AVENUE

Autonomous Vehicles to Evolve to a New Urban Experience

DELIVERABLE

D2.6 Final Passenger needs analysis and specifications

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Acronyms

ABSV	(German) Association for the Blind and Visually Impaired
ADS	Automated Driving Systems
AI	Artificial Intelligence
API	Application Protocol Interface
AV	Fully Automated Vehicles
AVAS	Acoustic Vehicle Alerting System
BMM	Business Modelling Manager
CAV	Connected and Autonomous Vehicles
CB	Consortium Body
CERN	European Organization for Nuclear Research
D7.1	Deliverable 7.1
DC	Demonstration Coordinator
DI	The department of infrastructure
DMP	Data Management Plan
DSES	Department of Security and Economy Traffic Police
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	Federal Roads Office
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
LA	Leading Author
MEM	Monitoring and Evaluation Manager
OCT	General Transport Directorate of the Canton of Geneva
ODD	Operational Domain Design
OEDR	Object And Event Detection And Response
OFCOM	Federal Office of Communications
PC	Project Coordinator
PEB	Project Executive Board
PGA	Project General Assembly
PIS	Passenger Information System
PRM	Persons with Reduced Mobility
PSA	Group PSA (PSA Peugeot Citroën)
PTO	Public Transportation Operator
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	Cantonal Vehicle Service
SDK	Software Development Kit
SMB	Site Management Board
SoA	State of the Art
SOTIF	Safety Of The Intended Functionality
SWOT	Strengths, Weaknesses, Opportunities, and Threats.
TM	Technical Manager
TSI	Technical Specifications for Interoperability
UITP	*Union Internationale des Transports Publics*
UNECE	United Nations Economic Commission for Europe
WP	Work Package
WPL	Work Package Leader
WTORS	Wheelchair tiedown & occupant restraint systems

Executive Summary

User experience and accessibility, e.g. for Persons with Reduced Mobility (PRM), play a major role when trying to develop and establish innovative and disruptive urban public transport services. Moreover, access of PRMs to public transport is a human right and mandatory in Europe (and member states). To ensure that the AVENUE minibuses and the services around them are not only usable but also well accepted by all users including PRM (elderly, people with disabilities and in general potentially vulnerable users) we are following the human centred design process for interactive systems (ISO 9241-210). Following this standard, we ensure that all relevant stakeholders play an important role in the requirement phase and throughout the project.

This is the final version of the AVENUE Passenger needs and analysis document which is due one and a half years after the 2nd version. While the D2.5 had its focus mainly on users that have already used or are even familiar with fully automated vehicles in public transport this version has a special focus on the passenger needs using AVs including services inside and outside of the vehicle.

Due to the COVID-19 pandemic, a big user study with onboard evaluation in the running vehicles was not possible. Instead, before the pandemic the results were gathered during several events organized for persons with special requirements and observations in several cities, and during the pandemic in classical PT. The pandemic not only confronted us with restrictions that hindered our surveys and studies. It also presented us with an unexpected experiment: To protect the bus drivers, barriers were erected separating them from the passengers and cutting off communication between passenger and driver. From the passengers' point of view, the offered service was a simulation of a driverless vehicle.

1 Introduction

AVENUE aims 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 2 to 3 replicator cities. The AVENUE vision for future public transport in urban and suburban areas, is that fully automated vehicles will ensure safe, rapid, economic, sustainable and personalised transport of passengers. AVENUE introduces disruptive public transportation paradigms on the basis of on-demand, door-to-door services, aiming to set up a new model of public transportation, by revisiting the offered public transportation services, and aiming to suppress prescheduled fixed bus itineraries.

Vehicle services that substantially enhance the passenger experience as well as the overall quality and value of the service will be introduced, also targeting elderly people, people with disabilities and vulnerable users. Road behaviour, security of the fully automated vehicles and passengers' safety are central points of the AVENUE project.

At the end of the AVENUE project four-year period the mission is to have demonstrated that fully automated vehicles will become the future solution for public transport. The AVENUE project will demonstrate the economic, environmental and social potential of fully automated vehicles for both companies and public commuters while assessing the vehicle road behaviour safety.

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, citizen's 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 fully 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.

1.2 Fully Automated Vehicles

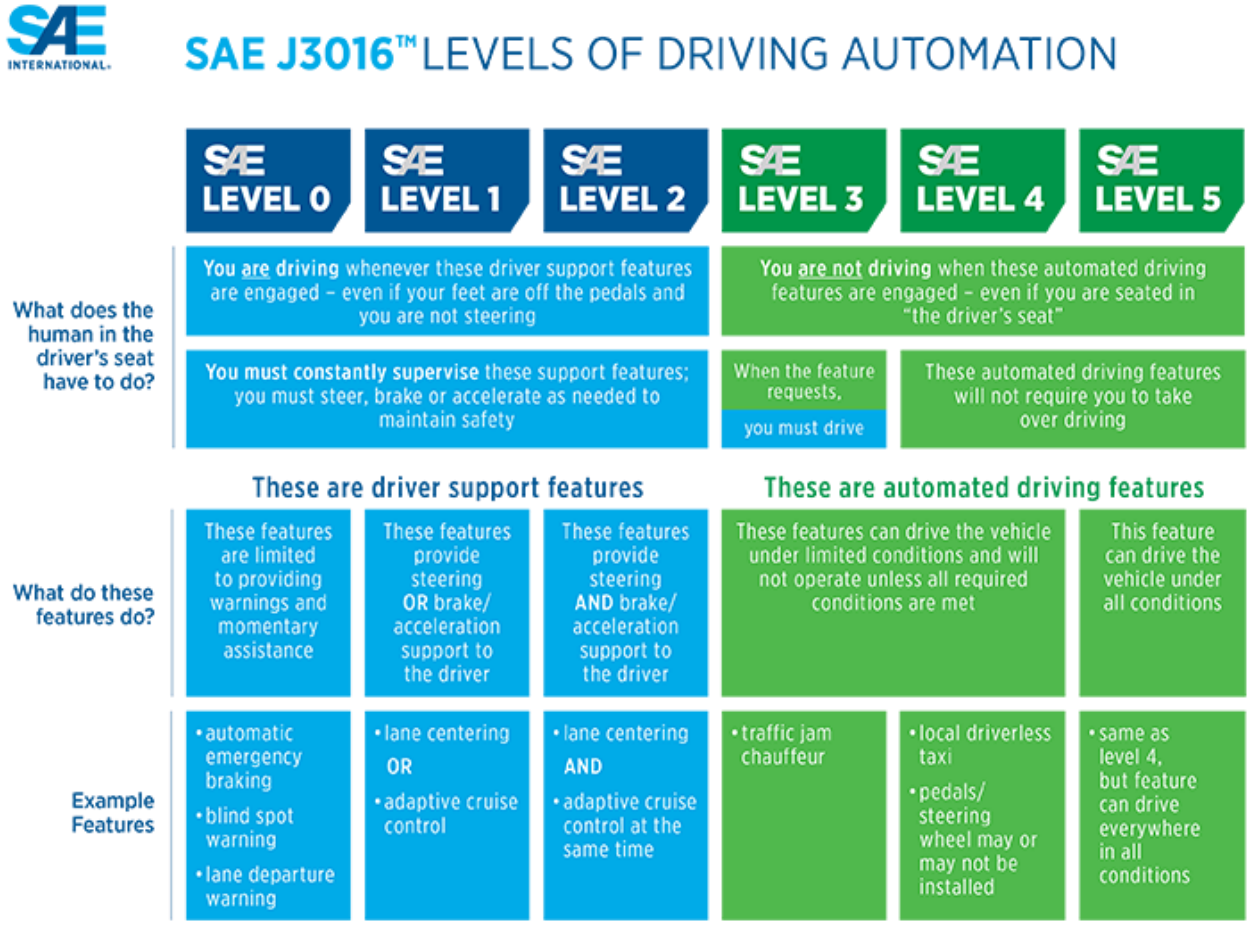
A self-driving car, referred in the AVENUE project as an Fully Automated Vehicle (AV), also referred as Autonomous Vehicle, is a vehicle that is capable of sensing its environment and moving safely with no human input.

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 AVENUE we operate Fully Automated minibuses for public transport, (previously referred as Autonomous shuttles, or Autonomous buses), and we refer to them as simply Automated minibuses or the AVENUE minibuses.

In relation to the SAE levels, the AVENUE project will operate SAE Level 4 vehicles.



1.2.1 Autonomous vehicle operation overview

We distinguish in AVENUE two levels of control of the AV: micro-navigation and macro-navigation. Micro navigation is fully integrated in the vehicle and implements the road behaviour of the vehicle, while macro-navigation is controlled by the operator running the vehicle and defines the destination and path of the vehicle, as defined the higher view of the overall fleet management.

For micro-navigation Automated Vehicles combine a variety of sensors to perceive their surroundings, such as 3D video, LIDAR , sonar, GNSS, odometry and other types sensors. Control software and systems, integrated in the vehicle, fusion and interpret the sensor information to identify the current position of the vehicle, detecting obstacles in the surround environment, and choosing the most appropriate reaction of the vehicle, ranging from stopping to bypassing the obstacle, reducing its speed, making a turn etc.

For the Macro-navigation, that is the destination to reach, the Automated Vehicle receives the information from either the in-vehicle operator (in the current configuration with a fixed path route), or from the remote control service via a dedicated 4/5G communication channel, for a fleet-managed operation. The fleet management system takes into account all available vehicles in the services area, the passenger request, the operator policies, the street conditions (closed streets) and send route and stop information to the vehicle (route to follow and destination to reach).

