



Automated Vehicles to Evolve to a New Urban Experience

DELIVERABLE

D2.15 Final Definition of AVENUE services



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Table of Contents

Disclaimer	II
Document Information.....	II
Document History	II
Table of Contents	III
Table of Figures	V
Table of Tables	V
Acronyms.....	VI
Executive Summary	VII
1 Introduction	1
1.1 On-demand Mobility.....	1
1.2 Fully Automated Vehicles	1
1.2.1 Automated vehicle operation overview	2
1.2.2 Automated vehicle capabilities in AVENUE	3
1.3 Preamble	3
2 Methodology	4
3 Service needs definition: user stories	4
3.1 Service needs as an operator.....	5
3.1.1 ON1: High-quality public transportation service	5
3.1.2 ON2: Extension of PT offer thanks to automated minibuses	5
3.1.3 ON3: Competitive AV service to human-driven options	5
3.1.4 ON4: Safely removing the safety operator from the AV	6
3.1.5 ON5: Premium service	6
3.1.6 ON6: High-quality on-demand service.....	6
3.1.7 ON7: Optimised infrastructure at the stops	7
3.1.8 ON8: Comprehensive booking system.....	7
3.1.9 ON9: Service monitoring and supervision	7
3.1.10 ON10: Customized access rights and permissions for supervision tool	7
3.1.11 ON11: Data gathering and reports	8
3.1.12 ON12: Customized configuration of on-demand service.....	8
3.1.13 ON13: Ensurance that the right users are in the right vehicle.....	8
3.1.14 ON14: Passenger feedback	8
3.1.15 ON15: Safe service / ensure the safety of users in an AV without staff on board	9
3.1.16 ON16: Implementation of new routes	9
3.1.17 ON17: Flexibility in equipment and tools used	9
3.2 Service needs as a user (passenger)	10
3.2.1 PN1: Seamless and pleasant ride experience	10
3.2.2 PN2: Personalised travel assistance.....	10
3.2.3 PN3: Security and safety	10

3.2.4	PN4: Service information	10
3.2.5	PN5: Booking my ride.....	11
3.2.6	PN6: Managing my ride.....	11
3.2.7	PN7: Information about my ride(s).....	12
3.2.8	PN8: Information about best practices for boarding and alighting.....	12
3.2.9	PN9: Profile settings.....	13
3.2.10	PN10: No-trouble payment experience	13
3.2.11	PN11: Special needs users are able to use the service freely and independently	13
4	AVENUE services.....	14
4.1	AVENUE services	14
4.1.1	In-vehicle services	14
4.1.2	Out-of-vehicle services	15
4.2	Identified gaps or open questions	17
4.2.1	Infrastructure and on-site service.....	17
4.2.2	Vehicle.....	18
4.2.3	Software	20
5	Conclusions	23
6	Appendix A: Individual PTO service needs and requirements	24
6.1	TPG requirements/service needs	24
6.1.1	General.....	24
6.1.2	Requirements – As a user, I want to	24
6.1.3	Requirements – As a PTO, I want to	26
6.2	Keolis Lyon requirements/service needs.....	27
6.2.1	Background information	27
6.2.2	Example 1: Economic model of public transport.....	28
6.2.3	Example 2: New business model	29
6.2.4	What functionality is required for each service?.....	29
6.3	Amobility requirements/service needs	30
6.3.1	Operational requirements	30
6.3.2	Regular user requirements	31
6.3.3	People with special needs requirements.....	32
6.4	Sales-Lentz requirements/service needs.....	33
6.4.1	Luxembourg City – Pfaffenthal	33
6.4.2	Campus Contern	34
6.4.3	Replication site Esch-sur-Alzette	34

Table of Figures

Figure 1: SAE Levels of Driving Automation	2
Figure 2: Example - Economic model of public transport	29
Figure 3: Planned extension of route in Pfaffenthal (SLA)	33
Figure 4: Extended route at Contern.....	34
Figure 5: Planned route Esch-sur-Alzette Phase 1	34

Table of Tables

Table 1: Identified gaps / open questions – infrastructure and on-site service	18
Table 2: Identified gaps / open questions – vehicle.....	19
Table 3: Identified gaps / open questions – software.....	21
Table 4: Background information Keolis	28
Table 5: Main services Keolis.....	28
Table 6: What functionality is required for each service? - Keolis.....	30

Acronyms

API	Application Protocol Interface
AV	Automated Vehicle
CRM	Customer relationship management
D	Deliverable
D2D	Door-to-door
ETA	Estimated time of arrival
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
LIDAR	Light Detection And Ranging
MT	MobileThinking
ON	Operator Need
PC	Personal Computer
PN	Passenger Need
PTO	Public Transportation Operator
SAE Level	Society of Automotive Engineers Level (Vehicle Autonomy Level)
SLA	Sales Lentz Autocars
SSO	Single Sign-on
T	Task
TA	Traveler App
TPG	Transport Publics Genevois
V2I	Vehicle to Infrastructure communication
VIP	very important person
WP	Work Package

Executive Summary

This Deliverable D2.15 outlines the service needs and requirements as expressed by the AVENUE Public Transport Operators (PTOs), map them to the AVENUE services. It identifies any outstanding gaps and open questions linked to the service needs.

