seamless-integrated and economically viable AV-based public transport service across diverse European regions. To achieve this goal, understanding stakeholders' needs is crucial. Within the scope of Work Package 2 (WP2), our central focus is the exploration of passenger and Public Transport Operator (PTO) requirements.

Deliverable 2.3 contributes to this goal by defining essential requirements and use cases and aligning user needs with the development of AV-based transport system. We achieve this through active engagement with passengers and key stakeholders to collaboratively define use cases and involving citizens in the definition of services and giving them a voice through collaboration with all relevant stakeholders.

This first version of the report describes the methods used and an initial description of the needs based on the experience with the transport services provided, as well as the anticipated needs for full implementation resulting from active citizen co-creation.

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 of 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.

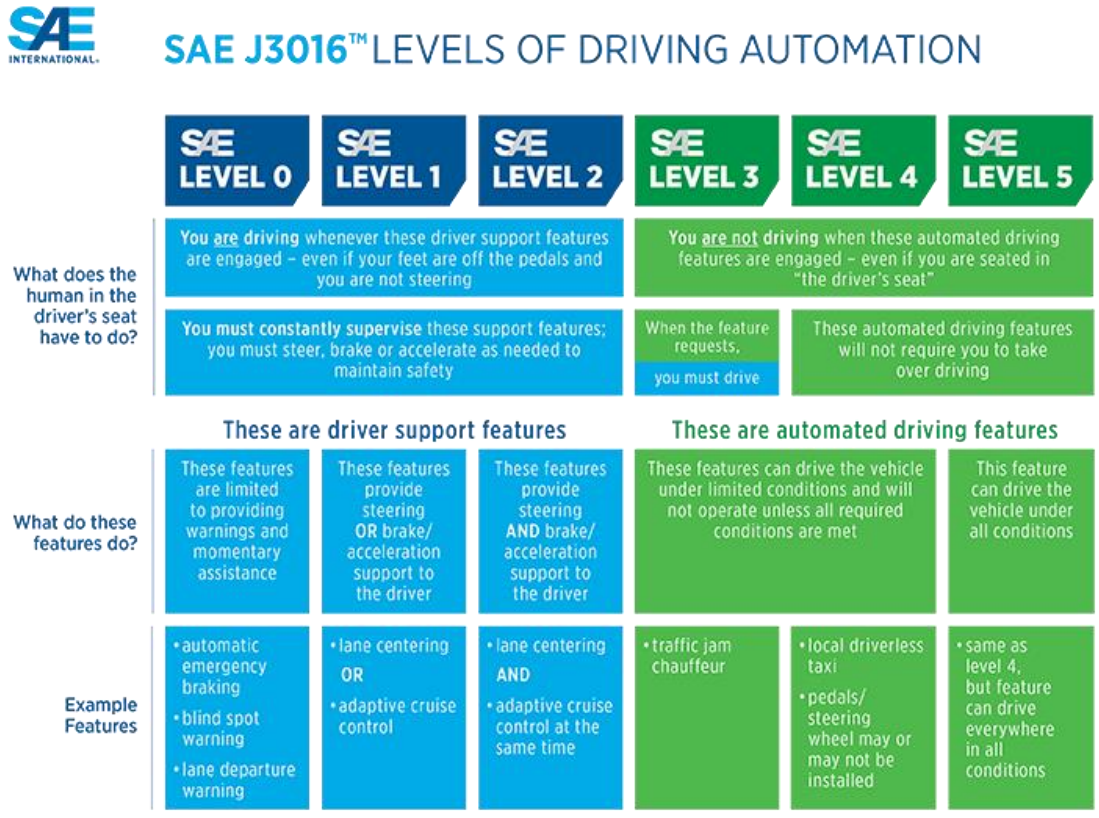

Table 1: SAE Driving Automation levels (©2020 SAE International)

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 mini busses 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 ser-vices 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 re-strictions, 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 centre to the distribution centre (hub, many to one or one to many) or even transport their VIP customers directly to their offices or exposition centres. 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 time period..

1.3 Preamble – Inclusion, accessibility and co-creation

WP2 is dedicated to defining the overall operational environment of future public transport services, involving citizens in the definition of services and giving them a voice through collaboration with all relevant stakeholders. It aims to realise door-to-door passenger/user-centred public transport that is made accessible to all, paying particular attention to differences in mobility patterns by gender, age, physical and sensory limitations and other social groups, including tourists, etc.

Deliverable D2.3 reports on the assessment of accessibility of services and co-creation outcomes.

This first version of the report describes the methods used and an initial description of the needs based on the experience with the transport services provided, as well as the anticipated needs for full implementation resulting from active citizen co-creation.

2 Inclusion and Accessibility

2.1 Methods

The methodology for the evaluation of the inclusion and accessibility of automated vehicles (AVs) in public transportation, encompasses a focused approach that consists of three main elements: a review of results of existing and past projects, analysis through personas, and direct empirical research.

Firstly, the study conducts a thorough review of prior and ongoing initiatives in the realm of automated public transport. This review aims to extract valuable lessons and identify best practices to improve AV implementation and accessibility. By learning from the successes and failures of these projects, the study seeks to avoid repeating past mistakes and to build on effective strategies.

Secondly, it employs a persona-based analysis with a special emphasis on individuals with special needs. This analysis explores how automated public transport can enhance mobility and independence for those who rely on public transportation due to physical or other limitations. It critically assesses the need for inclusive design and service provision that ensures no individual is left behind as transport systems evolve towards automation.

Lastly, the methodology includes interviews and onsite visits to gather firsthand insights and observations. This direct engagement with stakeholders, ranging from users to technical experts, provides a real-world perspective on the operational challenges and opportunities of integrating AVs into public transport systems.

By combining these elements, the study aims to create a detailed understanding of how automated public transportation can be made more inclusive and accessible, ensuring that the benefits of AV technology are equitably distributed across all segments of society.

2.1.1 Previous and current other projects

Automated public transport is a recent and hot topic. As there are many opportunities, but also risks, and the technology is still in its infancy, there have been and still are many research projects in this field. In the following sections we look at some of the projects that have had and still have a similar focus to ULTIMO, in order to learn from them, because as George Bernard Shaw said *"Success is not about never making mistakes, but never making the same mistake twice*".

2.1.1.1 AVENUE

AVENUE (Horizon 2020 grant agreement No. 769033) aim was to design and carry out full-scale demonstrations of urban transport automation by deploying, for the first time worldwide, fleets of Automated Minibuses in low to medium demand areas of 4 European demonstrator cities (Geneva, Lyon, Copenhagen and Luxembourg) and on 2 replicator cities (Uvrier and Esch-sur-Alzette). The objective was to take into consideration special needs and time constraints, instead of trying to accommodate AVs to the existing solutions of prescheduled bus itineraries. AVENUE introduced disruptive public transportation paradigms

on the basis of door-to-door services and the nascent concept of 'Mobility Cloud', aiming to set up a new model of public transportation. This model enables multimodal public transport, combining traditional public transport with new service models such as the sharing economy, and using all possible modes of transport.

Vehicle services have been introduced that significantly improve the passenger experience as well as the overall quality and value of the service, including for older people, people with disabilities and vulnerable users. Road behaviour, the safety of the automated vehicles and passenger safety were key aspects of the AVENUE project.

AVENUE project results related to the perception of PWD regarding AVS are reported in the article of Nanchen et al., (2022). In summary, insufficient efforts are made at the regional and city levels to assist individuals with disabilities (PWD). Typically, public transportation focuses solely on main routes, neglecting the crucial "First Mile, Last Mile" (FMLM) connections where PWD particularly lack support from public authorities. While these observations may seem obvious, there is a notable lack of awareness at this level. Our findings regarding the perceptions of PWD on Automated Vehicles (AVs) are mixed. While AVs represent a promising new assistive technology that could improve mobility for PWD, they also pose potential risks and limitations, especially if the design of these new mobility services fails to adhere to universal and inclusive design principles.

2.1.1.2 HEAL (Dez. 20 – Jun. 23)

Bad Birnbach is the first place in Germany where a highly automated bus was put into regular service. Since then, they have stuck to this innovative project and gradually expanded the route. Now, another important step is to be taken towards demand-oriented (and thus future-proof public transport). The overall goal of the project is therefore to further develop the existing operation of the highly automated bus line in Bad Birnbach by adding a demand-driven supplement in an expanded environment. To achieve this, certain streets around the town centre are to be developed internally, which will be served by the highly automated shuttle as needed. This development also includes other areas of daily need (shops in the commercial area) and facilities for sports, leisure, and culture, as well as healthcare, where the existing public transport only offers a limited service. Both locals and guests can benefit from this traffic improvement. The barrier-free nature of the vehicles and the reduction of the first and last mile support especially people with mobility restrictions, underlining the enormous importance of such a project. The project can also test connectivity with other means of transport. In particular, with the existing regular service of the first highly automated bus, but also other buses and the Rottalbahn.

Furthermore, the focus is on "highly automated health transport". In cooperation with the Chair of Public Health and Health Services Research at LMU Munich, questions of public health relevance or from the spectrum of prevention and health promotion are being investigated. With a demand-driven highly automated shuttle, patients can be taken to and from their doctor's appointments, for example, or older people without family support have the opportunity to get to leisure facilities or cultural events independently. Parameters to be investigated include the effects of the newly established "On Demand" offer on the movement and social network behaviour of vulnerable groups of people such as older (single) people or people with health impairments, as well as the determinants of social inclusion in this population.

2.1.1.3 SMO II (Jan. 2022 – Sept. 2024)

Like many comparable cities outside of the metropolises, the model municipalities involved in SMO II also face the challenge of public transport to keep it financially viable over the long term and counter this with a clear long-term strategy automation and digitalization. To meet the expectations of the next generations regarding climate protection and to fulfil mobility, an efficient public transport system is essential. Especially the so-called last mile can are often not served for economic reasons. Automated shuttles as highly innovative solutions can help here because they can be used flexibly in terms of time and personnel the electric drive is quiet and locally emission-free. They should be part of a multimodal mobility chain become.

The first evaluations of the operation in Upper Franconia, but also the experiences from several stored shuttle projects at home and abroad show that the focus when it comes to automation is usually only aimed at getting from A to B, but less so at several rather crucial questions:

What really happens when the accompanying operator on board becomes dispensable? How can a company use automated minibuses are completely safe even in everyday use and, from the customer's perspective, low threshold be usable? Or: Does this also apply to people with limited mobility?

Accessibility and user communication were identified as central pains. Requirements for a smart, barrier-free access system were collected, kinematics concepts for barrier-free access assistance were developed and combined with virtual user tests checked. The SMO II project is intended to ensure product maturity for the user-centred and inclusive access and interior space should be promoted to achieve a real to bring accessibility into the field in the automated ecosystem, as it is in the current personal local transport is rarely available. There are none, especially regarding automated shuttle traffic possibilities of a makeshift manual solution for barrier-free access.

2.1.1.4 Drive2theFuture

The Drive2theFuture[1] (H2020, Contr. No. 815001) project aim was to prepare “drivers”, travellers and vehicle operators of the future, to accept and use connected, cooperative and automated transport modes and the industry of these technologies to understand and meet their needs and wants. Drive2theFuture developed training, HMI concepts, incentives policies and other cost efficient measures, in order to promote and then to comparatively assess, several alternative connected, shared and automated transport Use Cases for all transport modes and with all types of users (drivers, travellers, pilots, VRUs, fleet operators and other key stakeholders), so as to understand, simulate, regulate and optimize their sustainable market introduction; including societal awareness creation, acceptance enhancement and training on use.

Within this framework, inclusion and accessibility was taken into account in different stages of the work and under several concepts. To start, the project has extensively investigated user acceptance, through a detailed identification of user clusters and the realisation of a large-scale voice of customers survey, along with defining appropriate use cases. Moreover, behavioural models have been developed, addressing on one hand the interaction of the

[1] https://www.drive2thefuture.eu/

automated vehicle and its surrounding traffic and, on the other, the interaction of the vehicle with VRUs (e.g. pedestrian). Great focus has been placed on the HMI, with activities working on affective and persuasive HMI for AV, conspicuity enhancement of external HMI for interaction with other traffic participants, while rules for adaptability and personalisation of HMI were defined, along with the creation of an HMI development toolkit for AV, allowing for customisation of HMI. Numerous training activities, tools and material were developed and used within the project, aiming at different user groups, while a dedicated activity has investigated ethical, sociocultural and gender issues on AV, identifying current norms and status while also providing relevant recommendations.

The project has been concluded in October 2022 and public deliverables, including details on the above and many other topics, are available online[2] .

2.1.1.5 SHOW

The SHOW[3] (H2020, Contr. No. 875530) project aims to support the deployment of shared, connected and electrified automation in urban transport, to advance sustainable urban mobility. During the project, real-life urban demonstrations taking place in 20 cities across Europe will see the integration of fleets of automated vehicles in public transport, demand-responsive transport (DRT), Mobility a Service (MaaS) and Logistics as a Service (LaaS) schemes.

Among others, within SHOW there is an activity focused on user experience. In particular, specific add-on functionalities were developed in the framework of vehicle demonstrators' preparation for this purpose. These are described in SHOW D7.4 Final Demonstrators. They were aiming to enhancing both the passenger and the operator's user experience and improve safety and functionality of the vehicle and the provided service. These include (indicatively):

a) Blinkers management (by Navya), activating blinkers outside the vehicle before and after the stop (in pre-defined distance) indicating the arrival/departure of the bus.
b) Acoustic Vehicle Alert System - AVAS (by Navya), indicating the presence of an electric vehicle with an additional audio signal, for better perception of the road users in the surroundings of the vehicle.
c) Passenger HMI (by EasyMile), allowing 3rd party content in the in-vehicle HMI (passenger screen) to provide useful information to the passengers according to their preferences or area (e.g. flight departure information for airport shuttles).
d) Safety operator's station (by Transdev), allowing full (also manual, with steering wheel and pedals) control of the vehicle to the operator, for facilitating the transition period and allowing more advanced testing.
e) Door button positioning for wheelchair users (by Transdev), by lowering the door button position both inside and outside the vehicle, to be better accessible to all users.
f) In-vehicle comfort and well-being (by Transdev), by adapting the texture and colours of seats, integrating scent capsules in the ventilation system for enhancing the sense of well-being to the passengers and providing wi-fi access and in-vehicle enter/info-tainment options.

[2] https://www.drive2thefuture.eu/dissemination/public-deliverables/
[3] https://show-project.eu/

g) Passenger counter system (by Sensible 4), adhering to GDPR as being fully anonymous, functioning through a tablet operated by the safety driver. It counts both current vehicle occupation and total passenger counts of the day.
h) Emergency case phone (by Sensible 4), a VoIP phone system that can be used in case of emergency or customer service. The phone can call the Remote-Control Centre and the Remote Operator can also call the vehicle.

Moreover, relevant considerations are included in the definition of the Use Cases, the pilots' set up and the Impact Assessment framework. For instance, accessibility has been considered in all SHOW pilot sites through different Use Cases (see SHOW D1.2[4]), while in the pilots' set-up and impact assessment, accessibility and inclusion are employed both in terms of provided/tested service and as impact assessment criteria. Moreover, representatives of related user groups are involved as stakeholders in the impact assessment process (see SHOW D9.3[5]).

2.1.1.6 AWARE2ALL

AWARE2ALL[6] (HE, Contr. No. 101076868) is facing the challenge of future highly automated vehicles, where occupants can freely orient themselves to engage in non-driving activities. This new environment prompts questions about how car occupants will actually be seated, what activities they will engage in, and how they will be informed through the HMI to keep them in the loop if necessary.

Towards this aim, AWARE2ALL will develop safety and HMI systems that will be interrelated through achieving a holistic understanding of the scene to ensure safe operation of the Highly Automated Vehicles (HAV). It proposes a common conceptual universal safety framework for considering Human Machine Interaction (HMI). The project is built on the results of projects funded under H2020 and other R&D programs addressing the identification of new safety-critical situations and the most likely positions and postures considering the expected HAV applications.

The main objective of AWARE2ALL is to address the new safety challenges posed by the introduction of HAVs in mixed road traffic, through the development of inclusive and innovative safety (passive and active) and HMI (interior and exterior) systems that will consider the variety of population and will objectively demonstrate relevant improvements in mixed traffic safety.

As AWARE2ALL is an ongoing project, up to date relevant available deliverables[7] deal with accessibility and inclusion, through relevant personas and use cases, while these are also considered in the definition of the systems requirements.

[4] https://show-project.eu/wp-content/uploads/2021/04/SHOW-WP01-D-UIP-002-02_-_SHOW_D1.2_SHOW_Use_Cases_SUBMITTED.pdf
[5] https://show-project.eu/wp-content/uploads/2022/10/D9.3-Pilot-experimental-plans-KPIs-definition-impact-assessment-framework-for-final-demonstration-round.pdf
[6] https://aware2all.eu/
[7] https://aware2all.eu/resources/

2.1.1.7 MOVE2CCAM

Move2CCAM[8] is a European project which uses a cooperative and co-design methodology to generate use cases, scenarios, and KPIs for the application of cooperative, connected, and automated mobility (CCAM) solutions in passenger and freight transportation.

This project proposes a number of workshops with a diverse variety of participants under the co-design framework. From specialists, associations, social organizations, and citizens, who help identify new needs and difficulties related to the aforementioned topics. A wider range of perspectives and experiences are shared as a result of the multidisciplinary and diversity of backgrounds and nations of participants.

Throughout the co-design process, a number of initiatives were taken to promote inclusiveness and accessibility. A good example is the development of personas taking into account characteristics such as age, income, residence and even ownership of a vehicle or driver's license. A variety of personas facilitates the creation of use cases that match a greater range of profiles, and all of these characteristics have the potential to impact inclusion and accessibility within the public transportation network. A similar approach is used in the ULTIMO project, where in D2.1 Passenger and PTO requirements, needs and use cases chapter 5, several personas are presented as potential users of future on-demand services with automated vehicles.

Including associations and organizations that have worked with people who are considered vulnerable is another initiative. An example is the non-profit organization APA network[9], whose activities include combating the isolation of the elderly, they were present at one of the workshop sessions. The involvement of companies working in the field of transport of people with reduced mobility is also a significant contribution, since it allows to obtain inputs from their own experience in the field.

Some of the use cases proposed by the Move2CCAM project, and highly focused on inclusiveness and accessibility for all types of users are:

- AV Minibus for mobility-restricted users and disabled people: The objective is to propose a door-to-door service, available for any kind of travel purposes but focused on medium distances. The vehicle must have ample space for multiple wheelchairs, guaranteeing an effortless on/off boarding process, with up to 12 seats available.
- AV Pod for mobility-impaired passengers: The service proposes a surveillance system with features that allow users to travel safely without the need for assistance. The service should be constant, reliable and punctual, and its main public are users with restricted mobility, users under 12 years of age and residents of rural/urban areas.

Additional logistics-focused use cases are being developed up, such as the use of drones, which was mentioned as a way to assist in delivering goods to elderly individuals who are unable to move around.

[8] https://move2ccam.eu/

[9] https://www.reseau-apa.fr/qui-sommes-nous/

2.1.1.8 INDIMO

INDIMO is a three-year EU-funded Horizon 2020 project that aimed to extend the benefits of digitally interconnected transport systems to people that currently face barriers in using or accessing such solutions by improving the understanding of the users' needs. Through the co-design of the INDIMO Inclusive Digital Mobility Toolbox, the project results enable developers, policy makers and service operators to always include the user perspective when dealing with digital mobility and delivery solutions.

The INDIMO project had five pilot sites with different target groups and characteristics:

- Emilia Romagna "Introducing digital technology to enable e-commerce in rural areas" with user profiles older people and migrants/foreign people who receive/send parcels
- Antwerp "Inclusive traffic lights" with user profile vulnerable pedestrians, esp. PRMs
- Galilee "Informal ride sharing in ethnic towns" with user profile ethnic minority, language barrier
- Madrid "Cycle logistics platform for delivery" with user profile PRMs, socially isolated, not-connected (digitally), low income
- Berlin "On-demand ride sharing" with user profile caregivers, PRMs, lack of digital skills

Across all pilots, users have general needs:

- **Trust**, with the following aspects:
  - the service and app must come from a trustworthy and reputable organization
  - the service is used and/or recommended by their social network and contacts
  - the service is rated favourably by other users
  - the service informs them of how their information will be used in addition to any privacy risks
- **Safety**, esp. for transport in the evenings
- **Accessible** service and information, esp. fully accessible app and web site
- **Ease of use**:
  - Online tutorial or YouTube video to get familiar with the service
  - Assistance in their own language
  - Easy to use app that allows user to make mistakes and restart the process easily
  - Clear instructions/information
  - Transparent pricing
- **Convenience**
  - Pick up points close to their homes
  - Flexible on-demand services

2.1.1.9 DIGNITY

The DIGNITY project has been a three-year exploration of inclusive transport and digital mobility in Europe. The overarching goal of DIGNITY (DIGital traNsport In and for socieTY) is to foster a sustainable, integrated and user-friendly digital travel eco-system that improves accessibility and social inclusion. The idea is to support public and private mobility providers in conceiving mainstream digital products or services that are accessible to and usable by as many people as possible. The end result that DIGNITY is aiming for is an innovative decision support tool that can help local and regional decision-makers formulate digitally inclusive policies and strategies, and digital providers design more inclusive products and services.