1.2.2 Automated vehicle capabilities in AVENUE

The Automated vehicles employed in AVENUE fully and automatically manage the above defined, micro-navigation and road behaviour, in an open street environment. The vehicles are Automatically capable to recognise obstacles (and identify some of them), identify moving and stationary objects, and Automatically decide to bypass them or wait behind them, based on the defined policies. For example with small changes in its route the AVENUE shuttle is able to bypass a parked car, while it will slow down and follow behind a slowly moving car. The AVENUE vehicles are able to handle different complex road situations, like entering and exiting round-about in the presence of other fast running cars, stop in zebra crossings, communicate with infrastructure via V2I interfaces (ex. red light control).

The shuttles used in the AVENUE project technically can achieve speeds of more than 60Km/h. However, this speed cannot be used in the project demonstrators for several reasons, ranging from regulatory to safety. Under current regulations the maximum authorised speed is 25 or 30 Km/h (depending on the site). In the current demonstrators the speed does not exceed 23 Km/h, with an operational speed of 14 to 18 Km/h. Another, more important reason for limiting the vehicle speed is safety for passengers and pedestrians. Due to the fact that the current LIDAR has a range of 100m and the obstacle identification is done for objects no further than 40 meters, and considering that the vehicle must safely stop in case of an obstacle on the road (which will be "seen" at less than 40 meters distance) we cannot guarantee a safe braking if the speed is more than 25 Km/h. Note that technically the vehicle can make harsh break and stop with 40 meters in high speeds (40 -50 Km/h) but then the break would too harsh putting in risk the vehicle passengers. The project is working in finding an optimal point between passenger and pedestrian safety.

Due to legal requirements a Safety Operator must always be present in the vehicle, able to take control any moment. Additionally, at the control room, a Supervisor is present controlling the fleet operations. An Intervention Team is present in the deployment area ready to intervene in case of incident to any of the minibuses.

1.3 Preamble

Work package 2 *Requirements and Use Cases* paves the foundation for developing and establishing innovative and disruptive urban public transport services.

Task 2.2 *Passenger needs (including PRM) and requirements specification* takes care of all users and their needs. To ensure that all needs are considered, AVENUE aims to continuously involve users throughout the project.

This Deliverable is the update of "D2.5 - Second Passenger needs analysis and specifications" and is the 3rd version of a series of three deliverables. It provides an overview of consultations and observations made in and out of fully automated vehicles in Geneva as well as experiences gathered during bus rides during the pandemic situation, as well as the resulting analysis and the definition of the user requirements. These requirements have been derived from the conducted observations and interviews with users and user organizations and from relevant normative and legal documents.

1.4 Motivation and context

Public transport has changed a lot in the last 30 years. In many cases the whole infrastructure provides tailor-made services like e.g. mobile tickets or mobility services for the wide range of people who frequently use the different transport systems. In particular the requirements of people with disabilities and older persons are now considered during all development stages of new vehicles, bus stops or ticket machines to really fit the special needs of the different target groups. New service solutions include the support of smart devices like e.g. mobile phones to allow people to use their preferred method to purchase tickets, to schedule their transport as well as to get a lot of useful information while they are on the go. Some PTOs already offer a Bluetooth connection to the board computers1 of buses and trams allowing users to get additional information on the route or allow passengers to remotely control the vehicle by transmitting signals to trigger stop and other service requests using their Smartphone. Being used to these services the expectations of future mobility services is rather high.

Figure 1: Radar APP

Therefore, to set up a new model of public transportation targeting also elderly people, people with disabilities and vulnerable users, a user centred design approach is essential. Such an innovative model will only be successful when the needs of the users (passengers) are considered sincerely in the specifications and functionalities. Consequently, AVENUE aims to include and consult users-right from the beginning of the project and throughout the project. It is important to identify these requirements as a first step of the project. For that reason, a survey acquiring these needs has been conducted right at the beginning. The goal of these interviews was to gather all requirements, problems and identify strategies that passengers have developed to overcome barriers. As problems and solutions might vary between local areas and between nationalities, interviews have been conducted by all involved partners and in all participating countries.

Besides users, also regulations in Europe and in the different countries play a major role. The following directives and laws have direct influence on our developments (an extract of the most important ones can be found in Annex A: Legal Overview

- Bus & Coach Directive 2001/85 ECE (Repealed 2014): Accessibility of the vehicle (ramps, kneeling systems, lifts) & wheelchair & occupant restraint systems (WTORS) for wheelchair occupant & bus passenger safety
- REGULATION (EC) No 661/2009 [1] *(successor of Bus & Coach directive) Article 7* 4. Vehicles of Class I shall be accessible for people with reduced mobility, including wheelchair users
- Regulation No 107 [2] of the Economic Commission for Europe of the United Nations (UNECE) — Uniform provisions concerning the approval of category M2 or M3 vehicles with regard to their general construction
- REGULATION (EU) 2019/2144 of the EUROPEAN PARLIAMENT and of the COUNCIL. Article 11 Specific requirements relating to automated vehicles and fully automated vehicles

[1] PaderSprinter Kompass APP https://www.padersprinter.de/kompass-app/ ivantoCore https://www.ivanto.de/home_en/

- In Switzerland Section 3 of the Directive on the technical requirements for the accessibility of public transport defines the Special requirements for bus and trolleybus services.

Indirect influence:

- COMMISSION REGULATION (EU) No 1300/2014 [3]

When applying today's regulation to our project, there are many things that need to be clarified.

E.g.: Regulation No 107 Annex A 3.3.4: *If a vehicle is fitted with a ramp or lift, a means of communication with the driver shall be fitted outside, adjacent to the door, and at a height between 850 mm and 1 300 mm from the ground. This requirement shall not apply to a door situated in the direct field of vision of the driver*.

How can operators follow this rule in a driverless vehicle?

2 Evaluations and user studies

The aim of the first user studies in 2018 was to fully understand the needs, the issues and the problems of public transport users and the personal tricks and strategies they have developed for themselves. The aim of the 2nd version of this deliverable was to go beyond anticipated experiences and to figure out the issues, the problems and the missing services in fully automated vehicles. The final version aimed at identifying requirements that have not been identified or even solved in the earlier deliverables. The idea was to make a requirement analysis with frequent users of AVs and even in regions with real AV door-to-door service.

Due to the COVID-19 pandemic all plans had to be reconsidered: Travel and meetings with passengers were no longer possible. Even more: in most European countries, the lockdown completely brought public transport to a standstill. After the lockdown public transport was only partly relaunched, as of today, in many cities public transport remains well below the pre-crisis level.

However, the pandemic not only confronted us with restrictions, but it also presented us with an unexpected experiment: To protect the bus drivers, barriers were erected separating them from the passengers and cutting off communication between passenger and driver. From the passengers' point of view, the offered service was a simulation of a driverless vehicle, therefore being a real alternative to observe and gather requirements in times where the AVENUE minibuses are out of service. Given their size and the fact that there is a safety operator on board, AVs were even more compromised: The distance rules to prevent COVID-19 cannot be respected in such a small vehicle and separating the driver was not really feasible. This resulted in the fact that the AVs were brought down even longer than a classical bus.

Therefore, evaluations and user studies are limited to meetings conducted before the pandemic, as well as observations in public transport in pandemic mode as well as literature research and remote interviews.

2.1 Walkthrough with (disabled) users

Passengers are the most important source when gathering user requirements and to raise awareness. Due to the fact that people with disabilities have special requirements they play an important role when gathering user requirements and trying to identify barriers. Taking into account that every human will have some type of disability in his/her life or can be situational induced disabled (e.g. wearing a headset), the requirements derived from people with disabilities will be useful for all.

The AVENUE partner TPG is organizing regular so called "social audits" to identify barriers and to raise awareness in their workforce. During such an audit, persons with disabilities from the local disability association as well as TPG drivers come together and form small groups (One disabled person and two drivers). Each group then commutes for two hours through Geneva, whereby the disabled person is observed from a distance by the two drivers. The results of this observation are than discussed together to exchange experiences.

The AVENUE project took the opportunity to join the social audit in February 2020 just before the pandemic took hold of Europe and the world. During this audit a blind person and a person in a wheelchair were observed using the AVENUE minibuses.

2.2 Driving a bus in a pandemic situation

Public transport in the pandemic situation is somehow a simulation of "fully automated driving" of buses on a large scale. To protect the driver, they were completely isolated from the passengers and only the rear doors may be used. In some cases, the driver section including the front row was completely separated, e.g. with foil or plexiglass. Therefore, the driver is no longer available as a contact person.

3 Analysis of the results

3.1 Analysis of the social audit

The AVENUE project took the opportunity to join the social audit in February 2020 just before the pandemic took hold of Europe and the world. During this audit we got the opportunity to observe a blind person and a person in a wheelchair while commuting through Geneva including the usage of the AVENUE minibuses. After the commuting we got the opportunity to discuss with both users their experiences and their wishes.

3.1.1 Detailed walk-through with wheelchair user

The wheelchair user that was observed has a lot of experiences with public transport. The trams in Geneva are equipped with an automatic ramp, therefore besides of the crowded Tram, no major issues could be identified while commuting with standard vehicles.

Figure 2: Tactile markers and automatic ramp

The usage of the AVENUE minibuses on the other hand was a bit different.