Chapter 2 clarifies the methodology used to achieve the results of this deliverable.

Chapter 3 focuses on the service needs definition. The needs are grouped by the “requester” – is it a need for the operator or the end-user, the passenger? – and are formulated as user stories.

Each service need contains several aspects which are listed in a bullet-point list under the need description. All service needs are referenced back to the needs described in Deliverable D2.6, except for the needs for operators in chapter 3.1 as these are not addressed in D2.6).

Each service need is then referenced is given to AVENUE services addressing this need, both for services already developed as for services currently still in development and/or testing. Where no AVENUE service applies, the gap is identified.

Chapter 4 focuses on the gaps and open questions identified in chapter 3 when comparing the operator and passenger needs with the AVENUE services provided. Since these are linked to different service and ecosystem aspects, the chapter is split into three sections, infrastructure and on-site service, vehicle, as well as software.

The AVENUE services implemented and planned are not further detailed in this deliverable D2.15 since this is covered in detail in deliverables D4.5 and D4.8, to which final versions are to be delivered by August 2021 (D4.6 and D4.9).

Finally, appendix A provides the full list of inputs received by the operators during the workshop sessions.

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 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 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 Automated vehicles will become the future solution for public transport. The AVENUE project will demonstrate the economic, environmental and social potential of 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, 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.

1.2 Fully Automated Vehicles

A self-driving car, referred in the AVENUE project as a **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.



SAE J3016™ LEVELS OF DRIVING AUTOMATION

	SAE LEVEL 0	SAE LEVEL 1	SAE LEVEL 2	SAE LEVEL 3	SAE LEVEL 4	SAE LEVEL 5
What does the human in the driver's seat have to do?	You <u>are</u> driving whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			You <u>are not</u> driving when these automated driving features are engaged – even if you are seated in “the driver’s seat”		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
	These are driver support features			These are automated driving features		
What do these features do?	These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/acceleration support to the driver	These features provide steering AND brake/acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met	This feature can drive the vehicle under all conditions	
Example Features	<ul style="list-style-type: none">• automatic emergency braking• blind spot warning• lane departure warning	<ul style="list-style-type: none">• lane centering OR• adaptive cruise control	<ul style="list-style-type: none">• lane centering AND• adaptive cruise control at the same time	<ul style="list-style-type: none">• traffic jam chauffeur	<ul style="list-style-type: none">• local driverless taxi• pedals/steering wheel may or may not be installed	<ul style="list-style-type: none">• same as level 4, but feature can drive everywhere in all conditions

Figure 1: SAE Levels of Driving Automation

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1.2.1 Automated 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 automated minibus 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 automated minibuses 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” aims to define in detail the use cases of each demonstrator, the scenarios for each implementation phase, and the value-added services required for the success of the demonstrators. A human-centered design approach for the design of the use cases will be followed. The required data to be collected for the impact analysis will also be defined. Existing know-how and best practices will be surveyed, assessed, and analyzed. The work in the tasks of WP2 is

iterative, and as the provided demonstrators and services become more sophisticated, new iterations of the work of the different tasks will be integrated.

Task 2.5 “Demonstrator use case definition” target is on the one hand to develop the use case scenarios and on the other hand to enrich the provisional list of AVENUE services, selecting at least 10 services for demonstration. Part of the work in task 2.5 feeds into deliverables 2.16-2.18, while the work of T2.5 that feeds into this deliverable focuses on the AVENUE services. The task foresees that these services will be further detailed in line with the needs and feedback from the demonstrator and replicator cities.

This Deliverable D2.15 outlines the service needs and requirements as expressed by the AVENUE PTOs, maps them to the AVENUE services, and identifies any outstanding gaps and open questions linked to the service needs.

2 Methodology

This deliverable outlines the service needs as expressed by the AVENUE PTOs.

This input has been gathered since the start of the project (see for details also D2.13 and D2.14) and was most recently updated throughout a series of workshops with the AVENUE operators. The workshops were organised during Q4 2020 around the topic of service needs and requirements from the PTOs. The objective of the workshop series was to gather the service needs and requirements for each AVENUE PTO until the end of the project as well as (optionally), with an outlook to the future, beyond the end of the AVENUE project.

The series was kicked off with an “input workshop”, where project partner Siemens presented the outcomes of the user needs analysis in T2.2., with a focus on passengers with special needs. This first workshop also provided the chance to highlight again the key objectives of the AVENUE project, to which the service needs and requirements are to relate: on-demand services with a fleet of 2-3 vehicles, disappearance of safety driver from AVs, AV automated minibuses in urban environments, innovative services for passengers, etc.