DIGNITY worked directly with four regions/metropolitan areas (Barcelona, Flanders, Tilburg, Ancona), engaging with city and regional decision-makers. Each pilot targeted different user groups that might be vulnerable to exclusion:

- Barcelona (ES): Unemployed, low educated (particularly immigrants, women) and elderly.
- Ancona (IT): Visually impaired and blind people, disabled or people with reduced mobility, migrants and low-income users.
- Tilburg (NL): Elderly people in rural context and with low income in urban context
- Flanders (BE): Elderly people, low income groups having no access to a car and/or having no driving license, disabled people and/or people living in rural areas.

For the participants of their studies, opportunities and challenges were identified for each target group:

Elderly

Opportunities

- Have more time, travel outside peak hours, often for leisure and family.
- Usually no problem operating vending, check-in or payment machines (after learning phase).
- Able to ask for help (but need to feel comfortable doing so).
  Some elderly have good digital capabilities.

Challenges

- Often insecure about their digital abilities
- Don't trust the information they find because they don't trust their abilities to find information online.
- Use paper travel directions to always have the information at hand.
- Vulnerable to unexpected changes in travel directions.
- Lack of restroom facilities or shelter from harsh weather is a reason not to travel.
- Find it hard to process apps, websites and signs with much information.
- Sometimes completely dependent on their partner/family for help.
- Feel embarrassed when asking for help, besides their partners/family.
- Forgo a journey because it is too complex to figure out with public transportation.

Low Income

Opportunities

- Financial exclusion does not limit their digital skills.
- Check fare prizes beforehand to feel secure.

Challenges

- Smartphone dependent (often no access to a computer)
- Only travel when necessary
- Rely on discount tickets.
- Cash payment is preferred over digital payment.
- Depend on Wi-Fi for internet while traveling.
- Perceived unsafety of public transport can cause anxiety and fear (esp. women)

- Lack of confidence in the public transportation system due to unreliable travel times, punctuality or fear to miss the bus stop --> participants would stop travelling by bus if they had another option.
- Unsafe neighbourhoods, untrustworthy passengers, fear of robbery and wild animals are the main causes of unsafety.

Wheelchair-Bound

Opportunities

- Good digital capabilities.
- Digital tools help them to move around.

Challenges

- Bumpy pavement and poor infrastructure inaccessible bus stops)
- Rather use tram than bus (tram always takes the same route with the same stops)
- Reliability is extremely important.
- Often experience a combination of challenges, e.g. old age and low income
- Rather not travel alone.
  Feel like a second-class citizen or a burden to society.

Blind / Bad Eyesight

Opportunities

- Screen reader compatibility is a must for travel apps.
- Relay more on computers than smartphones due to readability
- Bigger fonts help visually impaired people.

Challenges

- Avoid travelling to new locations if possible.
- Depend on family members when travelling to new locations.
- Unhelpful bus drivers are problematic for visually impaired users who depend on them for information provision.
- Not all websites and smartphones are screen reader compatible.
  Fonts are often too small.

Deaf

Challenges

- Invisible disabilities make people less compassionate and helpful.

Illiterate

Challenges

- Illiterate people cannot read signs, information boards, websites or apps.
  Ask several people for directions because they do not trust one answer.

Women

Opportunities

Develop tactics to feel safer, like take the car, travel in groups, leave early, choose streets with good lighting.

Challenges

- All participants limited by safety are women: 69% of the women feel limited due to safety when travelling. 35% feel very limited due to safety.
- Rather travel during the day.
- Female participants in Barcelona feel less safe than female participants in Tilburg, Flanders and Ancona
- Car drivers feel safer, but not everyone can afford it, making women's safety a social, economic problem.

What all target groups have in common

Opportunities

- Feel less embarrassed to ask family members for help.
- Make it very explicit that service is there to help them.
  Discount cards are effective.

Challenges

- Little to no trouble paying with cards and recharging them.
- People hate feeling embarrassed for their inability.
- People downplay their problems, especially elderly.
- Bus is perceived as transport for the poor.
- All plan new trips upfront at home.
- Often struggle with understanding the boards and signs during the trip.
- Elderly with low digital capabilities are more likely to use their phones than computers.
- Shared mobility is hardly used and cannot be seen as a solution as those who feel most excluded are the least likely to use it.

2.1.2 Personas

While individual personas have already been addressed in D2.1, this section will take a general look at the benefits and challenges of automated public transport for people with special needs.

Automated public transport can improve the life of those that have to rely on public transport, due to their inability to drive a car, ride a bike or a scooter. AVENUE surveys[10] have shown that the acceptance of automated public transport increases with the distance to the nearest public transport and with less frequent timetables. Interviewees mentioned that accessible automated vehicles would give them the possibility of moving into the countryside, where live is more silent and cheaper than in the city. Automated public transport could give this group of people a new kind of mobility, and with it a level of freedom and self-determination that was previously impossible. Automated vehicles are therefore an opportunity to improve the quality of life, particularly for people with disabilities.

However, there is also a high risk of being left behind.

Nowadays the bus drivers give assistance to persons that need help. A blind person, for example needs help by identifying the correct bus number, or to find and open the door. Wheelchair users need help to board the vehicle if there is no automatic ramp available. These are just two examples of many services currently provided by the driver.

It is therefore understandable that there is a general fear that automated vehicles are just a means of getting rid of the driver and that services that are currently provided by the driver will no longer be available. Ultimately, this would mean a loss of mobility for many people.

To provide an accessible automated public transport all these services must be provided by the system itself (possibly with the help of smartphones). In addition, it must be ensured, that at least the usual services in regular public transport are also implemented in automated buses. This includes simple and self-evident services such as a passenger information system providing the two-channel principle (announcements and displays). Which is sadly currently not available in actual automated vehicles.

2.1.3 Interviews and onsite visits

2.1.3.1 Interviews in Soest (Jan 23)

The LWL Berufskolleg in Soest is an educational centre for the blind and visually impaired. The Siemens Accessibility Competence Center conducted a workshop at the Soest campus on January 10th, 2023, with 13 students. The workshop started with a short presentation of the ULTIMO project. After this there were stations where participants could try out several apps and discuss challenges and requirements regarding mobility and public transport. In parallel, individual interviews were conducted with the students about the use of public transport in general, and driverless public transport.

[10] H2020 AVENUE D2.4 First Passenger needs analysis and specifications

Demographic data

The students are between 16 and 22 years old. Eleven of them are male, two female.

All students are blind or visually impaired, five of them can read braille and do so on a daily basis. Four of them consider braille as their most important access to text. One participant uses mainly text to speech, which is also an important access for the braille users, esp. for longer texts.

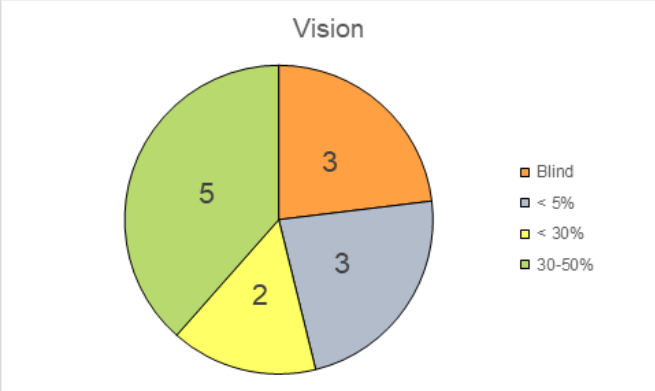

Figure 1: Vision with best possible correction

All participants have normal hearing. However, two students report problems with focusing or filtering out background noise, one has problems with orientation.

Use of public transport

All interview partners use public transport. They all use the train. However, many state that they avoid using the bus because the bus is very unreliable in their town. Only two students use public transport daily. Many commute on the weekend between boarding school and home. Some use public transport to go shopping or meet friends.

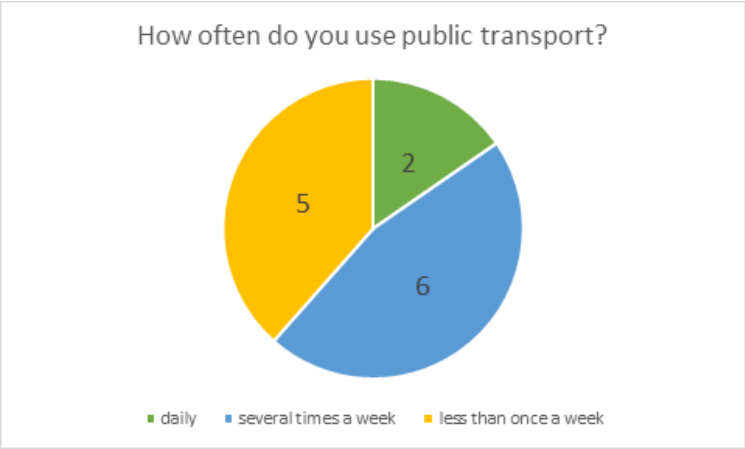

Figure 2: How often do you use public transport?

Three interview partners report that they have ever got off at the wrong stop or got on in the wrong direction. The reasons are lack of attention, missing announcements/display of the stops and travelling in an unfamiliar area.

Only one of the students usually take public transport being unaccompanied. Six say they sometimes contact the driver e.g., for buying a ticket, getting the correct bus route or stop confirmed, mainly in unfamiliar areas or bus routes.

When asked what they take along when using public transport, the mobile phone is mentioned by most interviewees. It can be assumed that they all have it with them. As many of our interview partners commute on the weekend, backpacks, bags and suitcases are also often brought up. Three students travel with a white cane, one with a guide dog.

The way to the bus stop

The distance to the nearest bus stop is no more than 500m for all interviewed students. For six of them, it is even less than 250m. Most require about 5 minutes to get to the stop, three of them less than a minute. For one student, it takes 10 minutes to get to the nearest stop.

Nine interviewees locate new, unfamiliar bus stops on their own. All three blind students and one with a severe visual impairment always have an assistant with them in such a situation. The mobile phone proves very helpful for this task: students use navigation with google maps or take a photo of the display panel at the bus stop, then enlarge it to check if it is the correct station. To be on the safe side, they ask the driver if the bus really goes to the desired destination.

Five interview partners report dangers or problems on their way to the bus stop:

- Icy roads
- Darkness in winter
- A particular problematic road crossing
- Glaring sunshine (blinds the eyes)
- No designated path for pedestrians, I have to walk along the road
- A specific traffic light where cars often run the red light
- Unclear and complex situation after a traffic accident: cars parked on in the bus stop, on the pedestrian path, etc.

There are also dangers at the bus stop itself: Crossing the road at a bus stop is considered difficult and potentially dangerous. Baggage standing in the way is a tripping hazard. The situation when there are several busses at the same stop at the same time is chaotic. In this complex situation it can happen that one accidentally enters the wrong bus. “It was at the correct time, at the correct stop, but nevertheless the wrong bus. I didn't notice it until the announcement on the bus.”

In the bus

Most interviewees prefer to sit in the bus rather than stand, especially during longer trips. It’s also considered safer when the bus breaks. When seats are not clean or it is very tight, then some prefer to stand (“I like to keep my distance”), at least for short bus rides. When with a guide dog, it is best to have a seat, because this means less stress for the dog.

When asked about dangerous situations on the bus, the most frequently mentioned was the driver's full braking. Another potential hazard is when bus and bus stops are crowded, and people are pushing.

After the bus ride

The distance from the bus stop to the (typical) destination is in most cases about 500m. It takes the interview partners between five and ten minutes to walk. One student has to walk about a kilometre, which takes more than 15 minutes. Three have less than 100m to their destination which they reach in one to five minutes.

The bus stops

Six interview partners report that they have bus stops with loudspeakers for announcements. However, they don't seem to work reliably. So, it is not surprising that most students don't rely on them or don't miss them when they are not there.

Eight students have electronic information panels at their bus stops. Some like them very much, some rather use the app of the PTO. For the blind students they are simply not accessible. Visually impaired users can take a photo with the camera and zoom in to see the content.

Use of smart phone for public transport

As already mentioned, the camera of the smartphone (together with zoom) is a valuable tool for some of the students. The phone is also used in other contexts:

In Germany, severely disabled persons do not need a ticket for local public transport. However, six of the 13 interviewees use a PT ticket app on their phone (mainly for the trains). Nearly all of them use their smart phone to plan their trip with public transport, only three don't. The information they look up are:

- Delays, cancellations
- Transfer options, transfer times, change of platforms
- Available bus routes/lines and train connections
- Departure times, arrival times
- Exact location of bus stop (esp. at bus terminals)
- Current location (where is the bus I am in) – because announcements are sometimes delayed

Additional information and functionality they wish to have:

- *One* app for all means of transport: trains as well as for local busses
- Booking of assistance for transfers integrated in the app
- Information: is the bus (the specific vehicle) accessible/barrier-free? How many seats are in the vehicle, how many are free?
- Zoomability of all information
- Clear display and arrangement of all information
- Information about train station buildings and terminals, exact location of station/terminal
- Real real-time information
- Clearly audible announcements

Using a smartphone at the bus stop or in the bus is no problem for most students. Some do not use their phones during the bus ride or use it with one hand only in order to have one

hand free to hold on. Sometimes it is required to place the bags/luggage on the ground to use the phone.

Driverless public transport

The city of Soest had a driverless automated e-minibus running from the school to the city centre/train station (https://ride4all.nrw/sofia) with a focus on inclusiveness and accessibility. At the time of the interviews, the project had already been finished.

All but one of the students have heard of the shuttle, many have seen it, but only two have ever tried it. The main reason for this is probably that the operating hours and the frequency of service were such that the service was not usable for the students e.g., it started at eight in the morning – right when school starts. Students also state that the route was not attractive/not what was needed and that the bus was not very reliable ("It said that it should be running but there was a supervisor who told everyone that it is actually not running"). Five students say they were interested in going but were discouraged by the speed of the vehicle ("I am faster walking"). One interview partner feels that with so few seats and other people who were not so good on their feet, it would be wrong to take the bus himself and take away the seat of someone who needs it more urgently.

The two students who took the bus give generally a positive feedback ("a new experience"). However, they complain about the braking and consider the slow speed a major obstacle ("Cyclists are faster, if you're good on foot you'll arrive faster walking!"). If the bus doesn't go faster, it is not considered helpful.

Generally, all but one student could imagine taking a bus like this. That one person does not yet have enough confidence in these vehicles to use them ("in the distant future, sure"). In addition, they are considered too slow to be really useful.

Many of the others who say they would use the bus add that they have some safety and security concerns ("What if it couldn't break?") Some would only ride with the automated vehicle with another person, like a friend or an assistant.

Remarkably, the absence of a supervisor in the bus doesn't seem to be an obstacle. Only two students (both blind) answer with a strict NO to the question if they would use the driverless bus with no supervisor on board. The other interview partners are more adventurous. However, this is subject to the condition that the shuttle has proven to be safe, secure and reliable.

While the low speed was mentioned as an obstacle so far, now it is considered an advantage: "Not much can happen if the vehicle is not travelling faster than 15-30 km/h."

The students have many wishes and requirements for a driverless shuttle:

- Most important: punctuality and reliability
- High frequency of service and coordinated with trains and other means of public transport
- Accessibility (incl. access for wheelchairs, ground-level access, seats with shade so passengers are not blinded by the sun)
- Information: complete and reliable; announcements as well as via app

- What is happening right now (e.g. someone is boarding, bus is doing a regular stop vs. unscheduled stop, doors are open, …)
- Where is the bus right now?
- Is the bus coming or not, when will it arrive at my position?
- Safety and Security, help in case of an emergency
- Free/low price tickets, tickets shall be included in regular PT tickets
- Higher velocity
- Creature comforts like heating in winter, more legroom, Wi-Fi in board, etc.

Door-to-door service

The interview participants see a lot of advantages in a door-to-door service ("sometimes you don't feel like walking to the bus stop, worst of all when it's raining or in winter"), esp. at night, in the countryside, wherever bus stops are too far away, in the wintertime or generally in bad weather. However, for them door-to-door also means losing the familiar bus stops, the known route to the destination, etc. The first and last "few steps" to the bus and to the destination could be different with every trip so the app must plan these paths as well as the bus trip.

In addition to the "usual" requirements like punctuality, reliability and safety, the visually impaired students have special needs as they rely on complete and correct information that is accessible to them. This information should be communicated to them via an accessible app as well as via announcements.

Finding and identifying "my bus"

In order to get safely into the correct bus, the vehicle has to identify itself and guide the passenger to it.

The vehicle needs to have a distinct identifier which it communicates to the passenger. In today's public transport this would be line and destination of the bus. In a future with door-to-door and on-demand services this could be an individual number or designation that is both displayed on the outside of the vehicle and referenced in the app. To avoid any mix-ups, the designations should be easy to distinguish from each other (not "6473" and "6743").

The vehicle has to announce its arrival acoustically as well as in the app and guide the passenger to its doors.

After the bus ride: Finding the way to the destination

With door-to-door services, the route from the drop off point to the destination is not always the same. Visually impaired passengers need assistance to safely find the way to their destination. The app should guide the passenger with navigation instruction e.g., "in direction of travel 80m straight ahead". Acoustical instructions are helpful for users with severe visual impairments while a map is beneficial to anyone with sufficient eyesight. The system should indicate if there are any potentially dangerous situations like a road crossing, a construction site etc.

Summary

The students of the Soest educational centre express concerns and requirements for public transport that are very similar to the results of interviews and surveys conducted in previous projects. As they are visually impaired, they depend on the general accessibility of the service, accurate information and in some cases support as compensation for the absent driver.

With these additions, they can benefit from automated vehicles in public transport. However, they are only willing to use a driverless service if they consider it safe and if it brings them a real benefit ("speed"). A door-to-door service is considered useful, especially in difficult situations such as at night or when there is snow on the roads. However, this option is also seen as problematic if door-to-door means that passengers regularly have to get off at different points in front of their destination and find a new route each time, even if these are very short distances.

2.1.3.2 On-site visit Monheim (Sept 23)

Since 2020, Germany's first automated shuttle fleet acts as a regular public transport service in Monheim, a small city in North Rhine Westphalia. The electric shuttles operate in the central area of Monheim, in the old town, where common public transport is by default not allowed. Every 15 minutes, the shuttles transport up to 12 persons in the narrow streets of the old town. Professional safety operators supervises the shuttles and offer assistance, if required. More info about the project can be found here: https://www.bahnen-monheim.de/autonomer-bus/kurzportrait-der-altstadtstromer. The manufacturer EasyMile provides the fleet of 5 vehicles which consists of two different model series. Using the automated shuttle service is completely free of charge for all people of Monheim.

At the end of September 2023, Siemens performed an on-site visit in Monheim. A group of 3 persons explored Monheim's transport service in terms of accessibility. In particular, two visually impaired persons took the opportunity to ride an electric AV for the first time. It was interesting to see that the shuttle offer was very well accepted by the residents. Other passengers, with and without impairments, were also observed during the bus rides.

General preparation

All participants prepared themselves to be able to use the automated vehicles completely on their own.

Visiting the above mentioned project page, the first difficulties occurred when trying to download an accessible information about arrival and departure times. An accessible PDF/UA version of the time tables was not provided. Moreover, the line map exists only as graphical version, a Screen Reader friendly list view was not supported.

Concrete information on how to find the exact departure position at the bus station or precise navigation instructions to the corresponding address were also missing.

At the main bus station

Arriving at the bus station, it was difficult for all persons, not only for the visually impaired, to find the correct departure stop for the automated shuttles. Neither tactile ground markings

nor other visual ground indicators could be discovered. The main bus stop was not equipped with loudspeakers, a passenger information system was not installed. Service staff for asking was not available. Later on the bus ride, although several bus stops were equipped with ground markings, the AV never stopped at the marked pick-up position.

Figure 3: Bus stop no tactile ground markings

Information about the automated shuttles

A real minus point is that EasyMile shuttle series do not support AVAS. Moreover, annoyed by the internal loudspeaker announcements, the safety operators had deactivated all other signal and alert sounds coming from inside the AVs. So, neither internal nor external announcements were available for passenger information. This situation made it impossible for visually impaired passengers to perceive arrivals or departures

Making the safety operators aware of this critical problem, they immediately switched back on all AV sounds.

Nevertheless, it remains difficult for blind passengers to perceive arrivals of shuttles, the noise level at the bus station is too high. This noise is caused by the arrivals and departures of conventional busses. And the only available internal loudspeakers of the shuttles are not sufficient to solve this issue.

Eye contact or hand signals between passengers and safety operators are difficult to perform due to the tinted vehicle windows. This lack of visible feedback makes many passengers feel unsafe.

Figure 4: View inside the shuttle from entry

Only one of the shuttle series is operable by visually impaired and wheelchair passengers without problems. The corresponding AVs are equipped with mechanical, tactile buttons to perform door, ramp or emergency requests. Outside, on the door, is one easy to find button for entry. And the ramp button is positioned in a way that there is sufficient space between the wheelchair user and the extending ramp.