As the automatic ramp of the vehicle does not comply with legal requirements in Geneva (it is too steep), the AVs are equipped with manual ramps. The safety operator had to install the ramp and help the passenger entering the vehicle, as the slope is still 17.3%.

Figure 3: Manual ramp and buckling up

The next difficulty occurred inside the vehicle: the wheelchair had to be buckled up sitting against the driving direction directly in front of the folded-up priority seat. Due to the installation of the belt, this can only be done with the help of the safety operator.

When leaving the bus, the wheelchair needs to be unbuckled and the ramp had to be installed again both by the safety operator.

A real driverless usage of the AVENUE minibuses by wheelchair users is actually not really possible, as the wheelchair driver can neither enter nor leave the bus without help.

3.1.2 Detailed walk-through with blind user

Like the user in the wheelchair the blind user that was observed has a lot of experiences with public transport. He takes PT every day to go to work without anyone accompanying him. The public transport stops in Geneva are equipped with tactile paving and markers (see Figure 2). A theoretically positive example is the marker to find the front door of the bus. While this is a good idea, finding the relatively small marker by the blind is very difficult. Better would be if the tactile paving would be used to guide the blind exactly to this point, or to use a huger marker.

Figure 4: Front door marker

The trams and busses in Geneva are equipped with good passenger information system. All necessary information at the station and in the vehicle is available following the two-channel principle therefore no major issues could be identified while commuting with standard vehicles. Even the language barrier (the blind traveller does not understand or speak French) could easily be solved by friendly drivers and passengers that could speak English or German.

The changeover from the tram to the autonomous minibus proved to be more difficult.

The environment was completely unknown for the blind user, and therefore he wasn't able to find the bus stop on his own without assistance, even though the address of the corresponding bus stop. The bus stop itself was neither equipped with audio signals (like e.g. attention signals on traffic lights) nor with tactile markers on the walkway, which could help blind users to find and quickly locate specific places on their own (see Figure 5).

Figure 5: Bus stop of the AV

This perfectly reflects the use case that will happen when real door-to-door services with fully automated vehicles will be available.

The autonomous bus is not equipped with Acoustic Vehicle Alerting System (AVAS), therefore the arrival of the bus was difficult to detect for the user, who wasn't able to perceive road noise from the bus due to environmental sounds. It was also difficult to find the button to open the door, but with the help of the safety operator he made it into the bus and could find a suitable place. Due to a missing suitable dual channel passenger information system the blind user was not able to distinguish between a stop caused by the traffic or due to an arrival at the bus stop.

3.2 Driving a bus in a pandemic situation

The idea for this source of information was given by blind passengers after using public transport during the COVID-19 pandemic. Blind users said that the current situation is somehow a simulation of “autonomous driving” of buses on a large scale: Suddenly in all buses the driver section including the front row was completely separated, e.g. with foil or plexiglass. Therefore, the driver is no longer available as a contact person.

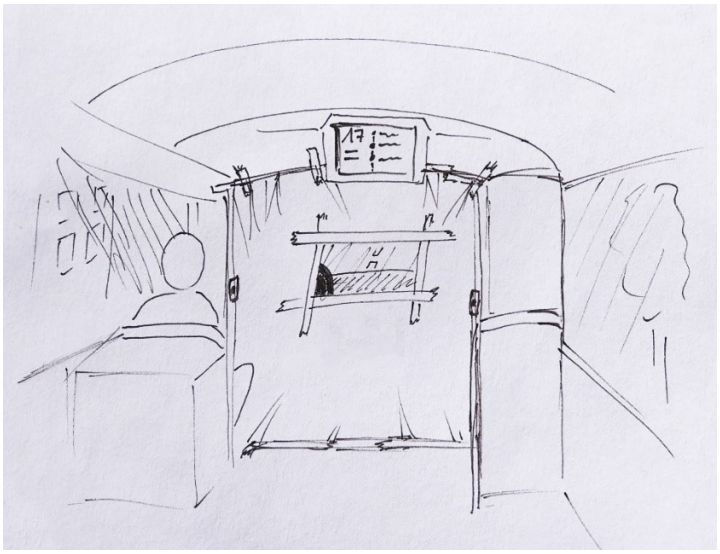


Figure 6: Bus during pandemic situation

Ticket purchases from the driver are no longer possible. Tickets could only be bought via app or at ticket machines which are installed at the major bus stops. This restricts the user group to users with an affinity for technology or to people who use the main stops anyway.

Besides the ticketing, also no assistance is given by the driver e.g. for the mechanical ramp which hinders wheelchair drivers to board the bus. Fortunately, it turns out that in these times people move closer together: it was reported that other passengers immediately helped to fold out the ramp, so that the wheelchair was able to board the bus.

Especially for blind people it has become more complicated, as the driver cannot support the blind to identify the right bus or to notify connecting buses about a blind willing to enter the bus.

Assistive apps that help to identify the correct bus or allow to open and close bus doors can be a solution, but they are never a 100% guarantee, especially at bus stops with a high bus frequency and many busses at the same time.

3.2.1.1 Summary

Some of the above-mentioned accessibility issues can be resolved by using the capabilities of a modern mobile phone. For example, GPS localisation, online timetables and Bluetooth connections to the bus could help users to successfully deal with these specific problems. But in most cases, there are a lot of additional improvements required to answer the needs of this user group and to ensure a comfortable public transport with fully automated vehicles. Chapter 5 provides a mock-up co-created with disabled passengers that tries to cope with these issues.

4 Acceptance of fully automated vehicles – obstacles and motivators

The list of obstacles and motivators in Chapter 3.4 of D2.5 still remains valid today. There is no reason why this (=the society's attitude) should have changed within the last year.

There is one exception, however:

Because of the Corona crisis there is an increased awareness that people might lose their jobs. While this issue has always been mentioned in connection with driverless vehicles, it can be assumed that this plays a bigger role than a few years ago.

We recommend to emphasize that it is not about replacing bus drivers who will then be losing their jobs but about establishing additional services especially in regions where PT is commercially not attractive.

5 Use cases and requirements

Although the COVID-19 pandemic did not allow us to conduct a bigger user study, the use cases and requirements gathered in D2.4 and D2.5 are still valid. To avoid duplication please refer to Chapter 4 of D2.5 and D2.4. To have a quick overview we leave the table-based overview also in this Deliverable

5.1 General User needs and requirements structured by application

5.1.1 Outside the vehicle

Bus station /Bus stop			
ID/Number	Requirement	Expectation	Source
1	The infrastructure at each station shall be identical.	Should have	Userreq.
2	The infrastructure at each station shall offer shelter.	Must have	
3	The infrastructure at each station shall offer tactile paving.	?	
4	The infrastructure at each station shall offer sufficient lighting.	Must have	Userreq.
5	Incoming busses shall be announced (audio) at the station (like at train stations): bus line and destination		Userreq.
6	There shall be audio and visual information at the bus stop that indicates the direction of all bus lines departing from this stop.		Userreq.

Line indicator / Identification of the line / Vehicle			
ID/Number	Requirement	Expectation	Source
7	The line shall be displayed on the vehicle (visual)	Must have	Userreq.
8	The bus shall announce itself at the bus station (audio) (route, branch letter, direction and destinations)	Should have	Userreq.
9	It shall be visually and acoustically recognizable when the vehicle has come to a standstill (very quiet vehicle).	Should have	Userreq.
	Acoustic Vehicle Alerting System (AVAS) Manufacturers shall install AVAS meeting the requirements set out in Annex VIII in new types of hybrid electric and pure electric vehicles by 1 July 2019. Manufacturers shall install AVAS in all new hybrid electric and pure electric vehicles by 1 July 2021.		EU 540/2014 Article 8

Doors and entrances			
ID/Number	Requirement	Expectation	Source
10	Doors shall be reliably and safely detectable (visually and tactilely) outside of the vehicle.	Must have	Userreq.
	Doors or the outline of doors operated by passengers shall be detectable by the visually impaired on the outside of the vehicle.		Switzerland: VAböV Art. 15
	When a door is automatically or remotely opened by the driver or other member of the train crew a signal shall be given: • that is clearly audible to persons inside the train • that is clearly audible to persons outside the train • that is clearly visible to persons inside & outside the train • This signal shall last for a minimum of 3 s from the moment that the door starts to open		FprEN 16584-2:2015 5.3.3.2 ff
11	Doors shall recognize objects of ≤ 1.5 cm diameter over the entire height (white cane or dog leash).	Should have	Userreq.
12	Doors shall open long enough for passengers to safely get in and out	Must have	Userreq.
13	Doors shall indicate before they close	Must have	Userreq.
14	Doors shall be prevented from closing on a passenger	Must have	Userreq.
	Automatic and semi-automatic, doors shall incorporate devices that detect if they close on a passenger where a passenger is detected the doors shall automatically stop and remain free for a limited period of time.		TSI/PRM (2008) 4.2.2.4.2.1.
	If the passenger enters or leaves the vehicle while the door is closing, the closing process shall be interrupted automatically and the door shall return to the open position. The reversal may be actuated by one of the safety devices referred to in paragraph 7.6.6.3.1 above or by any other device.		UNECE R107 7.6.6.3.2
Interface of door control device			
15	There shall be an acoustic detection signal for door button (outside)	Should have	Userreq.
	Door controls, whether manual, pushbuttons or other devices, shall contrast with the surface on which they are mounted.		TSI/PRM 4.2.2.3.1
	(1) A door control device shall have visual indication, on or around it when enabled and shall be operable by the palm of the hand exerting a force not greater than 15 N. (2) It shall be identifiable by touch (for example: tactile markings); this identification shall indicate the functionality.		TSI/PRM 5.3.2.1.