Figure 5: Mechanical Control Buttons Grey Customer Service Green Door Blue Ramp

Figure 6: Mechanical Control Buttons Detail view

The other series is equipped with sensor buttons. Visually impaired cannot successfully interact those kind of buttons. This user group relies on haptic exploration of surfaces and exactly this haptic feedback leads to unintentional triggering. Moreover, the placement of the external ramp buttons is not optimal, neither for wheelchair users nor for passengers with wheeled walking frames or prams. To avoid dangerous situations, only the safety operators are allowed to control the fast extending ramps for both series.

Figure 7: Model with Sensor Control buttons

Figure 8: Sensor Control Buttons inside

Waiting at the bus stop, visually impaired passengers cannot distinct between the different arriving model series. But the important information about the vehicle type is not available in the time tables.

The lack of this information caused three dangerous situations which could quickly be resolved by the safety operator. In all situations, a ramp request was unintentionally triggered by a visually impaired passenger who tried to open the door.

Considering the distance between AV and curb at the bus stop, a boarding gap announcement should be provided by loudspeaker.

Wheelchair users cannot leave the vehicles via ramp at all stops. Some bus stops do not provide the required curb height for ramp usage.

Figure 9: AV with Ramp (left) and passenger with rollator uses ramp (right)

The height of the entrance level is for both model series 0.37 meter. Most passengers, not only elderly or children, prefer lower levels for safe entry. The entrance height in combination with the gap represent a potential source of risk, as a Siemens colleague found

out by himself when getting off.

Figure 10: High Entry level

Six seats with seat-belts, three in driving direction and three in the opposite, are available for use. Inside the shuttle, one long side is equipped with a backrest for standing passengers. Priority seats for PRMs are missing. Grips and handles were available, the interior illumination and colour indication of control buttons seems to be sufficient for most PRMs. Blind passengers should be provided with a detailed description of the shuttle interior to ease orientation. A special training for this user group is recommended.

Figure 11: Row with 3 seats at back side

Figure 12: One of four handles at window side and Top level handles for standing passengers

Figure 13: Backrest for standing passengers opposite of entry

In front of the seating rows are two extra spaces for wheelchair users. Integrated floor mounts allow the fixating of Wheelchairs with safety belts for the transportation in the opposite direction of driving. Securing the wheelchairs required the assistance of safety operators. Rollators or prams cannot be fixated. Two „Emergency“ buttons are within the reach of the wheelchair spaces, at least for adult wheelchair users. But, ramp and door control buttons are out of reach.

Figure 14: Fixation of wheelchairs in front of seat row (left) and fixation at the floor (right).

Storage space is available behind both seating rows, in head level height. Only smaller luggage items can be carried here. A special fixation is not supported, the packing height is unsuitable for most children or elderly.

Figure 15: Storage space at head level of seat rows

Two external displays, mounted at the front and back of the vehicle, provided the line and direction information on the arriving AV. The placement, colours, contrasts and display sizes seemed to be comfortable for most passengers. But, QR codes or Bluetooth beacons, which ease the vehicle identification in particular for visually impaired passengers, were missing.

Figure 16: Busline number at front

During the bus ride

After getting an introduction on the bus interior, the visually impaired passengers were able to find a place in the empty AV on their own. Providing priority seats would ease the orientation for this passenger group.

Many elderly with rollators used the automated shuttle to overcome short distances, sometimes just to get from one stop to the next. For this reason, the safety operators often had to provide assistance at stops where the entrance level did not allow the use of the ramp.

The maximum AV speed was approx. 20 kilometre per hour. During the ride, braking can occur very abruptly and may cause dangerous situations. In particular, when passengers cannot fixate their rollators, prams or large luggage items. Nevertheless, some passengers tried to ignore these potential risks and only fastened their seat belts after receiving a friendly hint from the safety operator.

Figure 17: Supervisor camera with street view

A large passenger info display at eye level provided the list of stops on the course. Additionally, the next stop was announced by an internal loudspeaker. The estimated arrival time was not available, neither for the next nor for the destination stop.

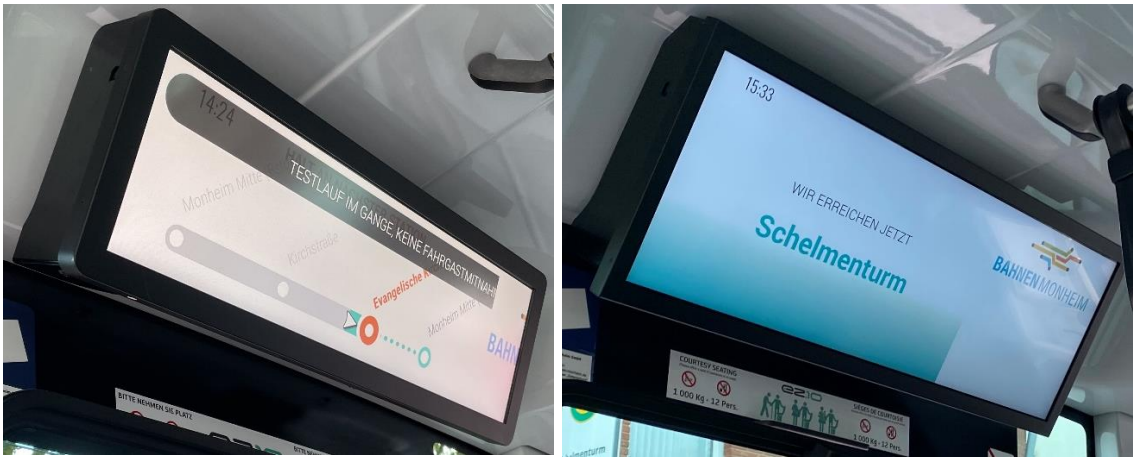

Figure 18: Passenger Info Display

On one bus ride, an unexpected hard braking triggered a loud warning signal inside. A quick look outside revealed the reason: A properly installed bike stand at the side of the road had caused the AV to brake. It took at least about 2 minutes to proceed with the bus ride. During this time, passengers did not receive any additional information. Although a warning signal indicated a dangerous situation, no further instructions on how to behave were provided. This handling is very confusing, especially for visually impaired.

The use of the ramp also revealed problems in terms of safety. It turned out that the ramp could be retracted despite active use and that persons on the ramp were simply ignored in this case. But, being aware of this issue, only the safety operators were authorised to control the ramp.

Control buttons to trigger actions, like e.g. to activate „Halt requests“, should be in reach of every seat which is currently not the case.

The AV should provide information about the ramp support for the next as well as for the destination stop.

Summary

There is a lot of room for improvements in terms of accessibility:

- the presentation of online information should be at least WCAG Level AA compliant
- the same yields for downloadable information
- a better indication of pick-up positions at bus stops
- detailed information about stops like e.g. ramp support, loudspeakers available, estimated arrival times, …
- an easier AV identification by providing acoustic signals, spoken announcements and other (visual) indicators
- accessible control buttons in- and outside the shuttle
- provision of priority seats
- Optimisation of passenger care
- Additional announcements on potential accidental risks for passengers like e.g. boarding gaps, hard braking or missing luggage fixation

For most PRM it is currently difficult to overcome the above problems without assistance. Even the well-trained and friendly safety operators sometimes reach their limits in case of special care requests. The next service level, completely driverless public transport, is not yet feasible under the current conditions.

2.1.3.3 On-site visit Kelheim (Oct 23)

On October 26, 2023, we tested the automated shuttle buses of the KEXI project in the district of Kelheim as part of the UX research for the ULTIMO project. KEXI combines conventional on-demand buses with automated vehicles to offer a flexible, on-demand mobility service.

The aim was to investigate user-friendliness for people with different needs. To do this, we invited participants to test the service with us. One person in a wheelchair and four people with visual impairments took part in the tests.

AV of the KEXI project parked in Kelheim, side view.

Figure 19: Automated vehicle in Kelheim, Germany (not in service at that time)

Service and booking

To reach the town centre of Kelheim, we use the conventional on-demand KEXI buses and book them (approx. 15 minutes in advance) via the KEXI app.

- KEXI app is not very user-friendly
- Problems with the recognition of the “Deutschlandticket” (lit. 'Germany ticket', is a subscription public transport ticket for all local public transport in Germany ticket): booking for two people and adding two "Deutschlandtickets” leads to double payment (two pax with D-Ticket and two pax who have to pay)
- Denial of transport service when refusing to pay the extra fee for passengers that do not exist (booking for four pax is in the system and can’t be corrected)

The automated vehicles are booked a week in advance by telephone.

- Not possible to explicitly book an automated vehicle via the app -> Booking by phone required with long waiting times on the phone
- Bookings of two different groups for the same day are mixed up (are interpreted as the same group): only the shuttles for one of the bookings arrive
- The automatic vehicles only run at the times we have booked. It is not possible to use them earlier in the day (one of the vehicles carries out test drives, the other is not in use)

Figure 20: Automated vehicles in Kelheim, Germany (during test drives)

Identify stop and waiting

We try to identify the stop via the app and wait at a wrong stop at the intersection opposite the right one.

- Accuracy of showing the stop in the app not sufficient
- Subtle stop labelling in reality
- Confusion of stops for conventional and automated shuttles
- Correct stop cannot be identified by blind or sighted people
- No shelter available at the stop -> no protection from the weather

Feedback and suggestions for improvement:

- Clearly perceivable visual indication of bus stop
- Clear, acoustically recognizable stop information for blind people
- Small transmitters at stops and vehicles could be useful
- Floor with grooved floor, stops with shelters, slatted floor
- App accuracy and navigation should be improved

Figure 21: PUDO indicator (a small blue sign, half hidden behind a tree) - finally detected but it indicates the stop of the conventional on-demand service

Identify vehicle and open door

Two different groups of people are waiting for a shuttle. We can identify the automated shuttles as our booking only by asking the security driver.

- No possibility to match booking and vehicle: It is not possible to see which booking an arriving vehicle refers.
- Vehicle unrecognisable for blind users: in a normal traffic situation, the electric shuttle is barely audible.
- Door opener cannot be found by blind people.

Feedback and suggestions for improvement:

- Confirmation that the correct bus is being boarded
- Bus identification and acoustically recognizable information on the vehicle and/or via the app
- Acoustic information that makes the door recognizable

Boarding and disembarking

For space reasons, the person in the wheelchair is first pushed onto the bus by the safety operator after the ramp has been extended. The bus stop is located on a level street without a sidewalk. When the ramp is extended, the door opens slightly, and the vehicle lowers.

- Noise present when extending the ramp.
- Quiet signal when boarding
- No further announcements when boarding.
- Lack of handrails next to the door for safe boarding and deboarding
- Deep step perceived as problematic when boarding and alighting without a sidewalk.
- Ramp as a better alternative to the deep step, but perceived as too slow.
- Ramp is too steep: Boarding via the ramp for wheelchair users only possible with assistance.
- Unclear why the vehicle only lowers when the ramp is extended and not when getting in and out without a ramp.

Feedback and suggestions for improvement:

- Further information and announcements when entering and when ramp is extending is desired.
- Vehicle should stop so that the ramp rests on the kerb to reduce the steepness/gradient; if this is not possible, lower the vehicle when boarding and alighting.
- Suggestion: combination of step and ramp, similar to regional trains

Figure 22: Extended ramp at a bus stop with sidewalk

Figure 23: Extended ramp at a bus stop without sidewalk (much steeper!)

Finding a seat

- No problem for blind passengers due to the small vehicle, they use a cane to find a seat
- Person in wheelchair is placed by the safety driver; incorrectly in the direction of travel

Buckling up

- Passengers are reminded to fasten their seatbelts
- The safety operators secure the wheelchair in the shuttle with several straps. Unfortunately, they do not secure the person in the wheelchair

Feedback and suggestions for improvement:

- Regular training for safety drivers to ensure the safety of users
- Photo of person in wheelchair incorrectly placed in the direction of travel is secured by the safety driver

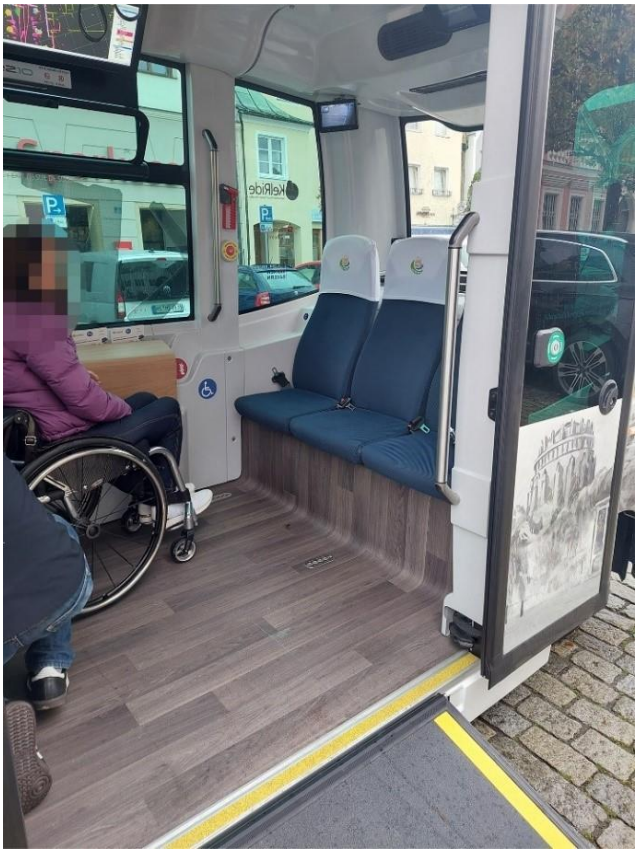

Figure 24: Wheelchair in the shuttle (in direction of travel)

Observations during the journey

- Safety operator shows high concentration and appears stressed, wants to avoid being an obstacle in traffic
- Efforts by the safety operator to anticipate and prevent incidents (in particular heavy braking of the shuttle due to overtaking vehicles)
- Constant jerky driving of the bus is perceived as very unpleasant
- Mixed opinions from optimal to poor about the available opportunities to hold on
  Lack of opportunities for wheelchair users to hold on

Information on the bus

- Lack of acoustic signals or announcements on the bus: failure to fulfil the 2-senses principle
- Need for acoustic signal for stops and current location; no acoustic announcements at all (except by the safety driver)
- Information on demand, screen switched on later
- Pointless screen without voice output for blind users
- Screen not helpful for sighted people either, as coordinates are displayed instead of stops

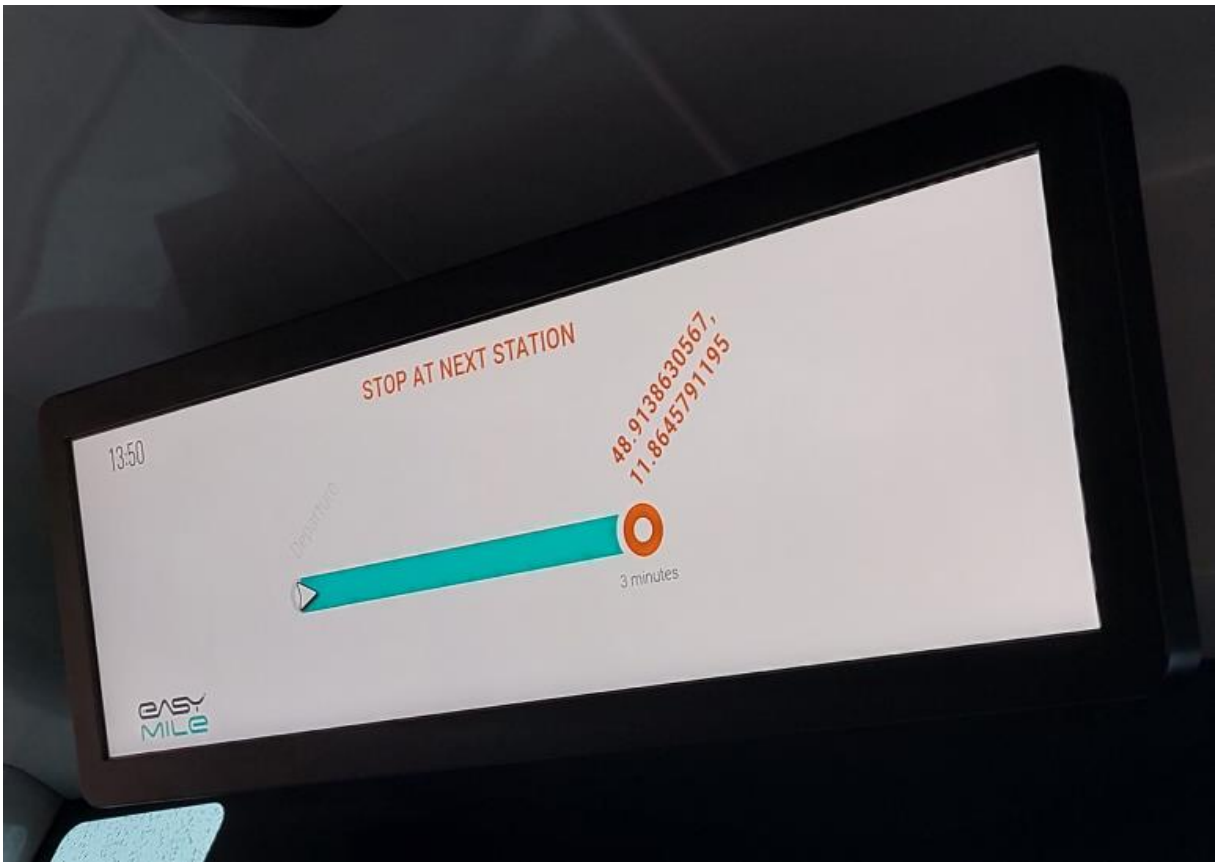

Figure 25: Screen content not helpful "Next station 48.9138630567, 11.8645791195"

Figure 26: Useless Screen

Figure 27: Useless Screen

Malfunction while driving

- Automated shuttle had malfunction and breakdown and would not restart
- Long waiting times (30min+) with open doors --> cold in the bus
- Curious message on screen in the shuttle "please stay inside"

Figure 28: Curious Message

Feedback and suggestions for improvement:

- Clear announcements and information system on the bus
- Urgent need for information at all stops
- Clear announcements in the event of unforeseen incidents

Braille lettering on control buttons

Figure 29: Hardware buttons with Braille lettering

- Braille lettering available, Braille dots clear
- Hardware buttons clearly tactile
- Braille dots clear, but text difficult to read.
- Not every blind user in the shuttle can decipher the labelling, the time required to read the labelling is high - would take too much time in case of emergency
- Problems are: Labelling in English (not expected) and two letters on top of each other, see below:

C A L L	D O O R	R A M P

- Three buttons arranged one above the other, all the same (same size, same type). Differentiation only possible with Braille skills

Feedback and suggestions for improvement:

- Need for high-contrast buttons, as they are different on every bus
- Improvement of Braille lettering so that it is easier to read

Feedback summary

- More user-friendly booking app
- Better identification of stops, also through acoustic signals
- Acoustically recognizable door openers
- Improved boarding and alighting facilities (for wheelchair users)
- Clear announcements and information system on the bus

- Urgent need for information at all stops
- Guidance system in the floor leading to the door
- Continuous training for drivers and security staff
- Extension of the operating radius and higher driving speed
- Clear announcements in the event of unforeseen incidents
- Improved Braille lettering and contrast on control buttons
- More options for holding on while driving
- Outside announcements and more detailed navigation via app
- Indoor announcements about stops and route

Future use

Users' opinions on the future use of the automated shuttle buses are mixed. There are concerns regarding use without a safety driver. Some users expressed uncertainty or a lack of trust in the technology. A larger operating radius, higher driving speed and improved driving style would have a positive impact on the frequency of use.

In summary, the study shows that there is still a considerable need for development in both the technology and the user experience of AVs until user confidence can be gained and the vehicles represent a real alternative in public transport.

2.1.3.4 On-site visit Frankfurt Riederwald (Oct 23)

The EASY+ pilot area Frankfurt Riedewald is located in a residential area between a subway station and a small shopping centre. There is also a retirement home in the neighbourhood. As in a typical inner-city residential area, the streets are relatively narrow and are blocked on the sides by parked cars. The test route is approximately 2.7 kilometres long and the vehicle used is an EasyMile EZ 10 Gen3. There are also NAVYA shuttles which were not on the road that day.

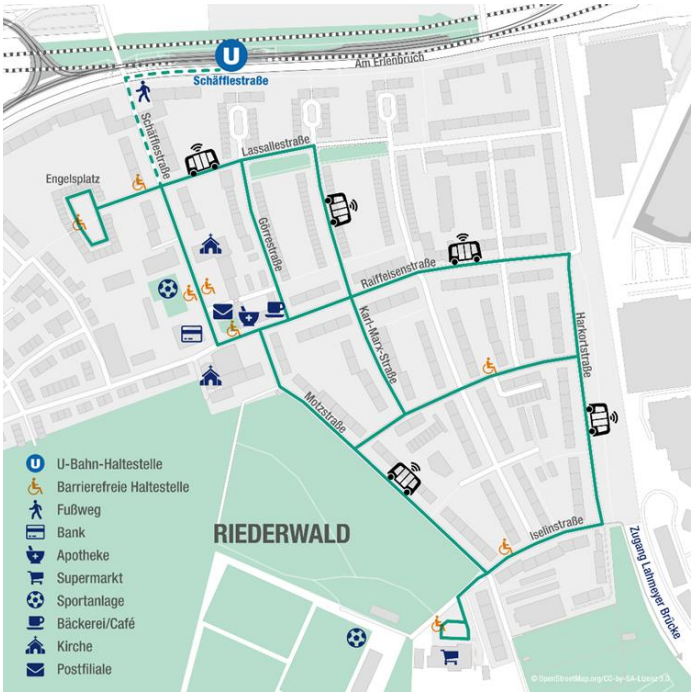

Figure 30: Map of the Pilot Site

The bus stops (PUDOs) in the pilot area are marked by coloured round "stickers" on the ground, about 30 cm in diameter. The position of these stickers varies: sometimes they are at the front edge of the kerb and sometimes in the middle of the pavement.

Figure 31: Two PUDOS

Some of the stickers are a little worn or "crumpled" at the edges.

Figure 32: Crumpled Sticker for PUDO

To be able to use the service, one needs to register and download the Easy+ app on either an Android or iOS device. A journey can be booked using the app, with the option to select the current location from which to start. The app will then show the nearest stop (Schäfflestrasse 20) on the map (see Image below).

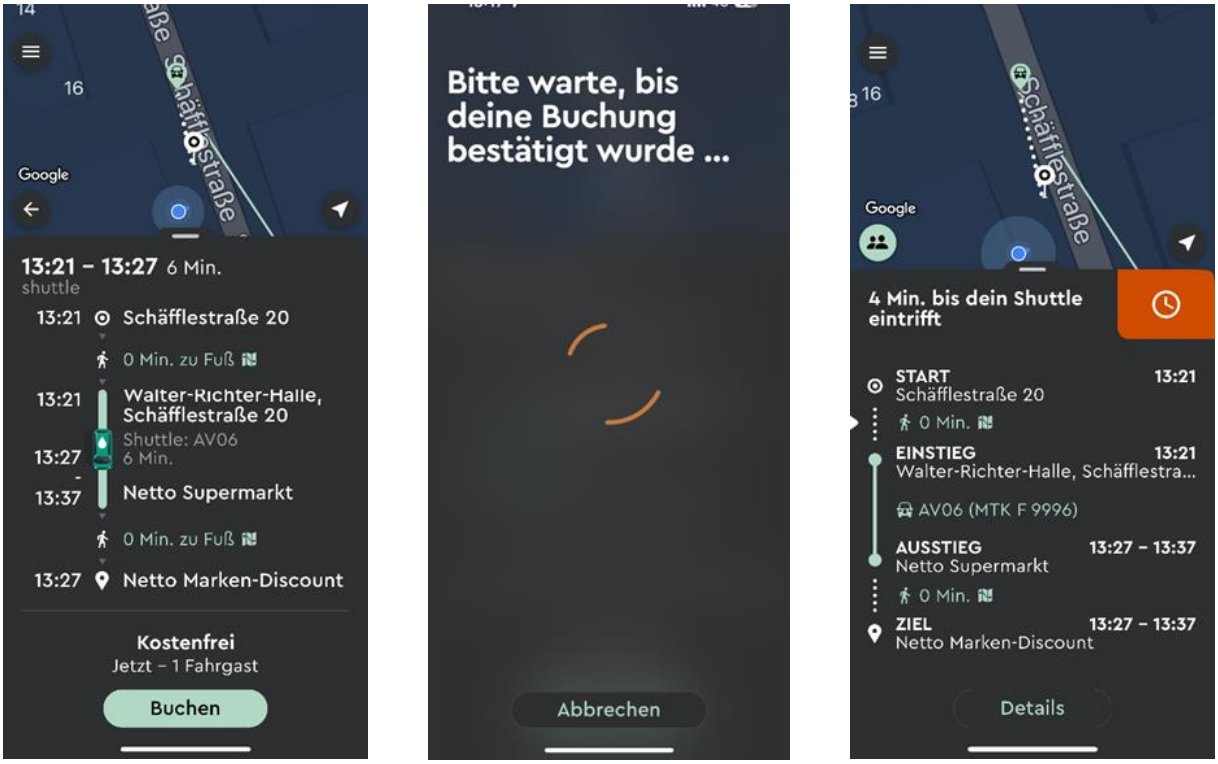

Figure 33: Screenshots of a booking process in the APP

The screenshots above show the booking process and the confirmation that the shuttle will arrive in 4 min. On a positive note, the app provides many messages in the header that accompany the entire process after booking: Your vehicle will arrive soon - It's here now, please board - You will arrive soon, don't forget your belongings - After the trip: Thank you and please leave a review. However, the app does not indicate the status of the service.

Using the app, we were able to book a trip from our current location to the shopping centre even though the vehicle was out of service. We received a message that the bus would arrive in 4 minutes, and after 3 minutes we received a cancellation of our booking without any information as to why this had happened. The funny thing was that we were able to book it again and again.

In the end, we successfully booked a trip. The safety operators on board reported that not many people use this service. However, there is a retirement home in the area and some of its residents occasionally use the shuttle to get to the supermarket. Without this service, they wouldn't be able to get there on their own. So this service significantly extends their radius of action.

The Neighbours, however, hate the shuttle, especially in the evening when they come home from work by car and want to get home quickly and not crawl along behind a slow shuttle. There are often tight overtaking manoeuvres. Once a cyclist overtook the shuttle, pulled in just before it and provoked an emergency stop, which he then acknowledged with a gesture of victory.

The safety operators warn passengers in advance of heavy braking (they can predict when and where this will happen). They also help passengers to board when they have difficulty with the high boarding height.

2.2 PRM'S needs and use cases

The following sections are derived from the results of the 2.1.1 and from the findings of the interviews and on-site visits 2.1.3.

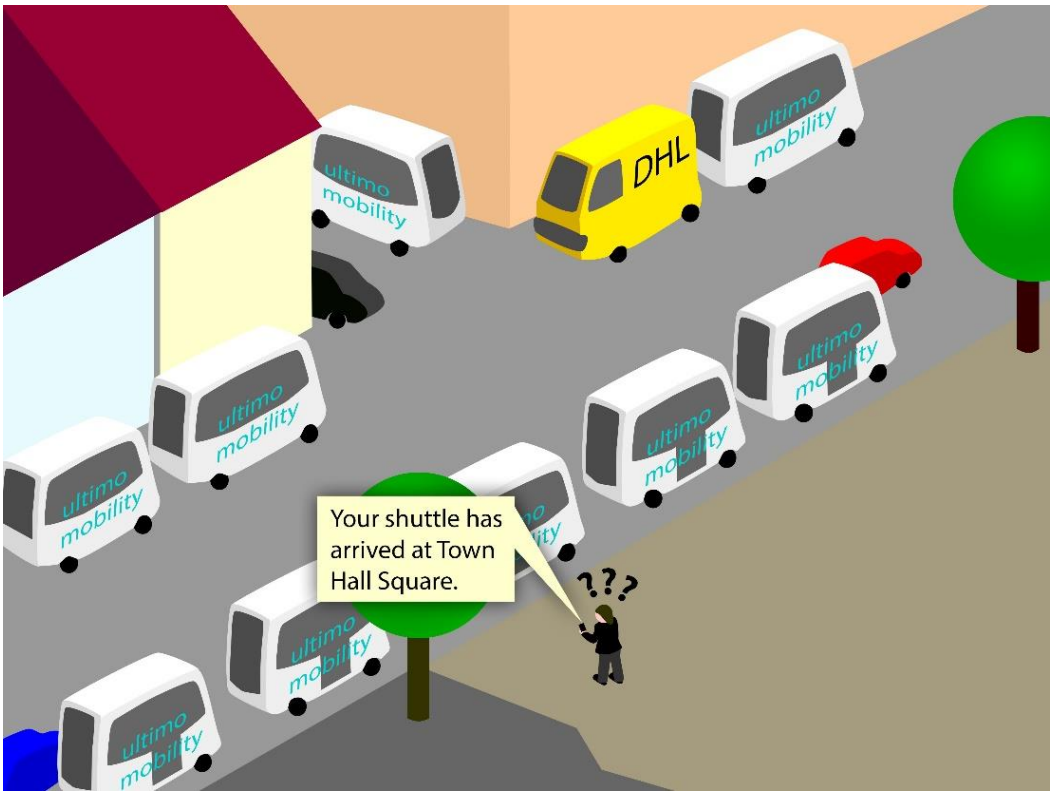

Figure 34: Potential situation at a PUDO

2.2.1 From conventional public transport to MaaS

Conventional public transport is a mass transport system. A certain number of vehicles (e.g. Busses) serve several "lines" with several stops. Neither the PTO knows who the passengers are nor do the passengers know which kind of vehicle they will get. While the PTO does not exactly know how many (and which) passengers will use the service at that time, passengers expect the service to be on time and usable for them. This means that for example, all vehicles need to be accessible, as the PTO does not know who and where will use the vehicle.

Compared to this in a demand responsive transportation system the PTOs will know the needs of their customers (passengers) and are therefore more flexible with the selection of vehicles. While a conventional car is a good choice for blind users, it might not be the best option for a family or for someone in a wheelchair. A demand responsive transportation offers also more flexibility and personal independence when the software (Apps, Websites, PIS) and the hardware (car) complies to the user's needs.

2.2.2 Specific user journey “A perfect day” (SAG)

A „perfect“ user journey from the perspective of PRMs still requires the creation of an extended persona offering an accessible public transport system. An optimal environment could look like this:

Michelle is a 40-year-old person who works as software developer for a public transport company in a medium-sized city in the Southwest of Germany. She studied Computer Science with a special focus on Usability. Suffering from congenital glaucoma, she is an Accessibility expert by nature. As a low-vision autodidact, she daily plays with new assistive gadgets and other smart technologies. As head of the development group, she works with Screen Magnifiers as well as Screen Reader (and Braille) in combination with desktop and mobile devices to accomplish her work. Part of her work is also the awareness rising in terms of accessible software solutions that fits the needs of all passengers. Her company supports by default the WCAG compliance for the complete software portfolio to faces the importance of the Barrierefreiheitsstärkungsgesetz (BSFG). The German BFSG and the European Accessibility Act (EAA) aim to give PRM equal access to products and services.

In her role as an accessibility expert, Michelle is a volunteer member of standardisation working groups to foster smart mobility for PRM. She shares her personal and work experiences also with Associations for Disabled. In close cooperation with the various organisations, she was able to build up a pool of test users. Involving this test pool at an early development stage helps her company identifying and removing potential usage problems. As a result, the residents' satisfaction has significantly increased when dealing with public transport apps and services in her city.

Based on this positive feedback, the public transport company decided to introduce a new pilot project: an automated on-demand shuttle service for PRM, completely driverless. Michelle was asked to lead several work packages in terms of Accessibility. The company plans to develop the accessible service from ground-up, offering a wide range of assistive technologies to meet all requirements.

Michelle lives with her husband in a suburb of the city, does not have a driver’s license and therefore often works from home. The new on-demand shuttle service offers her a real benefit in terms of personal independence. Now, she commutes often four times the week between home and work. She enjoys her new freedom to be able to visit her friends and parents on her own, or to go swimming at the evening. Other PRMs, who are also invited to use the automated shuttles of the pilot, share the same opinion.

Since the start of the pilot, the intensive dialog between PRMs and developers enhances an ongoing fine-tuning of existing and new service features. The valuable user feedback in combination with the expertise in accessible design and the close teamwork to overcome obstacles help both parties to optimise the driverless AV services step by step.

The „perfect“ user journey below reflects the current state of accessibility dealing with common Use Cases.

Michelle is standing in the kitchen, drinking her first coffee. It's six o'clock in the morning, today is Tuesday, maybe it would actually be a good idea to hold today's Jour Fix on site at the

company. This would also give Michelle the opportunity to meet the new colleague Christine who will be responsible for the accessible UI design of her company's mobile apps.

She reaches for her smartphone to request an on-demand shuttle, but the battery is low. Okay, time to recharge. Changing to her working room, after plug-in the smartphone to the base. she proceeds with the booking on the notebook.

The online booking for the on-demand service is up since about five weeks, is intensively tested by all shuttle users and works perfectly with screen readers/magnifiers, consistent colour schemes like Dark/Light modes and Voice control. Navigation by eye or head tracking is also supported. For persons with mild-cognitive impairments, all page content is available in plain language. Multiple language support is planned for the next release.

The mobile booking app and its respective web service comply with WCAG 2.2, level AA requirements. Both platforms also support the identical set of service features. In most cases, PRM prefer to use their smartphones to benefit from the less-complex user interface of the mobile application.

Michelle logs on to the web service, confirms the two-factor authentication via smartphone and tries to order a shuttle for 7:30. All required AV capabilities that ease the transport in terms of visually impairments are stored in her personal user profile. Her preferred shuttle provides features like:

- AVAS support
- In- and outside loudspeakers
- A high contrast passenger info display inside
- Provision of extended announcements and acoustic arrival/departure signals
- The vehicle identification service
- Mechanical control buttons
- Priority seats
- Specific smartphone support for remote AV control

Sometimes, she shares the shuttle with Martin, a colleague from the marketing division. When he rides with her, Michelle also has to select the "Ramp available" option in her user profile, because otherwise Martin won't be able to get on the bus with his walking aid. She would then have to find a virtual stop nearby that supports the ramp usage as well as her required tactile ground markings that ease the pick-up position finding. But Martin is currently on holidays, so she books the shuttle only for herself.

After entering the start and end locations, the PUDO database offers her a list of corresponding nearby virtual stops. Her preferred stops should meet the following requirements:

- tactile ground markings to find the precise pick-up position
- Bluetooth beacon support to discover the PUDO location
- Provision of QR Codes to verify the correct departure location
- Sufficient illumination
- Good perceivable borders between road and bus stop
- Low noise level
- Loudspeaker announcements to ease shuttle identification (optional)
- Acoustic signals to ease location finding (optional)

- GPS Geofencing support to ease location finding
- Coffee shop nearby (optional)
- Seatings nearby
- PUDO is located in pedestrian zone (optional)
- Roofing nearby, to protect against bad weather

Michelle has stored the above requirements as search filters for the PUDO database in her personal profile. Depending on the weather or her destination, she can now quickly adapt additional filters to find the perfect PUDO for her ride.

The forecast for today says sunny weather. Michelle chooses her favourite PUDO in the nearby park, less than 300 meters from her home. As always, she will leave 5 minutes early to feed the pigeons. She verifies her entered information and places her order.

Five seconds later, her smartphone vibrates. She smiles, the Push notification service works as expected. Using the screen reader on her smartphone, she checks the confirmed booking details. Everything is fine. She sets a timer to remind her to leave on time.

As a nice benefit, Michelle's booking confirmation includes navigation instructions for two locations. The first pedestrian route provides step-by-step instructions from her home to the pick-up place of the shuttle, the second route describes the way from the destination stop to her company. These navigation instructions are also very welcome for wheelchair users, as the avoidance of steps can be preset for route planning in the user profile. The use of mobile navigation apps is also supported.

She grabs her notebook and checks the battery power of the smartphone. 80 percent charged, that's quite enough. To be on the safe side, there is always a power-bank in the backpack. A push notification reminds her to leave.

Using her bone conducted headsets, Michelle follows the navigation instruction on the smartphone, still perceiving the ambient noise to avoid an accident. With the phone in one hand and the White Cane in the other, the navigation takes up all her attention.

Her good orientation skills, the familiar environment and the excellent GPS support of the PUDO quickly guide her to the exact pick-up position of the shuttle. Just reaching the PUDO, she hears the well-known AVAS sounds of a shuttle. A quick glance on the estimated arrival time and an incoming push message confirms the coming of her shuttle. Finally, the shuttle identifies itself via an announcement, it's definitely her shuttle. Sorry, no time left for the pigeons.

Triggered by GPS Geofencing, the shuttle automatically provides acoustic signals to ease the door finding. These signals in combination with the Bluetooth tracking capabilities of the shuttle help Michelle to easily get in. Using the secure Wi-Fi connection of the shuttle, she opens the door by her smartphone and takes the priority seat for the ride.

Michelle fastens her seatbelt and confirms by smartphone that she has entered the shuttle. Receiving her confirmation, the shuttle is now authorised to set off. The passenger info system announces the estimated arrival time, only 20 minutes

The vehicle slowly starts to move. It's rush hour. Hopefully there won't be as much traffic jams as last time. The expected arrival time is announced, only 20 minutes. So, there doesn't seem

to be a lot of traffic today. The endless starting and braking in the traffic jam is quite tiring and the hard braking is sometimes really unpleasant. Michelle almost dropped her notebook on the last ride. She is always surprised that braking is so abrupt, quite different from her own car.

Today she is lucky. The shuttle brakes only one time during her ride, accompanied by a loud warning signal that indicates an incident. The passenger info system announces the reason: A garbage truck temporary blocks the lane. After a short wait, the street is open again and the ride can move on. Only five minutes delay, according to the announcement. No problem at all, Michelle will be able to join the Jour Fix on time.

Her smartwatch says only five minutes left to reach her destination. At the same moment, the screen reader informs on an incoming call, it's the customer service. A friendly employee tells Michelle that the shuttle cannot stop at her desired PUDO due to a problem. The customer service proposes her another PUDO, which is not as close as the previous one. As she doesn't know the way, someone will assist her to manage the distance between the new PUDO and her company. Michelle agrees and asks about the delay. The employee ensures her not more than 10 minutes delay and ends the call. An incoming push message confirms the booking changes. The message also contains updated navigation instructions. The passengers can really rely on the professional customer service.

Michelle reaches her new drop-off address 10 minutes later. She opens the door with her smartphone and gets out of the shuttle. She confirms her arrival at the destination PUDO via smartphone. This final step sends the shuttle back to the depot.

A friendly voice behind her asks her name. What a surprise, it's Christine her new colleague who is also stranded here on her first shuttle ride. Asked by the customer service if she could provide assistance, she has immediately agreed to accompany Michelle. In order to get the right way to the company, both follow the navigation instructions on Michelle's smartphone. During the walk, they share their different public transport experiences in terms of accessibility.

At 8:20 they arrive the company. Perfect timing. Now a quick coffee and the Jour Fix can start.

2.2.3 Requirements of passengers with special needs

Requirements of passengers with special needs have also been described in the *ULTIMO Deliverable D2.1 Passenger and PTO Requirements, Needs, and Use Cases chapter 7*.
To avoid duplication of text, 2.2.3 refers to this deliverable and only considers additions like accessible PUDOSs and a reference to a related literature: To accompany and orchestrate AV design development taking into account the needs of PRMs,
Nanchen et al. (2022) developed an integrative model which helps policymakers and public transport companies to rethink mobility concepts while incorporating AVs and make them accessible to ensure the social inclusion of PWD.

Requirements to accessible PUDO
Virtual bus stops play an important role for the on-demand public transport with automated vehicles. The so called PUDOs differ from conventional bus stops in terms of equipment and quantity. Finding PUDOs which allow a trouble-free transport can be a challenge for PRM who

rely on specific boarding conditions to be able to get into their shuttles. To avoid any inconvenience, passengers should be able to get required information about their Departure/Arrival PUDOs already during their booking process. All PUDOs should provide a detailed description containing its various characteristics, similar to the user specific vehicle capabilities.

The Accessible PUDO database now categorises the characteristics for the virtual stops and provides an overview of available options for the passengers. Accessibility related options should be explained in detail to ease the correct assignment for all targeted passenger groups.

The following categories should be supported by the Accessible PUDO database (extensible!):

- Tactile ground markings at PUDOs indicate potential hazards, like stairs, platform edges, intersections, or boarding zones and ease the finding of a precise pick-up position.
- A selectable distance range for the Departure/Arrival PUDO in between 100 - 250 meters reduce the navigation efforts and offers an orientation in a familiar environment for PRM with vision impairments. PRM with walking aids also benefit from short distances.
- Bluetooth beacons installed at the PUDOs that provide information about current location/address, tourist sights, PUDO ramp support, PTO provider name, CS phone number or the driving direction of the shuttle ease the finding and orientation for all passengers.
- QR Codes systems at the PUDOs can additionally be used to quickly discover the precise pick-up position as well as to provide more dynamic environmental information such as temporary building sites or navigation instructions to alternative nearby PUDOs. A practise oriented QR Code system for visually impaired that ease orientation in public transport environments is offered by NaviLens QR Code (https://www.navilens.com/).
- A briefly description of the illumination situation at the PUDO
- A briefly description of the noise level at the PUDO
- A briefly description of the transition between street and PUDO. Is the curb level height perceivable for PRMs with visually impairments? A wheelchair friendly PUDO environment is often not practical for visually impaired and vice versa.
- Availability of seats
- Availability of loudspeaker for transportation announcements
- Support of GPS Geofencing at the PUDOs, ease the discovering of the PUDOs by providing automated acoustic signals (on available loudspeakers or on the smartphone) for visually impaired PRM approaching their pick-up position.
- A list of nearby POIs such as Coffee shops, snack bars, kiosks
- Specific PUDO information such as located in pedestrian or traffic-calmed zone, nearby interceptions, nearby accessible crosswalks with acoustic/haptic signals.
- Protection against weather available like e.g. roofs

Depending on their preferences and requirements, passengers are now able to select the corresponding PUDO options which answer their specific needs. All options are stored in the user profiles of the passengers to ease the booking process. The accessible PUDO database in conjunction with the vehicle capability options enable the passengers to configure their customised on-demand transport in terms of comfort and safety.