5.1.2 In the vehicle

Passenger Information system			
ID/Number	Requirement	Expectation	Source
16	The next stop shall be announced optically and acoustically (2-channel principle).	Must have	Userreq.
17	The announcements in the bus shall include information about available connections.	Should have	Userreq.
Displays			
	Displays shall be sized to show individual station names or words of messages. Each station name, or words of messages, shall be displayed for a minimum of 2 seconds.		TSI/PRM 5.3.1.1.
	If a scrolling display is used (either horizontal or vertical), each complete word shall be displayed for a minimum of 2 seconds and the horizontal scrolling speed shall not exceed 6 characters per second.		TSI/PRM 5.3.1.1.
	Displays shall be designed and assessed for an area of use defined by the maximum viewing distance according to the following formula: Reading distance in mm divided by 250 = font size (for example: 10 000 mm/250 = 40 mm).		TSI/PRM 5.3.1.1.
Acoustical announcements			
18	Volume of acoustical announcements shall adjust automatically depending on the noise level in the vehicle.	Must have	Userreq.
	The spoken information shall have a minimum STI-PA level of 0,45, in accordance with the specification referenced in Appendix A, index 5.		TSI/PRM 4.1.2.11
	The spoken information shall have a minimum RASTI level of 0,5, in accordance with IEC 60268-16 part 16, in all areas. Where provided, spoken information shall be consistent with essential visual information that is being displayed. Where spoken information is not provided automatically, an audible communication system shall be provided to allow users to get information upon request.		TSI/PRM (2008) 4.1.2.11
	Acoustic passenger information must be easily understandable for the hearing impaired, and in particular appropriate acoustic announcements in passenger compartments must be provided. If necessary, they must be repeated or be repeatable on demand		Switzerland VAböV Art 5

Vehicle			
ID/Number	Requirement	Expectation	Source
24	The floor shall be totally low with no steps.	Must have	Userreq.
25	The doors shall be reliably and safely detectable inside the vehicle.	Must have	Userreq.

Light			
ID/Number	Requirement	Expectation	Source
19	The lights in Busses shall be improved, lights shall not be dazzling.	Should have	Userreq.
20	The lighting in the vehicle must be bright enough to enable unobstructed movement in the vehicle.	Must have	Userreq.
21	Shadows shall be avoided in the vehicle	Should have	Userreq.
22	Indirect lighting shall be provided to avoid glare and reflections (e.g. on glass surfaces).	Should have	Userreq.
23	The door areas, step edges and danger areas shall be adequately illuminated	Must have	Userreq.
	Internal electrical lighting shall be provided for the illumination of: All passenger compartments, crew compartments, toilet compartments and the articulated section of an articulated vehicle; Any step or steps; The access to any exits and the area immediately around the service door(s) including, when in use, any boarding device fitted; The internal markings and internal controls of all exits; All places where there are obstacles;		Regulation No 107 7.8. Artificial lighting

Passenger Interaction			
ID/Number	Requirement	Expectation	Source
26	The interior of the vehicle shall be designed to enhance passenger interaction.	Nice to have	Userreq.

5.2 Passenger needs and requirements

A strict classification of passenger groups and their needs as well as recommended access criteria seems difficult to be defined. Visually impaired users also benefit from audio and tactile interfaces, like most other passenger groups. And not all members of the same group feature identical experience level in terms of mobility capability. For example, providing an assistance service through a smartphone app would only support those who are able to operate the smartphone.

Only taking all different group needs into account when deploying a public transport infrastructure leads to an accessible environment which is suitable for all potential passengers.

Classification of passenger groups (PG) (user needs are derived from EN301549 [4]):

PG 01: Passengers without vision	
User needs	Recommended access criteria
If visual modes of operations are provided, these users need at least one mode of operation that does not require vision. Audio and tactile user interfaces contribute the ease of use for this group.	▪ Tactile markers on the sidewalk to allocate the bus stop ▪ Audible notifications of arrivals, departures, and delays ▪ AVAS ▪ Appropriate indicator for ramp movements ▪ …

PG 02: Passengers with limited vision	
User needs	Recommended access criteria
If visual modes of operations are provided, these users need operation features that enable them to make better use of their limited vision. Magnification, reduction of required field of vision and suitable contrast, brightness and colour intensity contribute ease of use for this group. Users with limited vision also benefit from non-visual access (see PG 01)	▪ High contrasted markers on the sidewalk to allocate the bus stop ▪ Passenger info systems at eye level. ▪ Anti-glare displays ▪ …

PG 03: Passengers without colour perception	
User needs	Recommended access criteria
If visual operation modes are provided, these users need a visual operation mode that does not require a perception of colour. When significant features of interaction routines are only colour-coded, additional methods of distinguishing between the different features should solve the operating difficulties.	▪ Coloured door open button with additional label ▪ Coloured bus stop request button with additional label ▪ Passenger info display with appropriate colour configurations for easy perception of just-in-time notifications ▪ …

PG 04: Passengers without hearing	
User needs	Recommended access criteria
If auditory operation modes are provided, these users need at least one mode of operation that does not only require hearing. Visual and tactile user interfaces should ease the interaction for this group.	▪ Appropriate visual just-in-time notifications ▪ Locatable passenger info systems ▪ Perceivable guiding routines in case of complex situations, e.g. ramp request requires boarding delay ▪ …

PG 05: Passengers with limited hearing	
User needs	Recommended access criteria
If auditory operation modes are provided, these users need advanced audio features. Enhancement of the audio clarity, reduction of background noise, increased volume level and greater volume in the higher frequency range should reduce the difficulties for this group. Users with limited hearing also benefit from non-hearing access (see PG 04)	▪ Appropriate loudspeaker announcements at the bus stop ▪ Appropriate loudspeaker announcements in the bus ▪ Haptic feedback instead of auditory feedback in terms of interactions ▪ …

PG 06: Passengers without vocal capability	
User needs	Recommended access criteria
If vocal input is required from users, these users need at least one additional operation method that does not only expect a spoken reply. Keyboard, pen or touch based user interfaces provide sufficient interaction routines for this group.	▪ Provision of mobile apps or online services as alternative for conventional landline connection to initiate door-to-door service requests ▪ Keyboard, pen or touch based user interface in terms of required intercommunication with control centers in case of emergency ▪ …

PG 07: Passengers with limited manipulation or strength	
User needs	Recommended access criteria
If manual interactions are required, these users need additional options that enable them to interact through easier methods not requiring complex handling routines or hand strength. Operations that users may not be able to accomplish include interactions that require fine motor control, complex gestures, ankle or wrist twisting, tight grasping, or simultaneous manual actions. Easy to perform one-handed operation methods, voice control or alternative user interfaces like mobile apps should ease the interactions for this group.	▪ Fully automatic ramp operation after ramp request ▪ Easy handling of collapsible seats ▪ Easy usable storage space ▪ Noncomplex touch interface for passenger info system supporting single-finger gesture control ▪ …

PG 08: Passengers with limited reach	
User needs	Recommended access criteria
If an interaction requires operations with free-standing or installed components, these components need to be within the reach of all users. Taking the needs of wheelchair users and the range of different body heights of passengers into account, the appropriate placing of interaction components should resolve handling difficulties for this group.	▪ Installation of height adjustable passenger info systems ▪ Appropriate placement of door open, stop and ramp request buttons for comfortable & safe usage ▪ Appropriate low-floor busses and fully automatic doors reduce required boarding/exiting interactions for the passengers ▪ …

PG 09: Passengers with limited cognition	
User needs	Recommended access criteria
Persons with limited cognitive, language and learning abilities need easy, non-complex interaction methods that assists them and make it simpler to use the public transport infrastructure. Adjustable timings for boarding, exiting or changeover tasks, comprehensible problem indication and appropriate attention rising routines should enable this group to accomplish public transport tasks successfully.	▪ Appropriate user interface for passenger interaction like e.g. a mobile app with simple language support ▪ Easy comprehensible notifications and instructions for changeover tasks caused by delays ▪ A logical focus order for boarding/exiting/changeover instructions provided by the user interface of the mobile app that guide the user through these complex tasks. ▪ …

PG 10: Elderly	
User needs	Recommended access criteria
▪ see PG 02, due to age ▪ see PG 05, due to age ▪ see PG 07, due to age ▪ see PG 08, caused by walking aids	▪ see above ▪ …

PG 11: Commuters	
User needs	Recommended access criteria
▪ see PG 09, cognitive strain caused by need for punctuality ▪ see PG 02, distracted by reading news or books on smartphone/tablet/eReader ▪ see PG 05, distracted by listening to news or audio books on smartphonephone/tablet/eReader	▪ see above ▪ …

PG 12: Business travellers	
User needs	Recommended access criteria
▪ see PG 09, cognitive strain caused by need for punctuality ▪ see PG 02, distracted by mobile working ▪ see PG 05, comprehension problems due to language barrier or by headphone usage for mobile working ▪ see PG 08, restricted reach due to luggage/backpack	▪ see above ▪ …

PG 13: Families	
User needs	Recommended access criteria
▪ see PG 09, cognitive strain caused by caregiving ▪ see PG 07, limited manipulation caused by baby carrier usage ▪ see PG 08, restricted reach due to backpack, shopping bag or prams	▪ see above ▪ …

PG 14: Pupils	
User needs	Recommended access criteria
▪ see PG 09, cognitive strain caused by need for punctuality ▪ see PG 08, restricted reach due to backpack, school bag and body size (primary school pupils) ▪ see PG 02, limited reading skills (primary school pupils) ▪ see PG 05, distracted by smartphone/headphone usage	▪ see above ▪ …

PG 15: Students	
User needs	Recommended access criteria
▪ see PG 08, restricted reach due to backpack/luggage ▪ see PG 02, distracted by reading news or books by smartphone/tablet/eReader ▪ see PG 05, distracted due to mobile working or by listening audio content with headphones	▪ see above ▪ …

PG 16: children/teenager	
User needs	Recommended access criteria
▪ see PG 02, distracted by smartphone usage ▪ see PG 05, distracted by headphone usage ▪ see PG 09, distracted by environmental situations, e.g. group discussions	▪ see above ▪ …

PG 17: tourists/nonlocal passengers/non-native speakers	
User needs	Recommended access criteria
▪ see PG 02, limited reading skills due to language barrier ▪ see PG 05, comprehension problems due to language barrier ▪ see PG 08, restricted reach due to luggage ▪ see PG 09, cognitive strain caused by language barrier ▪	▪ provide user interface in native language ▪ see above ▪ …

PG 18: Passengers doing shopping	
User needs	Recommended access criteria
▪ see PG 08, restricted reach due to shopping bag	▪ see above ▪ …

Note: It is obvious that covering the needs of persons with disabilities results in the positive side effect that the needs of all other passenger groups are also met.

All required interaction routines of public transport services should be available in different operation modes. For example, a door-to-door service should provide bus requests via landline as well as per smartphone app or online service. Boarding and exiting processes should be possible by direct door interactions but also hands-free, e.g. by using a mobile app. Passengers are then in a position to decide on the most suitable operating option, depending on the situation as well as their individual abilities and needs.

This approach ensures the advantage that there is always a safe fail-back strategy available for each passenger to accomplish the required interactions within the public transport environment.

An adequate equipment of AVs and bus stops with the required technologies and user interfaces enables PRM and all other passenger groups to use public transport in a safe and comfortable way, and even without the need of any additional smartphone apps.

6 Proposed Implementation of User requirements

Based on the requirements gathering and needs analysis in the previous years, we have developed some suggestions how AVENUE could respond to the requirements and needs public transport users have stated. We focused on three aspects:

- the needs of PRMs because this benefits ALL passengers
- the need for information (which goes beyond what passengers expect in “normal” PT)
- trust building - because this will increase user acceptance

6.1 Mock-up for an accessible companion app

Modern Smartphones offer an ideal interactive communication channel to cope with public transport information on a bus ride. With appropriate PT apps installed, passengers get a lot of important information like e.g. dynamic arrival, departure times or potential delays, assistance to identify their correct line & directions, changeover guidance and more. A lot of this information requires quick passenger interactions, like notifications for safe boarding, on bus stop requests and to exit the bus at the right bus stop.

Passengers have to react within limited time frames, often less than 2 minutes, to successfully reach their destinations. Mobile PT apps therefore should offer a non-complex user interface to allow passengers to deal with just-in-time information and notifications in a comfortable manner.

In particular PRM benefit from mobile apps to interact with public transport infrastructures like e.g. to stress-less buy e-tickets or to easily plan a bus trip with an appropriate low-platform vehicle (ideal for wheelchair and walker users). Blind passengers are able to quickly identify arriving bus lines and older passengers can trigger stop requests on the bus ride without leaving their safe seats.

The most important requirement in terms of smart mobility for PRM is an accessible and easy to use mobile app that fits their specific needs. Elderly prefer good legible fonts and high contrast to be able to use the provided information under all weather conditions. Blind users rely on spoken screen reader support. Other passengers claim on hands-free voice control, provided by most modern smartphones (see [5] and [6]).

Related to the above mentioned user stories (see chapter 3) and based on the observation study analysis shown in Deliverable D2.5 (see chapter 3.3 [7]) and its resulting use cases and requirements (detailed described in chapter 4 of D2.5 [8]), a team of accessibility experts developed a tailor-made user interface for a mobile app mock-up in February 2020.

Following the rules of a user centred design for all, the UI of the app is fully accessible for blind and visually impaired passengers. Due to the screen reader support, the app additionally ensures a complete hands-free gesture and voice control to meet the requirements of a broad user range.

The app is intended to provide mobile assistance in driverless public transport situations. In particular time limited tasks like the boarding process and exiting or changing over busses can now be successfully accomplished under the guidance from good perceivable just-in-time notifications and sufficient interaction instructions.

In the following, the user story of the bus ride and its dedicated mock-ups will be introduced:

The scenario

- Bus ride from starting point A to destination B.
- The bus traveller knows start and destination addresses.
- Depending on the real situation, different people have different requirements to overcome difficulties when travelling with public transport.

On the way to the bus stop

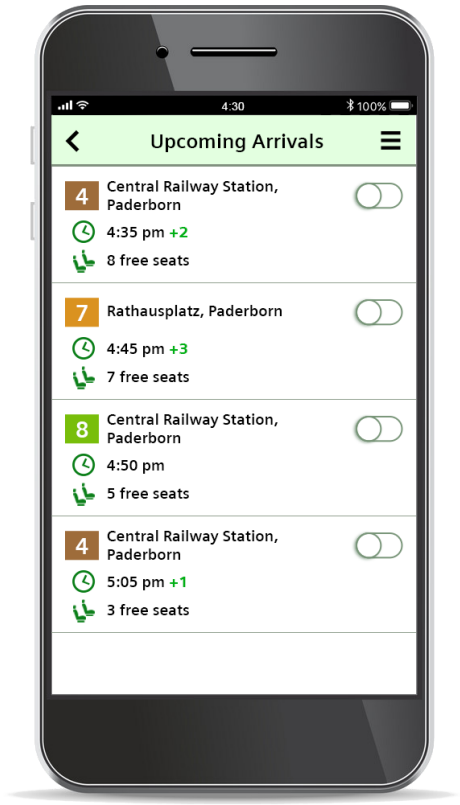
Finding the right bus stop requires …

- good perceivable bus stop signs,
- audio signals or tactile markers on the walkway for blind travellers,
- a GPS based localisation & navigation possibility for foreign travellers,
- human assistance.

At the bus stop

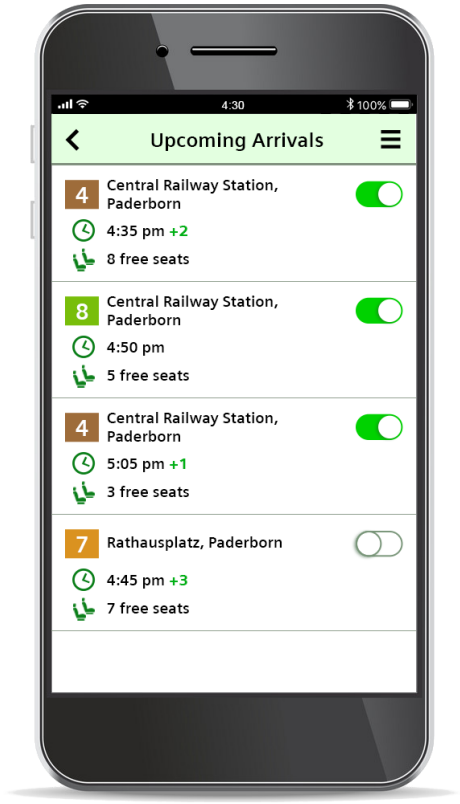
Requesting the right bus requires …

- a good legible traveller information system at the bus stop,
- loudspeakers announcing arrival/departure times for blind travellers,
- online traveller information system for blind or foreign travellers,
- an easy to find and self-explaining AV request button with tactile markers at the bus stop,
- a mobile app offering an online AV request for blind or foreign travellers,
- a landline or mobile based call service to trigger the AV request.



At the bus stop: *When arriving on site for departure*

- The app lists all busses that arrive at the bus stop where the passenger is now.
- Displayed information is
  - number of the bus line,
  - arrival time according to timetable plus delay,
  - number of free seats.
- The passenger can select one or more busses to request.



At the bus stop: *Waiting for arrivals*

- The app displays all requested busses at the top of the list.

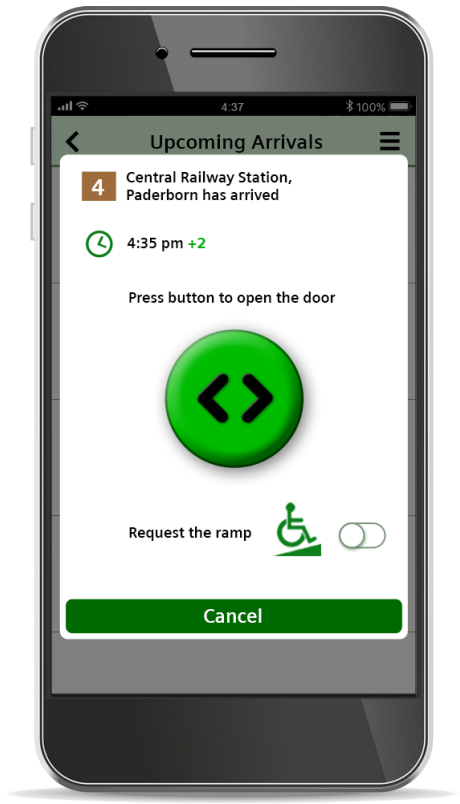
***At the bus stop**: After the arrival of a bus*

Identifying the right bus requires …

- identification of requested AV via good legible bus number & destination signs,
- loudspeaker announcements on arriving AVs for blind travellers installed at the bus stop,
- GPS triggered arrival notifications displayed on mobile apps for blind or foreign travellers,
- loudspeakers installed in the AVs announcing their own bus numbers and destinations,
- human assistance.