2.2.4 Derived service suggestions

The main and most important service that is developed in the scope of user accessibility is the General Accessibility Services (ser07_GenAccess). This service includes a number of features aimed to enhance everyday commute of all passengers, especially commuters with special needs. Accessible Pickup – Dropoff (PUDO) Database and Move/Safe PUDO are two features to be developed that will help with accessibility. A PUDO database provides detailed information to commuters about the Pickup and Dropoff points, to help them select a suitable option. This also includes considerations such as acoustic speakers, appropriate entrance levels for wheelchairs/ prams/ rollators, extended space for wheelchair users and human assistance availability. When the AV stops at the designated PUDO, in case the PUDO is not safe due to an obstacle (puddle, snow pile, bush, construction site etc.), the commuter will be able to request the vehicle to move to an appropriate position. This could also be helped by the AV to detect obstacles and ensure a safe environment for (dis)embarkation by moving to a safe spot. Vehicle Identification feature helps by "introducing" itself to the passenger with the dual channel principle (visual and audio). The AV could also greet the passenger with a defined code word or by stating the trip destination. Another very important feature is the emergency and safe exit, where an emergency call is initiated automatically when the system detects in-vehicle emergencies. For example, in case of fire or violence, doors should open as soon as possible to allow passengers to evacuate immediately. Moreover, if other situations (e.g. traffic and obstacles) are detected, a warning could be announced for awareness and safety precautions. More features that will be developed within the context of this service include "triggered emergency call" and "video communication to customer service (CS)". When a communication happens between commuters and CS, the video could be shown in the screen (without hiding PIS information), while when any incident is detected (e.g. emergency button pressed, vehicle has problems, safety camera detects another incident), a CS call starts automatically. Visual Location with AR can enhance the ability of the user to find their booked AV and highlight it on the screen. It could also offer audio/AR directions to guide the commuter to the AV. This service is developed in the context of T4.1 of WP4 and can be expanded to include features such as acoustic location/identification, visual location (for hearing impaired users), door location and flash notification.

Automated Passenger Presence (ser09_PP) is another service targeted at the operators' side of the AV framework. Developed in T4.3 of WP4, it offers features such as people counting and determination of space occupation, that could help operators plan and distribute the resources according to the needs of vulnerable passengers, like people with disabilities or the elderly. For example, by knowing the precise number of passengers on board, operators can better allocate space for passengers with special needs, such as those using wheelchairs or mobility devices. This ensures that there is enough room for them to comfortably maneuver onto the bus and secure their mobility aids in designated areas. The service could also assist these passengers find better seating arrangements. Knowing the exact number of passengers, allows room for priority seating which can be monitored by the PTOs, preventing the designated seating areas from being occupied by other passengers. The features provided can also assist with service planning. Operators can use passenger count data to improve journey planning for routes frequented by passengers with special needs. This could involve adjusting schedules, deploying vehicles with mobility features like ramps, to accommodate the needs of these passengers more efficiently. Lastly, the passenger data can accommodate emergency situations, such as stops decided by the commuter, or assistance requests, and help create

evacuation plans. The required passenger data are collected by sensors and dedicated software and can be used for a demographic analysis of the persons on board in order to provide a more inclusive service. Additional features that will be developed, such as "ticket control" and "sitting and standing passenger" information can further enhance the resource allocation for all users of automated public transportation. These accessibility considerations could offer significant transportation quality and integrate the Automated Passenger Presence service as part of the ULTIMO MaaS ecosystem.

The "Augmented Security and Trust" (ser08_S&T) service aims to improve passenger security and accessibility by enabling the detection of minor crimes within the automated shuttle, such as vandalism, passenger altercations, falls and bag snatching. In particular, the onboard unit (OBU), equipped with specialized sensors, is explicitly tailored for detecting a range of abnormal behaviors. Upon detecting an event, the OBU will send a notification to the supervision dashboard. Crucial for people with special needs, this module provides real-time monitoring and detection, ensuring immediate passenger notification and enabling the operator to take necessary action or provide instructions as required. This service is developed in the context of T4.3 of WP4, however it has immediate interaction with T4.1 and the "Mobility as a Service" concept.

Passenger Demand Forecasting is another service, developed in the context of WP4 T4.4, and, among other things, in the analyses in WP6, that could facilitate the planning of PTOs/PTAs and Fleet Orchestrators, to develop an inclusive service. The goal of this service is to find emerging patterns for the demand of each itinerary. This could enhance the Orchestrators' ability to include people with disabilities to their schedules. For example, in case a commuter with special needs has booked a ride, the specific demand forecasting can take into consideration the fleet planning to accommodate the surge in need of special vehicles, or an event notification that will help commuters with disabilities to make better planning of their trip. In this section, Arrival Time Evaluation (ser04_ATE) could also play a role to dig up delays due to specific needs of passengers, in order to consider such examples in the itinerary planning and possible delays that might cause frustration to commuters. However, a timely and accurate prediction of both time of arrival and specific passenger demand, could help commuters and Fleet Orchestrators for more inclusive and seamless transportation for all users.

V2X with vulnerable and non-vulnerable users (ser13_v2x) is a service that utilizes the Vehicle-to-Everything communications protocol which includes V2P (Vehicle-to-Pedestrian) among others, for transmitting safety messages and ensure safety for the road users. Connected users would be able to access safety messages through a connected device (e.g. smartphone), while non-connected users or users with special needs who are unable to use such devices would receive V2X messages - both visual and audio - through properly deployed beacons, namely Roadside Units (RSUs) of the infrastructure, thereby improving their accessibility. Messages may include the existence of moving vehicles on the road, traffic light state etc. or even vehicle status information directed toward the upcoming bus stations. Arguably, this service is crucial for the safety of road users, especially to people with special needs.

Manage accidents (ser02_ManAcc) is another crucial service for the passengers' safety. This service is developed in T4.3 of WP4. Primarily, it is a service that supplies real-time updates and intricate details regarding the accident's location, its nature and any other vital information essential for preparing the intervention team. This results in swift and well-

informed responses. In the absence of immediate on-site assistance for automated vehicle drivers, this service offers an automated, timely, precise and resilient system for detecting and managing various types of road accidents. Leveraging an amalgamation of advanced location tracking technologies, AI-driven software and V2X technologies, the service elevates response capabilities while prioritizing the safety of passengers involved in the accident. Actions related to accident management must consistently take into account the accessibility concerns of users. Specifically, following a car accident, detected by the vehicles kinetic (accelerometers or GPS) sensors, the vehicles' exits should open if feasible and they should be highlighted automatically. Additional audio messages could be employed to facilitate a safe exit from the vehicle. In the event that AI computer vision algorithms identify the presence of a person with kinetic disabilities in a wheelchair, the wheelchair ramp could deploy automatically. Furthermore, the intervention team should be promptly notified if individuals with disabilities (such as those who are blind, dead or have kinetic issues) or individuals with specific health problems are identified within the vehicle. Enhancement to the support from the intervention team can be achieved by utilizing Human Activity Recognition (HAR) through AI and Machine Learning methods to gather information about the user's status within the vehicle.

The Manage Incident Resolution service utilizing advanced software to automatically detect, recognize, and visualize incidents in automated vehicle operations. It enhances safety and efficiency by providing real-time notifications to intervention teams, enabling quick and effective emergency response for both fleet operators and passengers. This service ensures that a vehicle is more accessible, safer, and more reliable for everyone, particularly those with disabilities who may face additional challenges during public transport incidents. For example, assigning specialized intervention teams based on the incident, passengers with disabilities can receive the appropriate support they might need in emergencies. In emergency situations, the system could also send out notifications tailored to the needs of passengers with disabilities, providing them with specific instructions or assistance to ensure their safety.

Mobility as a Service (MaaS) is a series of services integration to the existing pilot site infrastructure. Padam, ZF and Trapeze need to provide a coherent and fulfilling environment for seamless transportation to commuters, including special features for passengers with disabilities. The point of ULTIMO MaaS aggregator services (ser01_MaaS) is to provide commuters with an infrastructure that enables them to use a number of transportation modes, depending on their needs and desired itinerary. Demand Responsive Transport in particular could enhance the experience of the end-users with disabilities, as their demands can be taken into consideration for a "perfect" journey. Finally, a MaaS platform, brokerage, MaaS Licensing & Certification creates an ecosystem that helps commuters to fulfill their needs, for example a request for vehicles with specific appendant hardware that helps commuting without any accessibility restrictions. This service is developed in the context of T4.1 within WP4.

V2X with vulnerable and non-vulnerable users is a service that utilizes the Vehicle-to-Everything communications protocol which includes V2P (Vehicle-to-Pedestrian) among others, for transmitting safety messages and ensure safety for the road users. Connected users access safety messages using a connected device (e.g. smartphone) while non-connected users receive V2X messages – visual and audio – via properly implemented beacons. Messages may include the existence of moving vehicles on the road, traffic light state etc. Thus, this service is crucial for the safety of road users, especially to people with special needs.

2.2.5 Future vehicles/perspective

From the view of passengers, public transport is changing significantly. Overcoming distances by seamless switching between transport systems gets more and more popular. Many suburban areas already provide Mobility hubs, car sharing stations are available in most cities and On-Demand services in rural regions often fill the gaps of conventional public transport.

In the above scenarios, ULTIMO'S automated shuttles play a special role. Focussing on the driverless passenger transport, the electric shuttles have to meet high standards in terms of robustness, user comfort and safety. And most important, the shuttles must be operable by all passengers, without requiring technical knowledge or specific mobility skills.

Current shuttle series only provide the basic equipment to answer the quality standards for passengers. They leave space for improvements in terms of user comfort and ease of use.

Nowadays, passengers try to manage minor transport difficulties either on their own or by the help of the safety operator. Direct communication or smart interactions with the shuttles are supported, but often only very limited.

PRM require the ease of physical and remote interaction capabilities by default to be able to deal with driverless shuttles.

To meet a wider range of passenger requirements, future shuttle series should provide:

- Extended communication with the shuttle to get information like current speed, defective controls, feedback about traffic incidents that cause delays, changeovers, route changes, street side announcement to ease orientation.
- Extended interaction capabilities like remote control of buttons, adjustment of loudspeaker volume or passenger info display brightness, height-adjustable entry levels, optional Voice or Gesture Control
- A V2X that allows the shuttle to find the current pick-up location of the passenger and vice versa.
- A standardised fixation system for wheelchairs that can be managed without assistance.
- Fixation options for rollators, prams, and larger luggage items
- Provision of shuttles with more flexible ramp systems like e.g. back-sided vehicle ramps, to enable a get in at all bus stops.

The above enhancements in combination with wearables, gesture or voice control can open up a new level of user experience in the matter of Design4All.

In the future, an AI-based process will be used to increase the optimization of public transport through the selective use of automated shuttles. This is done considering accessibility and travelers with special requirements. The increased needs orientation is characterized by suitable mobility offers for the needs predicted by the AI. This means that different vessels can be optimally scheduled in the existing public transport system and the automated shuttles included are able to calculate the most efficient route depending on the situation. Combined with vehicle modifications, access to mobility can be made easier and provided for different vulnerable groups.

3 Accessibility at ULTIMO pilot sites

3.1 DB

In Germany, the legal provisions for public transport (ÖPNV) regarding inclusion and accessibility are primarily governed by the *Personenbeförderungsgesetz* (PBefG). This law stipulates that public transport should be fully accessible by January 1, 2022. However, this deadline has passed and the requirement is not yet fully met everywhere. The responsibility for implementing this law primarily lies with the independent cities and districts as public transport authorities. The law, in fact, only imposes a planning obligation. Municipalities must consider the goal of accessibility in their local transport plan, which is established approximately every five years. However, this plan is not binding. The city of Herford also recently presented measures in its mobility concept. These are intended to improve accessibility for local public transport in Herford.

As a transportation company, Deutsche Bahn (DB) places great importance on making public transport more accessible, ensuring that all individuals can utilize it equally. DB is committed to promoting barrier-free travel across all its business areas. Currently, DB is implementing its fourth program for the years 2020 to 2025, which includes measures to enhance barrier-free travel.

3.1.1 Bus stops

The city of Herford is currently prioritizing the topic of barrier-free stops. Investigations from 2019 have led to the creation of a priority list of stops, which have a high need for barrier-free conversion. This list of stops is to be converted and implemented by 2025. The created list is regularly adjusted, and the stops are checked, the procedure follows the following scheme:

- Establishment of a city-wide stop register.
- Review and possibly further development of the standards set in the public transport plan with regard to equipment and design of the stops (including comfort, information offer, mobility interfaces); A standard equipment should be here: roofing, seating, easily understandable information offer about prices, the route network as well as intuitively readable timetables.
- Review of the stops regarding their barrier-free accessibility itself and barrier-free access routes (barrier-free accessibility in pedestrian traffic), successive creation of accessibility, barrier-free access, and the defined quality expansion on the basis of the cadastre, the equipment standard and prioritization

There are certain DIN standards that describe the accessibility of bus stops, which are also implemented in Herford.

Track-guided high curb with a minimum height of 18 cm
Tactile guidance system in the bus stop area, consisting of an

- Entry field made of ribbed plates of 120 cm x 90 cm at the first vehicle door

- A locating strip for reaching the entry field with a depth of at least 60 cm, better 90 cm x sidewalk width with ribbed plates.

Largest possible setup area for easy boarding and alighting of mobility-impaired persons, with a minimum width of 2.50 m, in the existing system with a required minimum width of 1.50 m to 2.40 m taking into account a suitable curb height.
Bus stop mast (in the direction of travel) 60 cm from the entry field and 75 cm from the front edge of the high curb, so that the vehicle front and bus stop mast are at the same height.
Max. longitudinal inclination of six percent in the entire bus stop area
Max. cross slope of two percent
Ideally, a uniform height of the high curb, at least at the first and second vehicle door

Even when stops are planned as virtual stops, they must be both legally compliant and barrier-free as a requirement for us as a company. This means that the criteria that a classic stop must meet must also apply to the PUDOs. Past projects, such as the HEAL project, have shown that this often poses a great challenge. As a transport company, we must work very closely with the city of Herford to guarantee as much as possible the barrier free entry and exit of vehicles.

3.1.2 Vehicle

The accessibility of automated vehicles in public transportation is a crucial aspect of modern urban mobility. The design of stops is influenced by the vehicles used, creating an interplay between the two. For instance, the position of the door in buses is particularly important for wheelchair users and passengers with strollers.

Vehicle-based entry aids such as kneeling (tilting of the chassis) and foldable ramps are most common, while lifts are used less frequently. In addition to step-free access, accessible public transport vehicles should have further features:

- Special use areas with sufficient space
- Slip-resistant floor coverings
- Grab bars
- Stop request buttons in sufficient numbers, at various heights, and with acoustic and optical signals after activation.
- Seats with stand-up assistance near the door
- A contrasting, glare-free, sufficiently brightly lit interior
- Edges in signal colours
- Tactile orientation system
- Acoustic and visual announcements of the line, final destination, and the next stop
- Diversion announcements
- Intercom system between the passengers and control centre
- Exterior lighting of the entry and exit area when the door is open.
- Emergency call button.
- Optical and acoustic door closing warning.

These features ensure that automated vehicles in public transportation are accessible and user-friendly for all passengers, regardless of their mobility capabilities. This is a key aspect of inclusive urban planning and design. Unfortunately, not all vehicles today fulfil these requirements. DB is therefore working with its partners in this project to increase accessibility by modifying the vehicles.

MaaS-Plattform

The Barrier-Free Enhancement Act (BFSG), which comes into force in mid-2025, obliges German companies to offer digital products and services without any barriers. The main focus is on passenger transport services, self-service terminals, and services in electronic commerce. In addition, digital accessibility is also required by the already applicable Passenger Rights Regulation, the Passenger Transport Act, and the Social Code (SGB).

Many of our applications and digital services must therefore be made digitally accessible. According to legal regulations, this affects all public digital services (including web appearances, apps, machines (B2C)). To become more specific and to gain clarity for implementation, the guideline “Digital Accessibility” was established. This allows IT and application managers to better assess their need for action, the impact, and urgency.

Therefore, the *Wohin-Du-Willst* (WDW) app, which is used in the project and serves as a customer front end, must also become more accessible. Currently, accessibility was not the focus of the developments. This will now be addressed this year in order to meet the legal requirements by 2025.

The first two steps to be implemented are as follows:

Enhancing Accessibility for Visually Impaired Users: We aim to make the app more accessible for individuals with visual impairments. This involves adapting the entire design to make it more contrast-rich, thereby improving visibility and ease of use.

Introduction of Voiceover: For individuals who are unable to see, we plan to introduce a voiceover feature. This will enable them to interact with the app using audio cues and commands.

In addition, the entire app is being audited for accessibility by a team from DB Systel, the IT company of Deutsche Bahn. This is to ensure compliance with the corporation’s digital guidelines. As a result, it is possible that additional development steps may need to be completed within this year to fully meet these standards. We are committed to creating an inclusive digital experience for all users.

3.2 TPG

Daily, TPG is committed to making travel easier for people with reduced mobility (PRM). Not only is this a matter of course for a public service company, but TPG is also bound to do so by legislation, by the Federal Act on the Elimination of Discrimination against People with Disabilities (DDA) and the Ordinance on Adaptation of Public Transport to the Needs of People with Disabilities (PTAO).

As an operator of public transportation in Switzerland, TPG, are dedicated to facilitating mobility for all residents, workers, and visitors of the canton. To achieve this, we ensure that our services are accessible to everyone in terms of vehicles and traveller information.

To assist people who have difficulty moving on their own but do not use a wheelchair, we established a personalized and free accompaniment service in 1997 in collaboration with the “Fondation Foyer-Handicap”. Volunteers from "Mobility for All" pick them up at home or their

workplace, help them obtain their transport ticket, and assist them throughout the journey to their destination, including shopping.

Since the end of 2014, the floor of all our buses, trolleybuses, and trams is at the same level as the platforms, and ramps can be deployed where the sidewalk is still too low. Consequently, people with reduced mobility, as well as those traveling with luggage or strollers, can more easily enter and exit vehicles. Many vehicles also have designated spaces for strollers and wheelchairs.

Regarding traveller information, we pay special attention to blind and visually impaired individuals to help them navigate our network. The compatibility of our mobile applications with smartphones allows all to plan their trips in the simplest way possible. Upon reaching a stop, drivers of the newest vehicles can activate an external voice message, indicating the line number and destination for their benefit. Additionally, on board vehicles, we have been announcing major connections approaching busy stops since spring 2014.

Accompanying Card

Individuals holding the Accompanying Card (legitimation card for travellers with disabilities) are allowed to bring along an accompanying person, a guide dog for the blind, or both. In this situation, either the person with a disability or the accompanying person must possess a valid paid transport ticket.

This legitimation card is available on the SwissPass. It must be ordered through the CFF (The major Swiss railway company), either online or by mail.

Visually Impaired Individuals

The "legitimation card for blind and visually impaired individuals" no longer exists as of January 1, 2024. Other tariff advantages providing access to reduced prices are available to assist you in obtaining your transport ticket (see below).

Individuals Receiving Disability Insurance (AI) Benefits

Individuals receiving an (Disability Insurance) pension equal to or greater than 70% can purchase their tickets and subscriptions at a reduced price upon presentation of a validated AI pension certificate by the relevant Disability Insurance office.

The reduced-price subscription for individuals benefiting from Disability Insurance must be purchased at a TPG sales agency, with the presentation of the certificate. The certificate must be presented during inspections to justify the right to the reduced price when purchasing a single ticket. The certificate needs to be renewed annually.

Free companion service

You can also use the Mobility for All support service. This is a free companion service (apart from the cost of the transport ticket), available from Monday to Friday from 7:00 a.m. to 7:00 p.m. (except for public holidays). Reservation 48 hours in advance at 022 328 11 11 or Monday to Friday from 8:00 a.m. to 1:00 p.m. and from 2:00 p.m. to 5:00 p.m.

TPG has been working to reach the goal of accessibility for all, following the LHand (Disability Equality Act).

Which door to use?

Always board the vehicle through the first or second door to be able to use the blue/yellow buttons, to be visible to the driver, and to access the seats reserved for people with reduced mobility. Whether sitting or standing, hold onto the bars or handles to ensure your safety in case of emergency braking. In case of heavy crowding, if nobody offers you their seat, it's not due to a lack of courtesy but because most passengers are not attentive to their surroundings. If you ask them politely, you will see that even the grumpiest ones will gladly stand up to give you their seat.