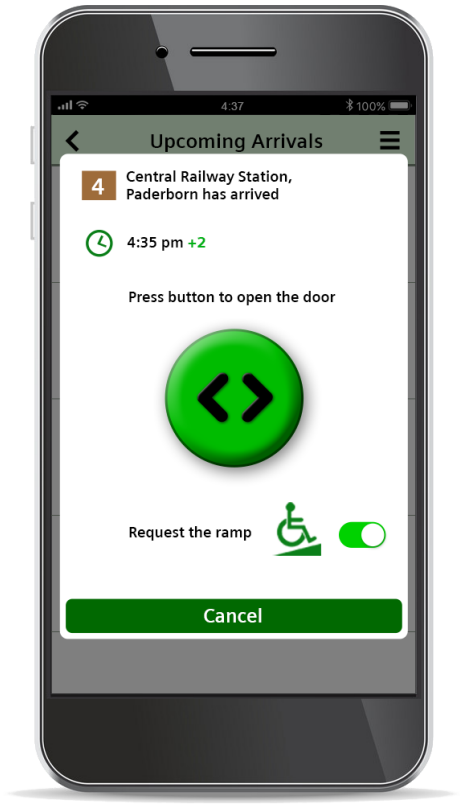
Entering the right bus requires …

- metro mode that opens the bus door automatically (not useful for ramps),
- easy to find self-explaining buttons to open the door or to request the ramp,
- tactile markings for the different buttons for blind travellers with appropriate trigger mechanisms,
- audible feedback if the ramp is requested to raise the awareness of other travellers who want to enter the bus,
- online "open door" or ramp request possibility via mobile app for seniors with walkers, blind or wheelchair travellers,
- human assistance.



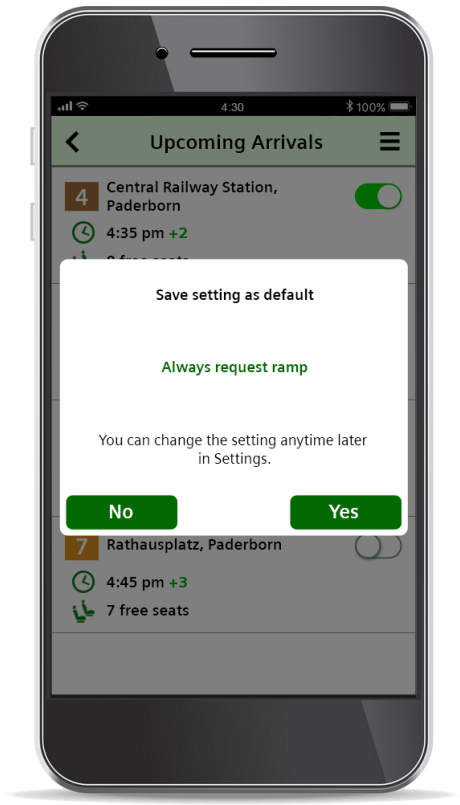
***At the bus stop:** After the arrival of a bus (1)*

- Bus 4 has arrived and has already released its door to be opened by the smartphone app.
- The smartphone vibrates and displays a modal notification in the middle of its screen providing a large opening button to open the entrance door of the bus.
- It also provides the option to request a ramp.



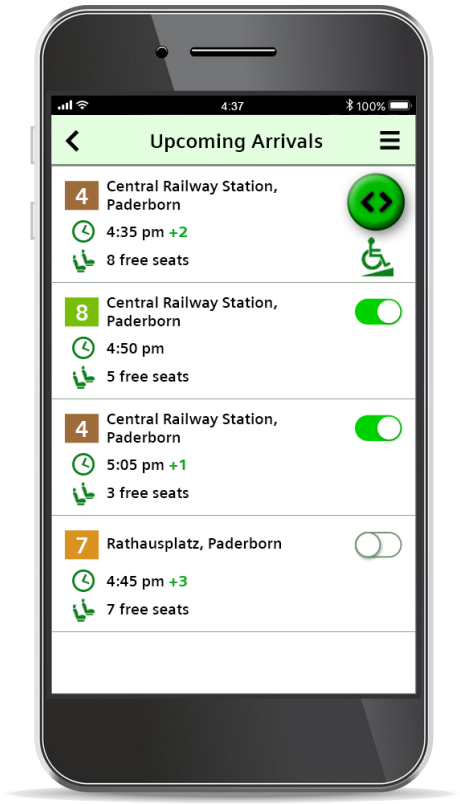
At the bus stop: *After the arrival of a bus (2)*

- Ramp request selected.



At the bus stop: *After the arrival of a bus (3)*

- The app offers to save the ramp request setting as a default.



At the bus stop: *After the arrival of a bus (4)*

- After (unintentionally?) cancelling the arrival notification of a bus, the bus entrance door can still be opened by the smaller version of the green opening button displayed directly right beside the respective bus list entry.
- The app also indicates if the ramp is requested.

On the bus

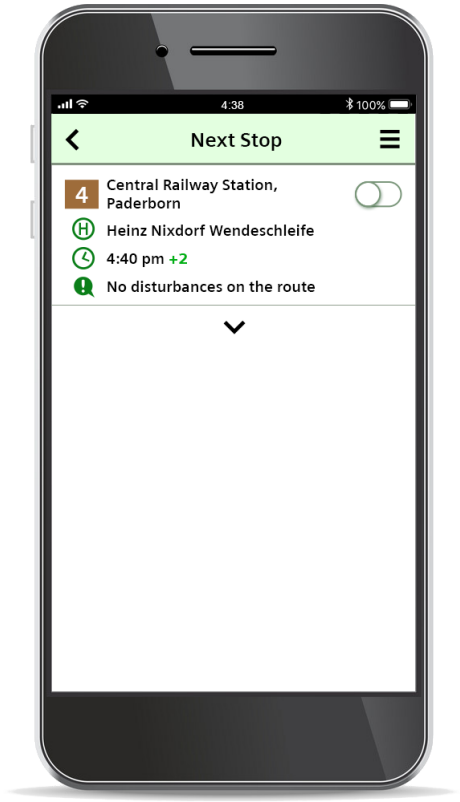
A comfortable bus ride requires …

- easy to find seats for blind and senior travellers with walkers,
- a secure bus area with mounting equipment for wheelchair travellers, seniors with walkers, family with pram,
- a good legible traveller information system,
- audible announcement of next bus stop,
- audible information on unforeseen halts,
- audible announcements on delays or changeover information,
- an online traveller information system for blind or foreign travellers,
- an appropriate number of handles and handrails for safe movement,
- an audio or message chat possibility in case of any problems while on the go via traveller info system,
- an online audio or message chat via mobile app.

Leaving the bus at the right destination requires …

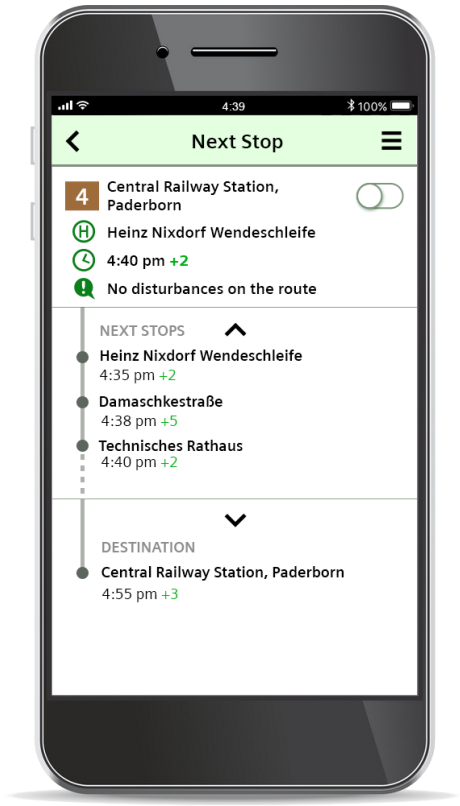
- good legible hints on the next bus stop via the traveller info system,
- just-in-time loudspeaker announcement for blind or wheelchair travellers,
- easy to find self-explaining buttons to open the door or to request the ramp,
- tactile markings for the different buttons for blind travellers with appropriate trigger mechanisms,
- an online „open door“ or ramp request possibility for foreign, deaf, blind or wheelchair travellers, who prefer just-in-time notifications on their smartphones,
- external audible signals if the ramp is requested to raise the awareness of other travellers who want to enter the bus,

- human assistance.