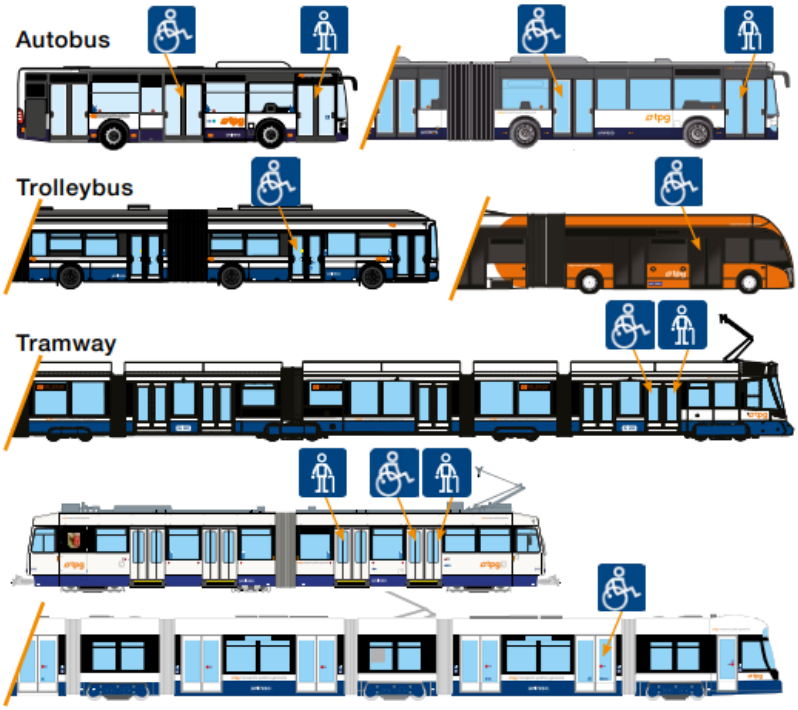

Figure 35: Accessible doors at TPG vehicles

People in wheelchairs or with assistive devices

Exclusively use the first or second door at the front of the vehicle, as they are equipped with a blue/yellow button. Additionally, reserved space is available at these locations.

Access Ramps Recent buses and trolleybuses are equipped with low floors or access ramps located directly in front of the accessible door (at the front of the vehicle). Simply lift the handle with the wheelchair icon to deploy the ramp; if you are traveling alone, seek assistance from the driver or another passenger.

Trams are accessible without ramps due to their low floors. However, some platforms may not be high enough to allow passage from the sidewalk to the vehicle without the assistance of a third person.

In buses, a safety belt system is provided to secure the wheelchair. It is recommended to ask the driver for assistance in using this system effectively. The wheelchair should be positioned in the direction of the vehicle's movement.

Figure 36: Wheelchair user entering low-floor tram

Blind or visually impaired individuals

For buses, use the first door located directly near the driver. The orange sticker or the tactile ground indicators at new tram stops will help you wait in the right place. Vocal announcements for stops and connections will inform you of your current location and where to alight for other lines.

When a blind person is present, the driver can activate an external vocal message announcing the line number and its destination. A clearly visible white cane or a guide dog will attract their attention.

Figure 37: Blind user with white cane waiting for the bus.

Visually impaired individuals: auditory information

Vocal announcements inside the vehicles indicate the next stop and provide information about line connections at the main exchange points of the TPG network.

A beep sound is heard when the doors are about to close.

For any additional information regarding the accessibility of our services:

Figure 38: Contact to TPG

STOP FACILITY

All information concerning stop facility can be seen at the following link: https://www.tpg.ch/sites/default/files/2019-12/8_Am%C3%A9nagement%20des%20arr%C3%AAts.pdf

Staff training and yearly evaluations

Internally at TPG, we have annual reviews with various local associations, as well as ongoing training courses for our drivers to broaden their awareness and understanding of Persons with Reduced Mobility (PRMs). The sensitivity training involves placing the drivers in real-life situations, having them wear restrictive suits, goggles reducing their visibility, and much more.

Pilot Area

For the project, TPG wants to do as much as possible in terms of accessibility. Pilots happening mostly in the countryside area where stop facilities are not always as well maintained and built. The demand responsive transport used allows some flexibility in terms of vehicle equipment meaning that for the fleet of vehicle used, one highly equipped vehicle could be used instead of equipping the entire fleet. Many features will be tested on this specific vehicle with its groom service.

Vehicle

For the vehicle TPG intend to have one vehicle in their DRT fleet dedicated to PRM with all the needed commodities authorized and homologated. This service would also come with a groom and many onboard tools to provide the best experience possible for passengers. The onboard tools should also be communicating between them to provide maximal effects.

3.3 Ruter

3.3.1 Ruter's Policy on Inclusion and Sustainable Mobility for All

3.3.1.1 Public Transport Is For Everyone

Ruter cannot have a situation in which disabled people opt out of travelling by public transport because they face too many obstacles. That is why we need to change. We have to be able to offer sustainable freedom of movement – to everyone.

From 2021, increased freedom of movement for the disabled is one of Ruter's most important strategic priorities.

For Ruter, this issue is also about our contribution to achieving the UN's Sustainable Development Goal no. 10: Reduced Inequalities. We know that equal access to transport helps to even out differences in society. This means that everyone should be able to travel to work and school, meet friends and participate in leisure activities on an equal footing.

Ruter has always ensured that as many people as possible could get to where they needed to go – in an efficient and environmentally friendly way. From that point of view, we have succeeded. But we are now broadening our scope: we need to create services that work for everyone, irrespective of ability level, gender, age, ethnicity, religion or budget.

3.3.1.2 Fundamental Change

A more comprehensive scope requires a new and broader approach: the most important changes are always psychological. We need to work on our culture, awareness and internal processes – as well as technology and physical solutions.

- Incorporating 'everyone' into everything we do has to be a matter of course – both at Ruter and in the rest of the public transport system.
- We have to view diversity as a strength and a fantastic starting point for innovation.
- We have to become even better at taking advice from those who feel excluded.
- We have to adjust our own work processes and bring this insight into all our development projects – from the outset.

In 2020, Ruter launched a major, internal project, in collaboration with the Norwegian Association of the Disabled, called Sustainable Freedom of Movement for All.

Disabled people make up a large group – about 18% of the population. They often face challenges when travelling by public transport which is why Ruter in 2021 made it a priority to ensure increased freedom of movement for the disabled in particular.

But we believe that what is needed for the disabled can be applied to many more customers at different times of their lives.

For example, a wheelchair user and a customer with a pram face the same obstacles, while the elderly experience many of the same challenges as visually impaired people.

Ultimately, it is not a matter of finding special solutions for the few, but solutions that work for everyone – throughout life.

3.3.1.3 Participation from Day One

The public transport offering in the Oslo region should be accessible and user-friendly for everyone. Therefore, Ruter is developing the future of automated transport services with a clear premise: It should be usable by customers with reduced mobility. Extensive participation, from day one, is crucial to meet the desires and needs of this customer group.

Ruter believes that automated transport services can contribute to increased mobility for customer groups that face challenges using today's travel options. In the picture, you see testing of an app-operated wheelchair ramp on an automated vehicle, conducted as part of the pilot project in Ski.

Figure 39: Testing of an app-operated wheelchair ramp.

3.3.1.4 From a Focus on Rules to a Focus on the Customer

We find that the organization has moved from focusing on rules to focusing on the customer. Previously, we asked ourselves: Have we met all the regulations for universal design? Today, instead, we ask: Are we meeting the customer's wishes and needs?

This means we are not satisfied with just ensuring that all buses have wheelchair ramps, as required. We are working further to ensure that manual ramps are replaced with automatic

ones in new contracts, because customer insights tell us how important it is for people with disabilities to be able to travel independently.

This transformation work helps us to realize another important goal we have defined for the future, about more personalized public transport.

3.3.2 Previous Work In This Pilot

At a high level, Ruter has worked on the following up to now:

- Meetings and interviews with representatives from The Norwegian Association of the Blind and Partially Sighted, The Norwegian Association of Disabled (NAD) and The Norwegian Council for Mental Health (NCMH) to gain general insight in mobility needs for their members.
- Internal anchoring and learning within Ruter
- Scenario testing with customers with disabilities
- Accessibility VoiceOver test of whitelabel booking application (iOS)
- Action list that can be used to prioritize accessibility features for the Grorud Valley pilot and future development
- Anchoring with the team that inclusive design requires prioritization and dedicated resources
- Extensive exploration and testing for use of a wheelchair in smaller (i.e. minibus) automated vehicle. This insight was gathered during the previous Ski pilot, and is ready for use for consideration when adding new vehicles to the Grorud Valley pilot

3.3.3 Pilot Area and Limitations in Equal Treatment

3.3.3.1 Accessibility Statement

In Norway, all public websites and apps must have an accessibility statement. The accessibility statement helps organizations to get an overview of the status and gives users of the solutions the opportunity to provide feedback when the website or app does not work for them.

Ruter's pilot project with shared, automated vehicles in Groruddalen will be conducted with a time-limited exemption from equal treatment.

Ruter's vision is to create sustainable mobility freedom for all – regardless of disabilities or other conditions. This means that a future, large-scale ordering service with automated vehicles should also be adapted to all user groups. However, we recognize that the pilot project in Groruddalen faces limitations in maintaining equal treatment across various disabilities. The limitations are mainly about the following:

3.3.3.2 Vehicle Design

In the first phase of the project, vehicles of the type NIO ES8 will be used. These are passenger vehicles with limited space. Practically, there will be room for 3-4 people in the vehicle, including one in the front passenger seat. Naturally, the driver's seat is not available.

There is no space for a wheelchair in the vehicle, and there will be limited luggage space for other aids such as walkers. In addition, the size of door openings may feel small for some users, such as the elderly. The project has nevertheless chosen to use this vehicle, as it was the best option available. It has been considered more important to be able to start user tests and service design quickly, rather than waiting for optimal vehicles to be available on the market. Efforts are being made to acquire more suitable vehicles for later phases of the project. It is also relevant to point out that the work done in the pilot project, and learning about what is required to make vehicles adapted for all user groups, will be direct input to later acquisitions of automated vehicles, as well as drive the market to produce necessary equipment.

However, several user groups with special needs can still be addressed, where the physical limitations of the vehicle do not play a significant role.

3.3.3.3 Use of White Label App

To quickly and cost-effectively start user testing and service development, it has been decided to use a "white label" app from Moovit in the pilot project, instead of a self-developed app. A "white label" app is an app developed by another company, which is rebranded to look like a Ruter app. We thus have reduced opportunities to make our own adaptations to the app's functionality and are more dependent on adaptations Moovit has already implemented.

Beyond this, efforts will be made to cater to the needs of people with disabilities as best as possible. Therefore, specific measures will be implemented to make the service in the Groruddalen pilot accessible to as many as possible:

- The app is optimized for the use of VoiceOver and TalkBack technologies (including screen reading) on both iOS and Android. This is especially intended for people with impaired vision/blindness, as well as people with reading and learning difficulties.
- The app's user interface is adapted for people with manual dexterity disabilities.
- Clear marking of entrances and other relevant areas with strong colours or tactile indicators to facilitate orientation for visually impaired and blind users.
- Available information about the service's limitations and alternative transport options adapted for different disabilities, including wheelchair-friendly transport services.
- Collaboration with interest groups and organizations representing people with disabilities to gain insights and feedback that can guide our adaptation strategies.

We commit to prioritizing equal treatment and accessibility throughout the development process of our services with automated vehicles. This time-limited exemption from equal treatment is intended to be a temporary step to gain faster access to customer value and valuable insights, and ensure that our service will be as inclusive as possible in the future.

In Ruter's previous pilot project, valuable insights were explored and collected about the use of wheelchairs and other aids in automated vehicles. However, it is important to recognize that Ruter's various pilot projects have different focus areas and learning objectives. Therefore, other aspects of the service are explored in the Groruddalen pilot.

3.3.3.4 PUDO – PickUp & DropOff Points

We aim to have as many PUDOs as possible to create a "point-to-point" experience as close as possible for our travellers. The PUDOs will be a mix of virtual and physical markers. Most of them will not be suitable and have the same requirements as when we construct bus and tram

stops, especially regarding physical accessibility requirements for the blind/visually impaired or wheelchair users. This also applies to many of the existing bus stops in the Oslo area today.

Yet, there is learning here too, through effective user participation. How should information be provided? Through which channels? How can future vehicle design requirements compensate for the lack of accessibility at PUDOs? These are questions we can explore regardless of what we achieve or do not achieve in the pilot, given the limitations the infrastructure presents us with today.

3.3.4 Target Audiences We Specifically Want to Address in This Pilot

What will mobility in Oslo be like in 10+ years with 30,000 self-driving cars? What is needed for us to achieve the vision of sustainable mobility freedom in the long run? It's fine for an early pilot that the target audience who can make use of the service is relatively narrow, but we must gather insights now so that the future service is inclusive for everyone. In other words: a shared, self-driving service in 2035 cannot be reserved for 30-year-olds with perfect vision, strong legs, and excellent digital understanding.

For the pilot, we plan to recruit closed test groups with various accessibility needs to test the operational pilot service. Here, we have the opportunity to gather specific information for different customer segments that we do not know will use the pilot organically (i.e., that they seek out and use the pilot on their own). This will be an addition to general user testing on target audience in Grorud Valley.

The recruited testers will be followed up in their use of the service to learn how the pilot/future service can be developed to meet their needs. It is likely that the pilot initially cannot meet all needs, and parts of the testing must be done together with representatives from the self-driving project team to observe a completed trip.

Customer segments we are considering at this stage:

- Elderly customer segment (70+), this segment may* be less keen on the fully digital booking and learning a new service (*not universally)
- People with visual impairments
- People who are hard of hearing
- People with mental disabilities such as anxiety – as this can affect individuals' ability to use regular public transport

Note: individuals with considerably reduced mobility (with and without wheelchairs) may need to be excluded from testing as the pilot cannot meet basic needs (picking up exactly where they are, space for a wheelchair in the vehicle, etc.).

The purpose of this testing is to gather input on how to build an accessible service, from customer segments who may not be early adopters of the Pilot service. These are people we need to learn from, despite the fact that the pilot in the initial phase cannot offer everything they need.

3.3.4.1 Vehicle future developments

Efforts are being made to acquire more suitable vehicles for later phases of the project. It is also relevant to point out that the work done in the pilot project, and learning about what is required to make vehicles adapted for all user groups, will be a direct input to later acquisitions of self-driving vehicles, as well as drive the market to produce necessary equipment.

Once we have new vehicles and know more about the form factor, we can reconsider what the pilot can offer for customers with disabilities. With an operational, mature pilot, there may be potential to offer trips to customers with mild to moderate disabilities. An example are young people with visual impairments: they are digitally savvy customers who are highly motivated to travel more independently. If we can identify and address some key needs, we can offer a service for certain customer segments with disabilities, if not all in the pilot stage.

3.3.4.2 Collaboration With Other Projects in Ruter

We will also learn from other pilots and projects within DRT in Ruter.

“The Hovinbyen Project” is a digital on-demand booking service with minibuses, will have virtually thousands of pickup and drop-off points (PUDOS), as well as a traditional driver. This potentially makes the MVP more attractive to other customer segments than the Grorud Valley Pilot, and we can make use of their insights.

This project will run concurrently with the Groruddalspiloten and can be used as a learning platform for use cases that cannot be covered by us due to vehicles and safety operator constraints.

3.3.5 Future prerequisites for a service in operational use

In the development of our service, we establish service qualities specifically designed to cater to our customers' needs, inclusive of any temporary or permanent disabilities they may possess. These considerations significantly influence operational management, business strategies, and technological implementations. Key service qualities encompass operating hours, pricing, travel duration, perceived safety, and service accessibility, particularly in terms of walking distance and wait times.

- The customer individual needs may concern:
- Items the customer will be bringing along, such as a stroller, wheelchair, pet, sports gear, bicycle, etc.
- Health-related factors that affect transportation e.g. allergies, disability, etc.
- The nature of the journey or target demographic, such as group travel or children who need child seats, etc.

To offer services that are customized to individual requirements, it is essential to maintain a fleet of vehicles that affords us the flexibility to adequately respond to these demands. Addressing users' mobility needs and offering a compelling alternative to private vehicle ownership, operating a service with up to 30,000 vehicles within our service area is pivotal in tackling the aforementioned challenges. At this scale, the service can become a formidable competitor to private vehicle use in the near future, potentially revolutionizing the reduction of vehicular traffic on our roads.

To position our service as a viable competitor and to capture market share from private vehicle ownership, it is imperative that we offer a service that is perceived as readily available, flexible, and affordable. This entails that the future service must be accessible at all times and boast a rapid response time. Mirroring the convenience offered by private car use, our service will facilitate nearly door-to-door transport for our clientele.

Flexibility demands a diverse fleet of vehicles designed for a broad spectrum of uses and requirements. Ruter's forthcoming Demand-Responsive Transport (DRT) Automated Vehicle (AV) service will allow customers to tailor their transportation experience by specifying their needs during the reservation process. This ensures the dispatch of a vehicle that precisely matches their requirements. Achieving this level of personalized service will be feasible with a scaled operation featuring a large fleet of vehicles distinguished by their varied shapes, functionalities, and intended purposes.

4 Co-creation framework

Open Geneva's role within ULTIMO is to engage citizens in the co-creation of this new public transport service by organizing citizen participation, both in the co-creation exercise and in the social acceptance of this future automated mobility service. Open Geneva proposes a unique methodology for citizen participation that goes beyond simple interviews and focus groups. Structured co-creation sessions, solution prototyping workshops and broader citizen consultations are all part of the process. This methodology ensures that the project's various target audiences are considered, particularly the specific requirements of PRMs. Their active and committed participation in co-creation events such as hackathons helps us to better understand the particular needs of these user categories.

4.1 Methodology

The methodology we followed, and which is described below, encompasses a comprehensive, participatory approach designed to foster innovative solutions in public transportation, particularly focusing on promoting the use of public transport over private, motorized transport. This methodology is structured around three key components: Futures Workshops, Ultimo Hackathon, and Deliberation.

4.1.1 Futures Workshops

Future workshops use back casting (as opposed to forecasting) to allow participants to explore complex topics by first imagining a desirable future and then defining the steps necessary to reach this future. In our case, the desirable future is one where everyone is using public transport instead of private, motorized transport. The exact future scenario can be adapted according to the long-term strategy of the local PTO. The backcasting approach bridges both the first (future workshop) and the second event (hackathon), as the preliminary steps to reach this desirable future will be identified during the future workshop, adapted into challenges for the hackathon, and then “hacked” during the hackathon itself.

The goal of the first workshop, “future workshop” was to understand local particularities in terms of the public transport service already provided, and the needs of the local community. Additionally, the event aimed at adding relevant challenges to the second event that reflect the needs of the local community, allowing us to engage with them more personally. We were also seeking to engage the local community in a low-stakes, low commitment event and create visibility for both the project overall and the stakeholders involved.

In the context of the ULTIMO, we expanded this event to the public at large by organizing a workshop for citizens. The challenge shaping activity proposed in this participatory framework allows citizens to determine their needs and wants for public transport/ MaaS that will then be addressed in a second event, the co-creation part (hackathon).

4.1.2 Ultimo Hackathon

The overarching goal of the hackathon was to address user needs, find practical solutions for identified public transport challenges from the Futures workshop, co-create use cases and build socially robust MaaS solutions in close collaboration with the citizens.

The participants are recruited over a digital platform (sparkboard), where everyone can sign up to the challenge, they are most interested in. Each challenge features a description, the issue(s) that should be resolved during the event and, if applicable, professional profiles that would complement the challenge. Each group should have a participant from one of the consortium members, such as a representative of the local transport operator or a vehicle manufacturer, depending on the nature of the problem that should be addressed. If not possible for a group to have a full participant, an expert should be available for questions at predefined times online.

This activity takes the form of a “social hackathon”. The idea behind a social hackathon is that collective intelligence allows problems to be solved in new ways by involving civil society. A social hackathon takes certain elements from a classic hackathon, such as the time constraint, the interdisciplinary nature of the teams, and the presentation of the final project at the end. However, there should not be any competition between the teams – collaboration between teams should be encouraged through cross-pitches during the hackathon and common activities. A social hackathon also aims to include as many people from different backgrounds as possible – no experience or expertise in the subject is necessary, rather than a technological output, the output should be conceptual or an idea.

4.1.3 Deliberation

The deliberation process spans multiple months during which citizens, businesses and other stakeholders can vote on the ideas proposed during the co-creation process (hackathon) and rate and discuss the proposals online. The deliberation allows the ideas proposed to be vetted and validated by the public at large. The use of platforms such as Decidim was also explored. This wider consultation phase was intended to enable "social" validation of the ideas/solutions proposed during the hackathon. The second round of co-creation events on each of the pilot sites could begin based on the results of this consultation.