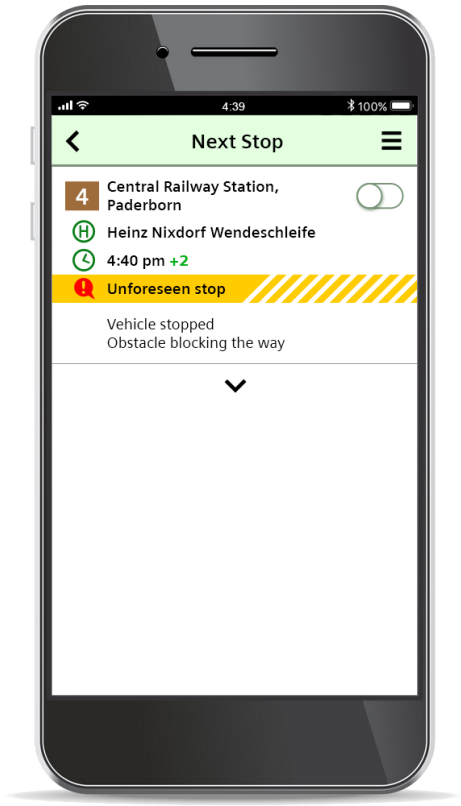
On the bus: *Display of next stop*

- The app displays
  - number of the bus line and destination,
  - next stop,
  - arrival time according to the timetable plus delay,
  - information about the route (disturbances, construction sites or the like),
  - a button to open the itinerary view.
- The passenger can request a stop at the next station.



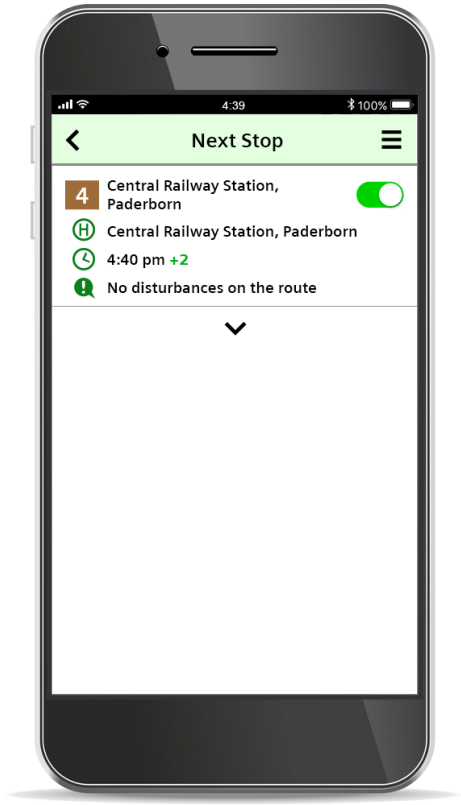
On the bus: *Display of next stop (expanded)*

- The app displays the upcoming stops and the according arrival times.
- The passenger can expand the itinerary view to see the complete list of bus stops on route to the destination stop.
- The traveller can close the itinerary view.

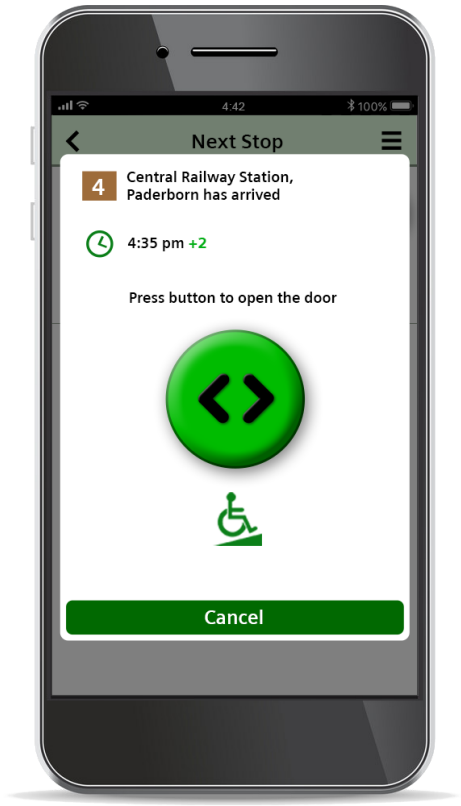


On the bus: *Unforeseen stop*

- The app displays when the bus has an unforeseen stop.

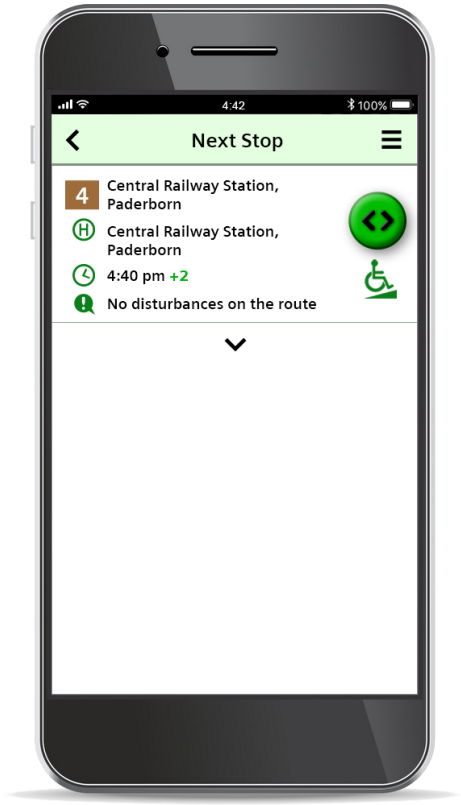


On the bus: *Stop requested*



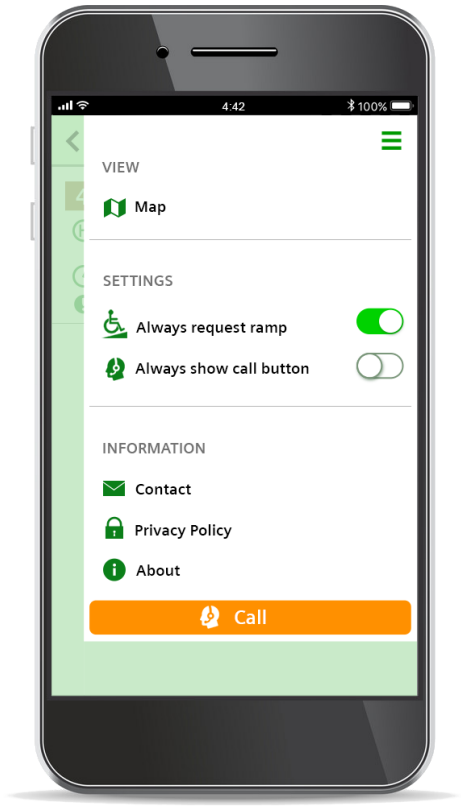
On the bus: *Arrival at the destination (1)*

- Notification with door opener.
- Saved ramp setting is displayed.



On the bus: *Arrival at the destination (2)*

- after (unintentionally?) cancelling the arrival notification of a bus, the bus door can still be opened by the smaller version of the green opening button displayed directly.
- the app also indicates if the ramp is requested.



Menu

- Settings with options, e.g.
  - always request ramp,
  - always show call button on page,
  - switch between Map view and list view.

Accessibility for a wide range of persons

Audio announcements or mobile notifications improve the awareness rising on-the-go and offer a higher comfort for a wide range of traveller groups like e.g.

- non-native speakers who prefer the UI in their native language,
- business travellers who work on their bus ride,
- persons with hearing impairments who need haptic notifications,
- blind travellers,
- younger children,
- online smartphone users.

So far, the introduction of the user story of the bus ride and its dedicated mock-ups.

The importance of smart mobility solutions for PRM in Europe is also reflected by the technical report E DIN/TR 13278 „Smarte Mobilität für Menschen mit Behinderung - Funktionale Ansätze“ (see [9]) that was published in February 2021 in Germany. The design of the Avenue app mock-up practically anticipates many of the recommendations outlined in that report.

With the amendments of the Passenger Transport Act (Personenbeförderungsgesetz PBefG), public transport in Germany is to be barrier-free by January 2020, with only a few legal exceptions (see section 8, paragraph 3 of the PBefG [10]). Smart mobility apps like the accessible Avenue mock-up ease the way to quickly achieve this challenging goal.

6.2 Suggestion for information monitor in vehicle

As most interviewed passengers ask for a passenger information system (PIS) that goes beyond the classical information we know from public transport today, we developed a concept for displays in the automated minibuses for public transport.

It consists of three major components:
(1) Classical PIS
(2) Sensor view
(3) Map view

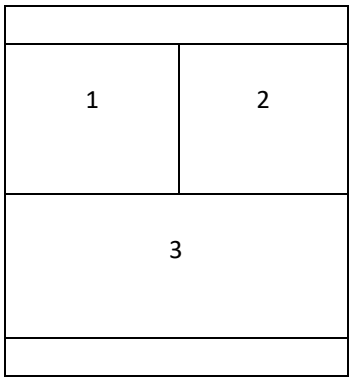


Figure 7: Suggested concept

The passenger information system provides a list of upcoming stops including information on actual (not planned) arrival times and delays. If there are any incidents or restrictions on the route, this is also displayed here. The number and destination of the bus are shown as well. Information like the current time and speed and if a stop is requested finds its place in the header.

The sensor view allows the passenger to "see through the eyes of the system". It was discussed that such a technology-focused view is more in line with an American approach, whereas in Europe the approach is to show passengers only the information they need. However, safety operators report that many passengers ask questions about the capabilities of the vehicle, especially regarding the sensors, so by indicating the sensor range and detected objects we can satisfy their curiosity and at the same time build trust in the technology.