An exploration phase on offline deliberation formats has also been carried out. Although more complicated to implement in methodological terms, it appears to be more qualitative in terms of the project's needs. After an exploratory phase of the different formats that this face-to-face consultation could take, a reflection process around the construction of a mobility game is taking shape.

4.2 Implementation

We decided to start testing a first iteration of our project activities in Geneva, for obvious logistical and cultural reasons. Depending on the results, we wanted to be able to adapt and adjust our approaches and methodologies before rolling them out in Norway and Germany. Geneva will therefore play the role of testing ground for this co-creation and consultation work. We had drawn up a program for deploying our activities in parallel on two sites, so that we could carry out our two iteration rounds on each of the 3 sites. Oslo was the 2nd target site for our activities over 2023-2024.

4.2.1 Futures Workshop

4.2.1.1 Futures workshop in Geneva

The workshop was held on the 24th march, 2023 at the 3DD Consultation Space which is a place owned by the State of Geneva and dedicated to participatory and citizen initiatives. It encourages the sharing of thoughts, actions, and useful resources to work together on local territories. The whole duration of the event has been foreseen for three hours and half.

The workshop consisted of two major parts: brainstorming (ca. 20 min) and deliberation (ca. 75 min), followed by a vote (ca. 10 min). The online tools used were explained before the start of each part. For the brainstorming part of group activity, we used Mentimeter. It is a digital tool that allows the creation of word clouds based on a specific question or topic, provided to the participants before submission of their ideas. Mentimeter enables real-time feedback, which can stimulate discussion within a group and among various groups. Mentimeter collected participants' responses in a knot of keywords. The more a word appears in workshop participants' responses, the larger the size of the word on the screen becomes.

During the workshop, participants had chosen randomly their tables of 4-5 people, while the organizers were ensuring diversity of profiles was met around each table.

The first round aimed to answer the question: "*In which situations do you not use public transport and why?*". To this end, we used a digital tool, Mentimeter, which collects participants' responses in a knot of keywords. The more a word appears in workshop participants' responses, the larger the size of the word on the screen becomes.

For the second round another digital tool that was used during the event was Pol.is. It is an online tool, allowing users to vote on various propositions that came out from the group discussion. Pol.is gathers open ended feedback from large groups of people and provides interesting measures of the voting tendencies of participants, while retaining authentic feedback and minority opinions. Furthermore, Pol.is allows the aggregation of various replies and regrouping the topics in bigger groups. The second round of discussions focused on the question: "*What works that tomorrow you no longer need to use a car to get around Geneva?*" In order to collect the best ideas and needs received by public transport users, we asked participants to submit their answers and statements using a Pol.is voting tool.

Figure 40: Examples of citizens statements made during the workshop.

Communication

Early January 2023, we informed our community about our participation in this ULTIMO Project thanks to our website creating a dedicated page: https://opengeneva.org/ultimo/.

When we launched the organization of our first future workshop, flyers were produced to reach out to our target population who are less present on social media channels, such as elderly people, or some part of the students' population. We dropped the flyers off at various locations around the city, including universities, community centres and retirement homes. For the communication campaign, we used LinkedIn and Facebook, as social media platforms. To engage an already existing Open Geneva audience, information related to the event was shared through two newsletters (newsletter 1 & newsletter 2) in two months and mailing lists. All the campaigns were set in an organic way and no sponsoring was involved in the process.

To maximize our reach to a broad audience, the workshop has been strategically integrated into the vibrant Open Geneva Open Innovation Festival, slated to take place from March 16th to 26th, 2023. This alignment ensures the workshop's dissemination in a key event dedicated to innovation and citizen engagement, enhancing the visibility and impact of the workshop.

4.2.1.2 Challenges definition

Optimizing a hackathon for success hinges on crafting challenges that resonate with participants and key stakeholders, including Public Transport Operators (PTOs) and Automated Vehicle (AV) manufacturers. Striking the right balance is crucial challenges should be broad enough to stimulate creative thinking yet tailored to address the specific concerns of stakeholders involved in each challenge.

These challenges have evolved from insights gathered during the Futures workshop, responding to a void in current Public Transport (PT) offerings identified by the citizens.

In a collaborative effort with the local PT authority in Geneva, challenges were meticulously identified and moulded to encapsulate a spectrum of outcomes derived from the futures workshop, aligning closely with the expressed needs of citizens.

The formulation of the challenges reflects a comprehensive understanding of the diverse needs identified, culminating in the definition of five challenges in conjunction with Geneva's public transport system. These challenges encompass Infrastructure & Environment, Multimodality & Comfort, Price, Safety, Security & Information, and User Experience & Accessibility, collectively addressing the multifaceted aspects of the citizens' needs and preferences. A comprehensive overview of the challenges outlined is provided in this document.

Impact Measurement

Through close collaboration with our partner ArgYou, we have developed a comprehensive keyword list tailored to the challenges of the ULTIMO Hackathon for ArgYou to effectively gauge the digital impact of the ULTIMO Hackathon. Comprising 1,053 keywords, this list is the product of rigorous collaboration aimed at aligning with the event's challenges. Through careful consideration of modifiers, we have ensured a comprehensive range of keyword variations to capture the intricacies of digital engagement. A keyword lists offers a detailed

breakdown of the list for further examination and utilization in impact assessment endeavours.

4.2.2 ULTIMO Hackathons

4.2.2.1 ULTIMO Hackathon Geneva – June 2023

The hackathon

Open Geneva successfully hosted the first ULTIMO hackathon in Geneva. The event unfolded on June 23rd and 24th at the SDG Solution Space in Geneva, engaging participants in a 24-hour hackathon designed to actively involve citizens in co-creating services provided by automated shuttles.

Figure 41: Group photo of Ultimo hackathon participants in Geneva

This pioneering ULTIMO Hackathon fostered collaboration with key project partners in and around Geneva, most notably Transports Publics Genevois, with whom Open Geneva collaborated and co-organised the hackathon closely. Significant contributions and collaboration were also received from Padam Mobility, Siemens, and the University of Geneva.

In addition to engaging ULTIMO partners, the hackathon emphasized the mobilization of local actors involved in mobility and citizen participation. This strategic outreach was crucial for disseminating information about the hackathon. Support from local associations (Genève Roule, Après Genève, Senior Lab, ATE Association transports et environment), student associations (Unicycle UNIGE, GSEM Unige), and academic entities (Campus biotech, SDG Solution Space, Edglands Institute) played a pivotal role in amplifying the event through their communications.

The ULTIMO Hackathon brought together a diverse array of challenges and valuable resources, all consolidated within a dedicated platform. This platform served as a seamless conduit between Open Geneva and citizen participants of the ULTIMO hackathon. Its primary function

was to provide a comprehensive overview of the challenges at hand, empowering participants to explore various avenues of interest. By facilitating easy navigation and access to pertinent information, the platform ensured a level playing field for all involved. Participants were afforded the freedom to align themselves with challenges that resonated with their needs, skills and interests, thus fostering an environment devoid of bias and encouraging genuine citizen engagement.

The opening ceremony at the SDG Solution Space featured addresses by Anne Hornung-Soukup, President of the Board of Directors of Transports Publics Genevois (TPG), and Dimitri Konstantas, the associate Coordinator and Technical Manager of the ULTIMO Project, representing the University of Geneva.

Figure 42: Photo of the Anne Hornung-Soukup and Dimitri Konstantas at the opening ceremony of the ultimo hackathon in Geneva.

This opening ceremony not only provided a platform to showcase TPG's mission within the ULTIMO Project but also included a talk by Jeroen Beukers, an expert in innovation focusing on automated driving and intelligent mobility. Participants also had the opportunity to explore the TPG automated vehicle during the event.

The identified hackathon challenges, co-defined with the TPG, spanned a broad spectrum:

- Challenge 1: What infrastructure is needed for automated public transport, and how can it be harmoniously integrated into the environment?
- Challenge 2: How can automated vehicles be safely and efficiently integrated into the existing road infrastructure, while improving service comfort and considering soft forms of mobility?
- Challenge 3: How can a new automated, personalized, on-demand public transport service be offered at a competitive price while remaining affordable for users?
- Challenge 4: How can we effectively present an automated bus service to users, while ensuring their safety during use?
- Challenge 5: How can automated public transport guarantee an inclusive user experience accessible to all?

Communication

Different channels have been used to disseminate the hackathon and encourage citizen engagement. We transferred the press release toward local and various media as well as that published on the website of Open Geneva. To further engage the Open Geneva's community

and in addition to promotion on social media, the ULTIMO hackathon was also promoted via a newsletter entirely dedicated to the event and the ULTIMO project (the newsletter is viewable here).

A presence within the public space was also essential to spread the spectrum of citizen reach towards populations who are less present on social media channels, such as elderly people, or some part of the students' population. Therefore, the Open Geneva team has displayed posters and flyers in key and strategic locations and institutions in Geneva.

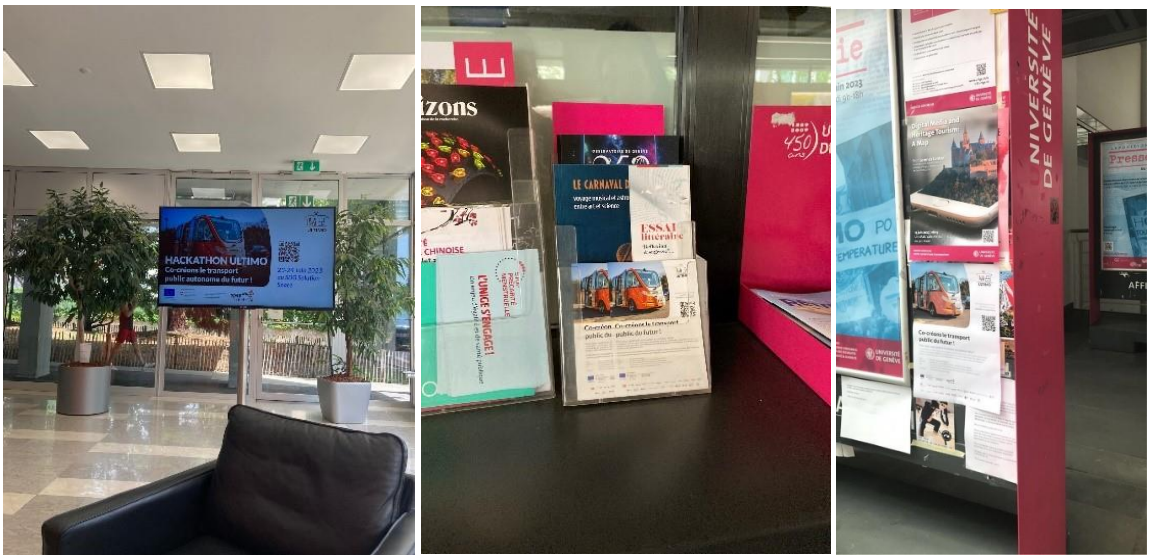

Figure 43: From left to right: Photo of the Ultimo hackathon visual at the EPFL Innovation Park in Geneva, photo of the hackathon flyer in a Geneva library, photo of the hackathon poster displayed at the University of Geneva.

One notable feedback received from participants of the first workshop was their misunderstanding of Open Geneva's mission within the ULTIMO project. To address this issue and ensure a more accessible and comprehensive understanding of our mission, we have developed a video explaining the methodology and action processes developed by Open Geneva.

To bolster the impact of the event, supplementary materials were crafted, comprising a roll-up and stickers. These artifacts serve the strategic objectives of advancing the hackathon's dissemination efforts, reinforcing ULTIMO's brand identity, and fostering greater awareness of Open Geneva within the public space and towards citizens.

To cultivate a profound dissemination of the hackathon's transformative ethos, we conceived "Hack Story" as a medium of unparalleled depth and resonance. Delving into the essence of the event, we meticulously crafted videos within the intimate setting of a TPG automated shuttle, an emblem of futuristic mobility, prominently displayed during the hackathon. Within this innovative space, participants shared not mere experiences, but profound narratives, encapsulating their journey, insights, and aspirations as they engaged with the disruptive potential of automated shuttles. This initiative seamlessly integrates with our broader strategy of promoting "communication by the citizens, through the citizens" as a means of fostering public acceptance of automated mobility services.

Through this immersive storytelling, we captured not just feedback, but the essence of innovation in motion, forging a tapestry of voices that illuminate the path towards a more automated and user-centric future. By intertwining the narratives captured in "Hack Story" with our engagement efforts, we aim to amplify the impact of citizen-led communication, cultivating a culture of transparency, inclusivity, and co-creation that drives widespread acceptance and adoption of automated mobility services.

Hack stories captured during the hackathon can be accessed for viewing through this link

Figure 44: Photo of Thibaut Chatelain, one participant of Ultimo Hackathon in Geneva during his interview for his hack story

4.2.2.2 Smart City Xperience Hackathon – Novembre 2023

Context

The ULTIMO hackathon held in Geneva has permitted to analyse the barriers encountered and lessons learned from citizen's involvement towards the ULTIMO project and Open Geneva's mission. It has been an opportunity for Open Geneva to pursue further challenges within the collective intelligence activities of Open Geneva facilitated collaboration with ULTIMO partners through the Smart City Xperience hackathon. Smart City Xperience is a 24-hour hackathon to come up with concrete solutions and projects for building a sustainable city. It aims to mobilize a wide range of stakeholders in Geneva (academic institutions, companies, associations, individuals, students).

The hackathon brought together 90 participants divided into 10 challenges around the theme of Smart City. The ULTIMO partners involved in this hackathon were the TPG, PADAM Mobility and Open Geneva.

Challenges

Two different challenges were addressed during the hackathon, one by the Open Geneva partner team - PALO IT (challenge 1) and one by the two Ultimo consortium partners - TPG and PADAM Mobility (challenge 2).

Challenge 1: To counter the barriers of accessing, visualizing and testing the automated vehicle services and technology for which many participants faced difficulties in fully developing their ideas within the given timeframe, one challenge owned by Open Geneva and its partner Palo IT focused on future mobility gamification. The aim of this challenge was to conceive a tool

aimed at citizens and future users of transportation to facilitate collective imagination to harness a diverse array of real needs, innovative and sustainable solutions, and participatory and civic reactions.

Challenge 2: One team of 9 participants (6 students from Business school, 3 professionals) worked on a specific challenge owned by TPG and PADAM linked to the ULTIMO project, on the MaaS interface. This challenge issued by TPG and Padam Mobility consists of firstly identifying users' perceived limitations by investigating the role of on-demand transport in their journeys, their perceptions of the service, and how it integrates into the overall transportation landscape. Secondly, the aim is about enhancing MaaS interfaces by determining users' needs for utilizing on-demand transport alongside other modes of transportation, understanding their preferences, and specifying the necessary features for the interface. This information will be documented in a deliverable to inform the design and development of the interface.

4.2.2.3 ULTIMO Hackathon – Oslo

Context

After starting our activities in Geneva, we talked to RUTER to understand how we could collaborate on our mission. While we were familiar with the ecosystem and culture in Geneva, we had no contacts other than our Norwegian consortium partners to prepare our activities on this pilot site. We were therefore keen to adapt our approach, our tools and our agendas to suit RUTER's constraints as closely as possible. We knew that our mission to engage citizens in this ambitious project would not be perceived in the same way in Geneva as in Oslo. Having gained the trust of RUTER and the wider consortium by presenting them with the results of our activities in Geneva, initiated at the launch of the project, we were able to discuss the best way to proceed in Oslo.

New participatory approach

The point that seemed most problematic for RUTER was this "direct exchange" aspect with citizens that we were proposing. While RUTER has a great deal of expertise in conducting interviews and sending out questionnaires to their beneficiaries to understand mobility trends and habits in Oslo, they are not inclined to deal with the "general public" in a participatory way, as we do in Geneva with hackathons.

We had to explain the added value of conducting this type of new participatory approach. Thanks to their intense, safe and open environment, hackathons enable truly innovative, even radical ideas to be formulated and brought to light by participants. RUTER placed their trust in us, and we were able to work closely together to design and organize the first hackathon in Oslo.

RUTER proposed to involve RUTER Customer Services employees in these workshops. This target audience seemed to us highly relevant in that they represent a quality "proxy" between the PTA and the future beneficiaries of the service. They know the constraints of the public transport operator and are also very aware of the concerns of public transport users, as they are in daily contact with them.

With the target defined, we set about defining the hackathon challenges. RUTER expressed the challenges encountered in the project, and 5 challenges were proposed to the participants:

- Challenge 1: Travel in all specific situations | Reise i ulike situasjoner
- Challenge 2: Accessibility | Tilgjengelighet
- Challenge 3: New mobility service | Ny mobilitetstjeneste
- Challenge 4: Combining the journey with other traveling modes | Kombinere reisen med andre reisemåter
- Challenge 5: Security on board | Sikkerhet om bord

These are presented in more detail on the hackathon platform

The format of the hackathon, co-constructed with RUTER, was also adapted to suit the constraints of the teams on site. In Geneva, we are accustomed to organizing hackathons over 24 hours, but we had to adapt the format and duration of the exercise to make it compatible with the schedules of Customer Services. To avoid disrupting the department, we proposed to organize 4 sessions with 4 different groups, spread over 2 days. Participants had to commit only half a day to the hackathon. In terms of methodology, we decided to maintain the same level of expectation, but in a reduced time period. The exercise was intense and productive.

After listening to a brief presentation of the ULTIMO project, particularly the activities linked to the pilot site, the teams followed, at their own pace, the 5 steps proposed to go from an idea to a concrete solution in just 3 hours:

1) Collide: express your ideas while listening to the others
2) Coalesce: integrate knowledge into ideas
3) Converge: select one bold use case from most promising ideas
4) Prototype: make your bold idea into a concrete solution
5) Share & feedback

The hackathon

On January 10 and 11, 36 Customer Services employees took part in the hackathon, divided into 4 sessions. The hackathon took place at Ruter S, RUTER's dedicated space for events and workshops. The 4 groups mobilized were divided into 11 teams, composed according to their choice. Each team was able to choose the challenge it wished to work on.

Motivating citizens to be part of the solution is the greatest challenge of citizen engagement. With Open Geneva, we do not implement a participant selection process based on knowledge level or population representativeness. Instead, we rely on the subject's interest and the participants' intrinsic motivation to engage in a co-creation exercise on a topic that is meaningful to them. We provide them with open dialogue spaces, free of pressure, where every voice can freely express itself, ensuring an authentic and citizen-driven engagement process.

4.3 Results

4.3.1 Future workshops

Results

After the event, the most spontaneous feedback was rather positive. People experienced that open discussions that lasted for more than 20 minutes were counterproductive and didn't lead to any concrete results. Rather, the members of the working groups got more distracted and disengaged from discussions.

Overall, the participants were interested to be informed about the next steps of the project, however they weren't sure whether they will participate in the other upcoming workshops. What was strongly appreciated was the communication ahead of the workshop as far as the community building and experience sharing, that allowed participants to extend their current knowledge on public transportation by discussing their experiences with other participants.

All the results from the workshop's discussions and votes can be found on the platform Pol.is under the following link. Additionally, we have compiled a comprehensive report encompassing all workshop outcomes.

There were 26 people who took part in the votes on Pol.is.

- 48% of the 26 respondents said they were female and 48% responded negatively to this statement, with 4% abstaining out of 26 participants in total.
- 45% out of 26 respondents said they lived in the rural area and the remaining 45% denied it. The question was not answered by 2 out of 26 people.
- 16% of people out of 26 respondents answered to be over 50 years old and 32% answered to be 25 years old or younger out of 26.
- 12% answered that it was a physical disability and 12% did not answer this question.
- In total, out of 26 voters, 76% said they lived in the canton of Geneva.

After the complete analysis of the outcomes from the Pol.is identifying various challenges for the hackathon has been possible. This was also interesting to share the results from the word cloud and from Pol.is with ULTIMO partners, the TPG, involved in the challenge definition process. This has helped to bridge the gap between the PTO and end users in terms of expectations.

Limits

In terms of methodology and tools, this workshop format has certain limitations that we have experienced. Indeed, the choice of these methodological tools necessarily implies that participants are comfortable with digital tools (computers), as everything takes place online. This can represent a significant limitation in terms of citizen engagement in the co-creation exercise. Also, the Pol.is deliberation tool we tested during this workshop is only available in English, which may also appear to be a barrier to its rapid and easy adaptation by a wide audience.

Next step

With a view to a second round of iteration, we'd like to rethink the format of this workshop to move towards a more adapted, more accessible format that's less dependent on digital tools.

4.3.2 ULTIMO Hackathon - Geneva

4.3.2.1 Ultimo Hackathon experience

15 participants took part in these 5 innovation challenges for 24 hours of co-creation at the SDG Solution Space in Geneva. The participants nonetheless represented a concrete cross-section of the population and its various needs. To provide a comprehensive insight into the atmosphere and highlights of the workshop, we have crafted an engaging after-movie, available for viewing at the following link: ULTIMO hackathon Geneva Aftermovie.

For a comprehensive understanding of the hackathon's outcomes, including detailed insights into the figures and metrics, we crafted the hackathon report. This comprehensive document offers valuable insights into the performance, impact, and success of the event. The hackathon report was dispatched to all participants and partners just a few days following the conclusion of the hackathon, ensuring timely access to vital information for further analysis and reflection.

Figure 45: Photo of an Ultimo Hackathon participant in Geneva pitching her solution idea "Train escape game"

During our co-creation events, we made deliberate efforts to ensure inclusivity for people with disabilities. Our communication and dissemination strategies surrounding our ULTIMO events were designed to be inclusive and inviting to all participants. We ensured that information about the events was accessible to individuals with various disabilities, including providing alternative formats for materials. Additionally, we offered accommodations such as sign wheelchair accessibility, and assistive technology support to facilitate participation for everyone. Our aim was to create an environment where all individuals, regardless of ability, felt welcomed, valued, and empowered to contribute their insights and perspectives to the co-creation process.

One striking example of this commitment was evident during the ULTIMO hackathon in Geneva in which a participant with reduced mobility experienced firsthand the challenges of accessibility related to shuttles and automated vehicles (AVs). This participant's direct encounter with accessibility barriers underscored the importance of considering diverse perspectives in our innovation endeavours. Her experience and valuable insights, captured in a testimonial video "Hack story", provided poignant reminders of the real-world impact of design decisions and citizen involvement.

Figure 46: Picture of Rozsa Illes-Valette, a participant of Ultimo Hackathon in Geneva

By actively engaging citizens, including those with disabilities, in the design and development process, we ensure that the resulting solutions are not only technologically advanced but also address real citizen needs and concerns. Citizens bring diverse perspectives, experiences, and insights to the table, enriching the conversation and contributing valuable ideas that might otherwise be overlooked. Moreover, involving citizens fosters a sense of ownership and accountability, as they become active participants in shaping the future of transportation in their communities. Ultimately, by prioritizing citizen involvement including people with disabilities in our co-creation initiatives, we strive to create AV solutions that are not only innovative and efficient but also equitable, accessible, and responsive to the needs of all members of society.

4.3.2.2 Hackathon use-cases

The different teams brainstormed and hacked during 24 hours of brainstorming and co-creation. To support the participants in framing and co-creating the solutions developed regarding the challenge, a support canvas has been developed.

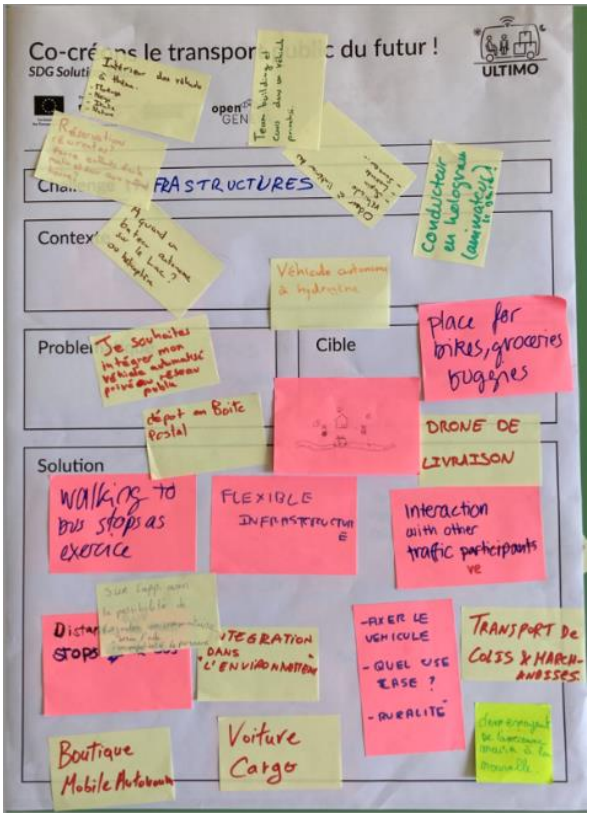

Figure 47: Screenshot of uses-cases canvas

The canvas played an important role as a tool for both brainstorming and structuring various challenges. Following an initial brainstorming session, the next step involved refining the ideas using a funnel logic approach.

Additionally, given the significant number of participants, the hackathon's format had to be redefined, making it more suitable for outlining use-cases. This highlights the strength of co-creating and open innovation events, allowing for adaptability and agility simultaneously.

This resource enabled participants to delve into user needs and articulate the desired services within the automated shuttle, aligning them with real-life user scenarios.

This collaborative and collective intelligence exercise produced 45 use-cases, including 9 "favourites", after a vote made by the participants during the closing ceremony. Participants demonstrated their creativity and explored a wide range of use-cases for the automated shuttle to serve different types of user-needs. The richness of the exchanges and the diversity of the ideas demonstrate the value of offering citizens spaces for exchange, co-creation and innovation. All these use-cases can be discovered directly on the dedicated platform. Indeed, to enhance the accessibility and inclusivity of communication regarding the hackathon outcomes and use-cases, we have transitioned all generated use cases into a digital format hosted on this dedicated and accessible Sparkboard platform. This digital tool offers a centralized platform for comprehensive access, fostering broader participation and understanding among stakeholders around these use-cases produced by citizens during the hackathon.

To exemplify a pertinent use-case, we scrutinize the accessibility of automated shuttle services for individuals with diminished mobility as evoked and co-created by the participants of the hackathon. The adjacent table meticulously delineates the service description, intricately aligned with the specified use-case. It synthesizes insights and inputs from participants as recorded on the left, offering a comprehensive portrayal of the service's deployment and its implications for users with reduced mobility.

Table 2: Table of specific use-case

Use-case name	Accessibility
Goal	Making wheelchair users independent
Service description	Providing wheelchair-accessible service and accessible entry to the autonomous vehicle
Target audience	Wheelchair users and people with reduced mobility
User story	A person with a motor disability and in a wheelchair needs to be able to enter the AV independently. Today, people can't do it themselves, as the inclination is too great.
Functional requirements	Need to design a system to lower the bus, i.e. a wheelchair elevator

4.3.2.3 Requalification

It is imperative to underscore that user co-created use cases must align with stringent technical, legal, and policy requisites to facilitate seamless deployment. This alignment is meticulously achieved through the integration of expertise from Patent and Trademark Offices (PTOs) and other key project partners into the co-creation process. By cultivating an atmosphere of active cooperation, our approach seeks to harness the collective intelligence of diverse stakeholders while preserving the unfettered creativity of participants.

In addition to functioning as independent use cases, those generated by users may undergo a convergence process with existing use cases from PTOs and manufacturers. This convergence not only enhances the robustness of the use cases but also establishes a foundation for the development of novel scenarios. User-created use cases further serve as a wellspring of inspiration for future citizen co-creation initiatives, showcasing the dynamic and evolutionary nature of our collaborative efforts. This iterative process ensures that the outcomes are not only innovative but also compliant with the established standards and guidelines, reinforcing the project's commitment to delivering impactful and sustainable solutions.

The uses-cases produced were then requalified as requirements for integrating into the "Ultimo requirement" working document shared with all project partners. The latter were free to express their views on the level of interest of these use-cases for the project. Over and above the use-cases that will be retained by the consortium, this work has enabled the voice

of citizens to be heard in the co-construction of the automated mobility service, as close as possible to their needs.

ID	Step/Category	Topic	Requirement	Type	Comment
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	Pax	validated by citizens (Open Geneva)
55	3_Getting to PUDO	Information	The user shall receive confirmation when they have arrived at the correct PUDO	Pax	validated by citizens (Open Geneva)
87	6_Boarding AV	special needs	The visually impaired passenger shall be able to board and disembark safely e.g., ramp does not move towards waiting passenger, ramp not in the way of passenger, etc.	Pax	validated by citizens (Open Geneva) > attention to ramp inclination
107	7_Onboard	special needs	The disabled user (deaf, hearing impaired, blind, visually impared, ...) shall get the same amount of information everyone else gets (preferrably by following the dual-channel principle)	Pax	validated by citizens (Open Geneva)
114	7_Onboard	Interior	The passenger shall have space under their seat for a guide dog/service dog	Pax	validated by citizens (Open Geneva)
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.		validated by citizens (Open Geneva)
325	Vehicle	Interior/ Special needs	The blind passenger accompanied by his dogs has a special place to seat his dog comfortably		expressed by citizens (Open Geneva)
326	Vehicle	Design	Passengers can suggest temporary decorations/designs for the shuttle		expressed by citizens (Open Geneva)
327	Vehicle	Interior	Passengers would like to have access to entertainment activities to make better use of their travel time (e.g. eating an ice cream in summer, drinking a hot beverage in winter, etc.).		expressed by citizens (Open Geneva)

Figure 48: Screenshot of uses-cases translated into requirements for the project

4.3.2.4 Smart City Xperience Hackathon – Geneva

The two hackathon teams spent 24 hours thinking about the two challenges proposed in the ULTIMO project.

Challenge 1: The solution developed through the hackathon by the team of Palo IT has permitted the development of an immersive experience tailored to navigating the evolving landscape of tomorrow mobility. The significance of this solution is further validated by its election as the "Coup de coeur" project in the conclusion of the hackathon, a recognition of its merit through the collective vote of the participants, reinforcing its relevance.

The integration of gamification ideas related to automated mobility services offers numerous benefits for the ULTIMO Project. By incorporating game-like elements such as rewards and challenges, this game can enhance user engagement and incentivize adoption of automated transportation. Gamification simplifies complex mobility concepts, making the service more accessible and appealing to citizens. Furthermore, it enables the ULTIMO project to collect valuable user data and feedback, informing service improvements and optimization. Additionally, gamification fosters community engagement and collaboration, strengthening ULTIMO project civic engagement and ecosystem. Overall, gamification enhances the user experience, drives adoption, gathers insights, and promotes community involvement within automated mobility services.

Challenge 2: The expectations from the TPG and PADAM Mobility team during the hackathon were understanding users' needs in terms of MaaS offerings, identifying the threats and opportunities of on-demand transport within the overall offering and gathering information on users' views on this type of service.

Through the 24h collective intelligence embodied by the Smart City Xperience, the partners and participants developed a solution which consisted of a versatile and user-friendly multimodal application that seamlessly integrates various modes of interaction such as voice, touch, gesture, and possibly other emerging technologies. This application will serve to enhance user experience and accessibility across different devices and platforms.

The benefits of these insights for the ULTIMO Project have yielded significant advancements towards enhancing the Mobility as a Service (MaaS) interface. Through collective intelligence and collaborative research and analysis, it has permitted profound insights into users'

perceptions, needs, and preferences regarding on-demand transport services. By trying to get involved via a user-centric approach, the results have effectively identified the limitations faced by users and have specified necessary features to improve the interface's usability and functionality. This informed decision-making process ensures that the final product aligns closely with users' expectations, leading to higher user satisfaction and adoption rates.

Furthermore, the collaboration with partners TPG and PADAM Mobility has enriched the project with valuable resources and expertise. Leveraging this partnership, the results from the hackathon developed an innovative, multimodal prototype application that enhances user experience and accessibility but also positions the ULTIMO project as a pioneer in leveraging technology to address user-centric transportation challenges in smart cities. Overall, these efforts have not only contributed to the advancement of the ULTIMO project but also provided valuable experiential learning opportunities for the participants involved, bridging the gap between ULTIMO contributors, user needs, academic knowledge and real-world application.

More information on the hackathon results on this detailed report.

Figure 49: Photo of participants in the Padam Mobility and TPG challenge during the Smart City Xperience hackathon in Geneva

4.3.3 Ultimo Hackathon - Oslo

The ideas presented by the groups were of the highest quality. They expressed their doubts, expectations and vision of what this new RUTER service should offer. As the teams were free to choose the challenge of their choice, this gave an indication of the main concerns of the citizens present. Over a third of the teams chose the theme of on-board safety as their topic of discussion. This choice shows that, on the one hand, future users seem to be concerned about the change in habits implied by this new service, and on the other hand, they are keen to take part in discussions to propose socially acceptable solutions that will enable them to overcome their reservations about adopting these vehicles. Indeed, the proposed exercise enabled citizens to put their doubts into words, but also to overcome them by proposing solutions. While some ideas came up, such as making available on the automated vehicle reservation application a direct exchange service with RUTER customer service in the event of an uncomfortable situation, to reassure the passenger, this may demonstrate a real interest in the need expressed. To facilitate exchanges and encourage participants to express themselves freely, the teams discussed and presented their results in Norwegian.

Figure 50: Group photo during the ULTIMO project presentation at the Ultimo hackathon in Oslo

Each group focused on specific issues, proposing imaginative solutions to improve safety, accessibility, integration, and user experience in public and automated transport services. Below are the summaries of some problems identified and solutions proposed by some groups:

Group n°1 – Security Onboard

- Problem: The discomfort and safety concerns of sharing a vehicle with strangers.
- Solution: Introduced options for solo rides at a premium, implemented in-vehicle surveillance, provided emergency assistance buttons, and established a registration system for users to enhance safety.

Group n°2 – Travel in All Specific Situations

- Problem: The existing services are not catering to the needs of families with children.
- Solution: Proposed the introduction of vehicles with stroller spaces and integrated booster seats and considered the classification of vehicles to better accommodate families.

Group n°4 – Security Onboard

- Problem: Enhancing the sense of safety and control for users within the transportation service app.
- Solution: Offered various app functionalities for discreet help, direct police contact, and easy reporting of uncomfortable situations, alongside swift measures for banning users in cases of misconduct.

Group n°5 – Combining the journey with other travel modes

- Problem: Making public transportation a more attractive option compared to taxis and private cars.
- Solution: Suggested regulatory changes, the creation of no-drive zones, improved infrastructure, and dynamic routing to facilitate easier and more efficient travel across different modes.

Group n°10 – Combining the journey with other travel modes

- Problem: Achieving a service model that offers predictability and competitive pricing.
- Solution: Aimed to provide services for fixed routes at reduced prices for groups, inspired by delivery solutions, allowing users to choose from multiple commuting options based on cost and environmental impact.

Discover all the results of the hackathon in this report.

Figure 51: Photos of two prototype solutions devised by hackathon participants in Oslo

Of the hackathon participants, and although they were all RUTER employees, only 4 had heard of the ULTIMO project and the deployment of the automated shuttle service on the pilot site. Many participants were therefore novices, bringing a fresh perspective to the subject.

The hackathon was therefore a success in that it created a first contact for these citizens with the subject of automated mobility. At the end of each session, RUTER's ULTIMO team invited participants to join a mailing list to receive further information on the next stages of the project, and to invite them to come and test the pilot cars as soon as they became available. A community sensitive to the project's theme was born!

In terms of methodology, there are several best practices to be learned from this new hackathon format:

- Short but intense: we are convinced that the results obtained after just 3 hours of hackathon are just as relevant as after a traditional hackathon lasting several hours. This encourages us to rethink the format of our hackathons, moving towards shorter but more intense sessions. This is in line with the hackathon as a moment that is punctual, time-bound and intense.
- Without screens: participants at the Oslo hackathon came to take part with nothing but their ideas. No one had a laptop, no one used a smartphone. All were simply

focused on the co-creation exercise. This concentration and full presence were one of the keys to the quality of the results obtained in the very short time available. No distractions, just the exchange of ideas.

- Show rather than tell: although time was short, we were eager to encourage teams to turn their ideas into reality, using small-scale prototyping materials (cardboard, Lego, etc.) to achieve the best possible results. On the one hand, this allows us to be very clear in our explanations, and on the other, very proud to be able to show the culmination of our thinking.

4.3.4 Deliberation

In the course of organizing the first hackathons and while planning for citizen participation and deliberation, we realized that citizens have difficulties to overcome the cognitive barriers associated with representing automated vehicle technology and services, which do not exist yet, or at least have not been deployed to a point that it would feel concrete to people for envisioning a journey. From the first hackathon in Geneva with TPG in June 2023, it became clear that having citizens experience the vehicle (not moving) in a parking lot was not enough to build concrete deliberation on which automated mobility scenarios, compared to traditional mobility options, would be more desirable. So, the challenge is to build realistic journey scenarios, partially or fully involving automated mobility, and have citizens weigh them against non-automated mobility (pedestrian travel, bikes, public transportation). Because one core objective of Ultimo is to explore many scenarios, instead of one or few scenarios in usual citizen deliberation, Open Geneva needs a way to build a “factory” of scenarios, which involve travel choice trade-offs and uncertainty, exactly like when people face discrete short term travel choices11. Ideally, having people explore these scenarios and their trade-offs should entail some reward mechanisms. One solution would be to deliver a financial gratification to participants. However, the spirit of Open Geneva is rather the one of magnifying intrinsic motivation, i.e., the motivation of doing things for pleasure and for a sense of achievement, and by using collective intelligence12. Thinking of an instance of fast collective deliberation over many possible scenarios already set or to be invented, and implying choice trade-offs, we considered strategy board games. One example of a similar board game has been developed by students at the University of Geneva for dealing with trade-offs associated with the scarcity of sand, the third most consumed natural resource on Earth (Figure C). For transportation, “Ticket to Ride” board game is one famous example that stands out, with a large number of railway route building scenarios, associated with constraints, which are (i) endogenous, i.e., the route structure over the continent or the country), (ii) exogenous, i.e. the constraint of having wagons of same colour for each leg of the route, which drawn by chance, and (iii) interactive constraints, i.e., constraints born out of actions by other players (see Figure A) for a snapshot of Ticket to Ride Europe). Similarly, we can envision a board game for the test sites of the ULTIMO projects, which would encompass point-to-point travel scenarios, with endogenous constraints (e.g., geographical and technical), exogenous constraints drawn by lottery (e.g., type of mobility, age of the traveller, capital at hand to travel or to invest in optimizing mobility), and interactive constraints (e.g., policy choices by PTO/PTA, embodied by one or multiple players). The game can be designed to be cooperative, in the sense that participants (i.e., travellers and PTO/PTAs) must match demand and offer to reach socially efficient outcomes to earn points together by optimizing automated mobility offer. Capacity to reach consensus, i.e., a traveller choosing a proposed automated mobility option, or not, may reveal preferences. Repeated over many turns of the

game, many players, and many scenarios, one may elicit a new form of citizen deliberation. At this stage, Open Geneva is still in the phase of conceptualizing the game, in the coming months a laser-cut wooden prototype will be built for testing. Down the road, we could envision an electronic version of the game (c.f. Figure B) to scale up scenarios and citizen participation to enhance deliberation.

From left to right: Figure 52: Ticket to Ride Europe as a board game and Figure 53: Ticket to Ride Switzerland as an electronic version, allowing endless possibilities for scenario building and testing. Figure 54Example of the Sand Game, a serious game developed by students at the University of Geneva and the United Nations Environmental Program UNEP-GRID) to make the stakeholders of the construction sector (e.g. mining, rough material producers, architects, engineers, policy makers) aware of sand scarcity and learn how to envision alternative scenarios)

Annex

Blog post RUTER on Ultimo hackathon in January 2024

Self-driving hackathon with customer service at Ruter S

What will be most important for our customers when they travel with automated transport? What does Ruter need to manage in a good way for this to become a popular alternative to private cars? This was the theme at Ruter S last Wednesday and Thursday when Ruter's customer service participated in the self-driving project's hackathon, contributing their insights into what the residents in our region are most concerned about when they are out traveling.

"I believe the most fundamental aspect will be about safety and predictability. That the service is reliable and easy to use. But once the customer has started to trust the transportation, the popularity of the service in the long run will involve several factors, such as price, ticket options, and comfort," says Judith Ulstein Kvangarsnes from customer service. She is one of around 40 people who participated in the hackathon. Judith's group chose to focus on how Ruter's self-driving booking transport can compete against similar travel options from other providers, discussing discount and point systems, gamification, and methods to attract young people to prefer Ruter's services. Other groups have worked on completely different things, such as seat configuration in vehicles and how the digital user interface can be designed.

AGGREGATED KNOWLEDGE

The hackathon was organized by Ruter's self-driving project and the innovation company Open Geneva. The latter is one of Ruter's many international partners through the EU-financed consortium ULTIMO. Open Geneva organizes insight workshops and hackathons for various companies and is accustomed to involving groups of citizens in such sessions. They were positive about Ruter's proposal to use their own employees from customer service.

"The employees from customer service have an aggregated knowledge about what Ruter's many thousands of customers are concerned about. By tapping into their insights, we get a lot out of even relatively short sessions like this," said Julia Dallest from Open Geneva.

"And we see an advantage in that the people in the room know and work with each other from before. It creates a safe atmosphere where people dare to discuss openly and share ideas that are not completely polished."

FURTHER PROCESSING

Reflections, solution proposals, and simple prototypes from the work sessions at Ruter S will be further processed by the self-driving project afterward. Much of the material may become directly relevant in the Groruddalspiloten and the design of the self-driving booking service to be tested there.

But at the same time, Ruter must plan for the scaling of automated transport services that could happen after the pilot project in Groruddalen. Therefore, Tine Marthinus, Lene Godager

Kaas, and Heidi Aakre Juvik were also present. They work on respectively pre-projects for automated booking transport on a larger scale and on-demand transport.

"Through work sessions like this, we become a little wiser about what we need to offer our customers and demand from the operator market for our services to become popular. It is crucial that we meet the customer's needs for this to become a real alternative to private cars," said Tine." Additional information