The map view takes up the most monitor space. It answers the questions "Where am I right now?", "Where am I going?" and "What is nearby?". This especially benefits passengers who are not that familiar with the area. For them, the name of the bus stop is often not meaningful. The map with marked landmarks can support their orientation in the area and help them find the best way to their destination and the stop where they should leave the bus.

In addition, sights, restaurants, and stores along the route can also be displayed on the map so passengers can see what they can reach from the bus.

Regardless of its contents, the passenger information system needs to be readable from every seat and has to have sufficient contrast.

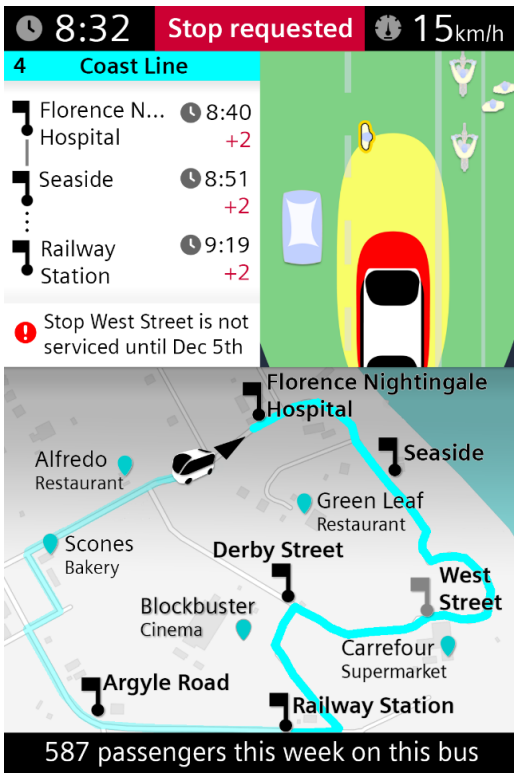


Figure 8: Suggested Layout

6.3 Trust-building measures

Interviews have shown that the trust of the passengers is crucial for acceptance and use of the automated minibuses for public transport.

Possible measures could be to make it known that the automated minibus - although new and innovative - has already proven itself in the field by publishing usage data like the no. of km driven this week or the no. of passengers transported this week. This data could be displayed on a ticker on the vehicles themselves, at major interchange stations or as part of the passenger information system.

Figure 9: Ideas for Trust-building measures

7 Requirements based on the Smart mobility assistance for PRMs workshop

The Workshop Smart mobility assistance for persons with reduced mobility was held in the framework of the H2020 project LIV_IN (grant agreement No 78799). The aim of this workshop was to openly discuss with persons with reduced mobility, with a special focus on blind or visually impaired persons, about their experiences, wishes and assessments on the question “What is the future of accessible public transport and the impact on their mobility?”.

The resulting document of this workshops was accepted by DIN in November 2020, editorial revised in the layout of a norm and published in February 2021 as E DIN/TR 13278 "Smarte Mobilität für Menschen mit Behinderung - Funktionale Ansätze" for public comments until March 2021.

8 Conclusions

The user acceptance increases to the same extent as the fully automated vehicles are optimised and adapted to fit the different user requirements.

Passengers with and without disabilities differ in their needs, but both user groups expect a significant added value in the use of automated minibuses for public transport.

While the problems of people with physical or sensory impairments are more related to the practical use of the technology used, other passengers tend to see difficulties in buying their tickets and in connecting to other public transport systems.

Looking at the results in detail, there is a high degree of potential for improvement, but these are all within a timeframe that can be accomplished within medium-term development cycles. This means that many of the outlined difficulties can be overcome without any higher efforts and optimized services could be provided for the individual user groups, so that an increasing user acceptance can also be predicted in the future.

In order to make the automated public transport a solution for ALL, a low-level entry to the bus, as well as a passenger information system following the dual channel principle are essential. However, trust is the prerequisite for the usage of AVs.

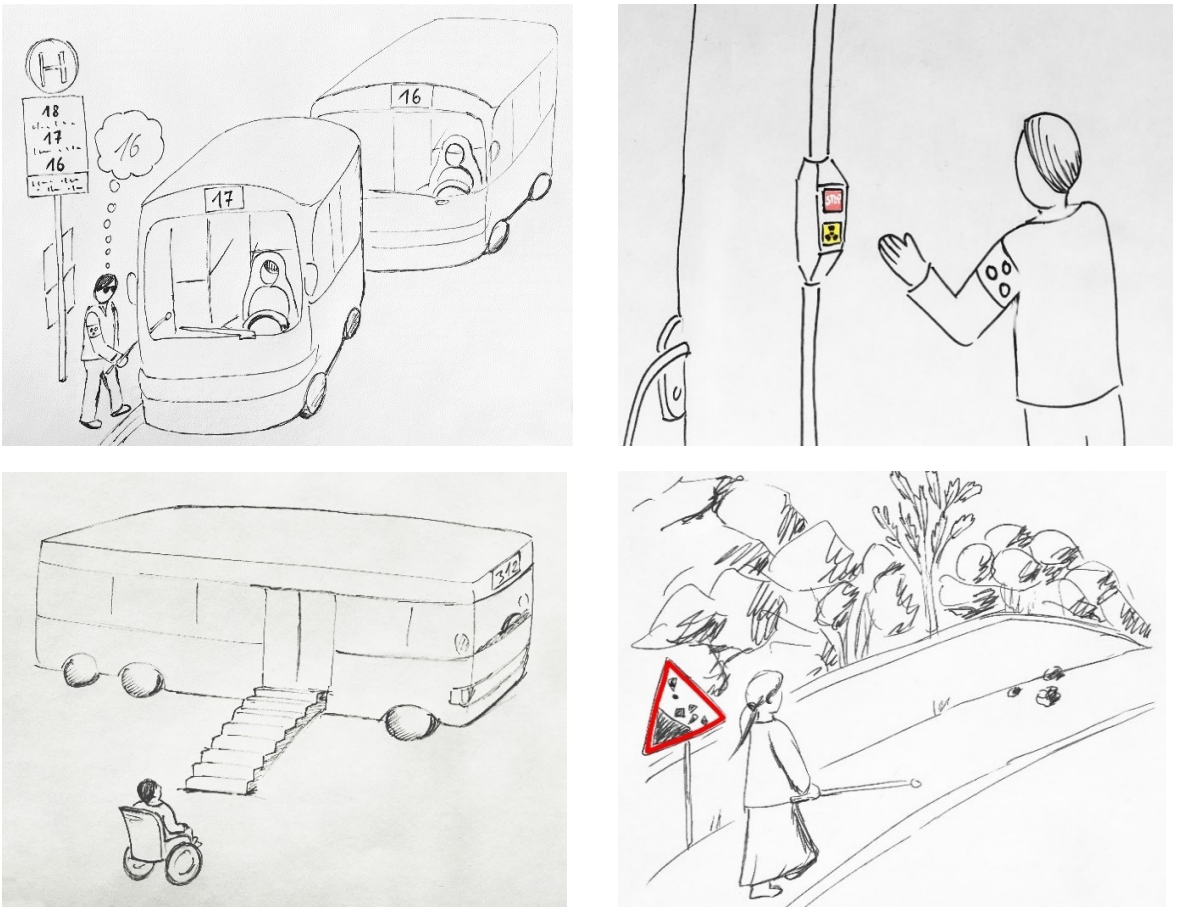


Figure 10: Barriers to overcome in public transport

9 References

[1] European Parliament and the Council, "Regulation (EC) No 661/2009," 13 7 2009. [Online]. Available: http://data.europa.eu/eli/reg/2009/661/oj. [Accessed 26. January 2021].

[2] Economic Commission for Europe of the United Nations (UNECE), “Regulation No 107 of the Economic Commission for Europe of the United Nations (UNECE),” 18 6 2015. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:42015X0618(01). [Accessed 12 February 2021].

[3] E. COMMISSION, “COMMISSION REGULATION (EU) No 1300/2014,” 18 11 2014. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R1300. [Accessed 12. February 2021].

[4] CEN/CENELEC/ETSI, “EN 301 549 Accessibility requirements for ICT products and services,” August 2018. [Online]. Available: https://www.etsi.org/deliver/etsi_en/301500_301599/301549/02.01.02_60/en_301549v020102p.pdf. [Accessed 22 March 2021].

[5] "iPhone Accessibility support," [Online]. Available: https://support.apple.com/accessibility/iphone-ipad. [Accessed February 2021].

[6] "AndroidOS, „Accessibility“," [Online]. Available: https://www.android.com/intl/us_en/accessibility. [Accessed February 2021].

[7] "AVENUE Deliverable D2.5 Second Passenger needs analysis and specifications“, Chapter 3.3 „Analysis of the observation study“, Dissemination Level Public (restricted)," 2019.

[8] "AVENUE Deliverable D2.5 „Second Passenger needs analysis and specifications“, Chapter 4 „Use cases and requirements“, Work package 2, Dissemination Level Public (restricted).," 2019.

[9] "Technical report E DIN/TR 13278 „Smarte Mobilität für Menschen mit Behinderung - Funktionale Ansätze/Smart mobility for persons with disabilities - Functional approaches“," 2021.

[10] "Gesetze im Internet, „Passenger Transport Act/Personenbeförderungsgesetz (PBefG), Section 8“.," [Online]. Available: https://www.gesetze-im-internet.de/pbefg/index.html.. [Accessed February 2021].

Annex A: Legal Overview

Annex A of Deliverable D2.5 gives a brief overview on the related legal requirements for public transport.

There has been no major updates or new legislation within the last year.