The workshop series then consisted of one workshop per PTO, where each PTO presents their individual service needs, requirements, and priorities on the basis of the experiences gathered during the first 30 months of deployment. The focus was on the identification of needs, problems, and requirements, as well their prioritisation, and not on possible solutions.

The outcome of the workshops is the main input to this deliverable. The complete overview of the contents of the workshops can be seen in Appendix A.

3 Service needs definition: user stories

This chapter identifies the AVENUE service needs and requirements as expressed by the PTOs. To allow for easier reading, both service needs and requirements are meant with the term “service needs” in this chapter.

The needs are grouped by the “requester” – is it a need for the operator or for the end-user, the passenger? – and are formulated as user stories. The service needs are numbered and named following the same logic: “ON” stands for an operator need, “PN” stands for a passenger need. Where applicable, reference is being made to the user needs from Deliverable D2.6 (in chapter 3.2, passenger needs).

Each service need contains several aspects which are listed in a bullet-point list under the need description. All service needs are referenced back to the needs described in Deliverable D2.6 (for the needs in chapter 3.2, as service needs from operators are not addressed in D2.6).

Lastly, for each service need, a reference is given to AVENUE services addressing this need, both for services already developed as for services currently still in development and/or testing. Where no AVENUE service applies, the gap is identified.

3.1 Service needs as an operator

3.1.1 ON1: High-quality public transportation service

1. As a public transport operator, I need to provide a service that is fully inclusive and allows me to transport everyone. I, therefore, need to ensure that all members of the society are able to use the service and that the service is also adapted to special needs, such as for wheelchair users, walking frames, hearing-impaired users, visually impaired users, users with a stroller, users with a lead log, etc. This aspect is considered in all of the below user stories.
2. As an operator, I want to offer public transport solutions that provide a high quality of service for my passengers, so that I encourage the use of public transport.
3. As an operator in public transport, I want the service to consist of shared rides.

→ AVENUE services addressing ON1: Ridesharing is part of the core functionality of the AVENUE platform. It can be enabled and disabled by the operator through the configuration settings available in the Bestmile Dashboard. Inclusivity is one of the key aspects of the AVENUE project and is further addressed in the passenger needs of chapter 3.2.

3.1.2 ON2: Extension of PT offer thanks to automated minibuses

1. As an operator, I want to offer public transport services in areas that are currently not serviced by a public transport solution thanks to automated minibuses.
2. As an operator, I want to extend the public transport service offers in areas that are currently served only in a limited way thanks to automated minibuses.
3. As an operator, I want to extend the public transport service offers to a 24/7 service thanks to automated minibuses.

→ AVENUE services addressing ON2: The AVENUE platform is completely flexible regarding the service hours as well as the service area. New operational areas can be defined and configured freely; 24/7 services are possible, as well as services restricted to certain service hours.

3.1.3 ON3: Competitive AV service to human-driven options

1. As an operator, I want to be able to remove the Safety Operator from the AV (see ON4).
2. As an operator, I want to be able to use AVs as a means to offer an economical transport mode and to spend less than for classical fixed-line bus service. This is dependent on removing the Safety Operator (see ON4).
3. As an operator, I want to ensure that the AV service is compliant with legal terms and the environment.
4. As an operator, I want to reach higher speeds with my AVs, at least 30 km/h, in order for the AV service to be a competitive solution.

5. As an operator, I want a smooth operation of my public transport service with an AV, regardless of the weather conditions and the road behaviour of other vehicles on the road. This requires
 - a. More intelligent sensory systems,
 - Better braking calculation,
 - Better safety zones,
 - Overtaking ability,
 - Closed corridor overtaking.

→ AVENUE services addressing ON3: None. See ON4 for the first two items. For the others, no AVENUE service can be linked to these needs, and these are thus identified as gaps. They are also included in the Final Gap Analysis in deliverable D2.3.

3.1.4 ON4: Safely removing the safety operator from the AV

1. As an operator, I want to ensure that the AV service is running smoothly without a Safety Operator onboard: specific manual interventions need to be possible to be done remotely / by teleoperation, such as pull to curb, use the horn, overtaking a vehicle that is illegally parked, etc.
2. As an operator, I want to ensure that the remote supervision team can perform certain actions at distance, such as door opening and stopping the automated minibus.
3. As an operator, I want to ensure that the passenger has the possibility to reach out to the remote supervision team and reverse (see more on that in ON15).
4. As an operator, I want to ensure that the remote supervision is able to observe the automated minibus movement and events inside the automated minibus thanks to a live video stream.¹
5. As an operator, I want to ensure that the passengers receive all crucial information about the service via displays inside the automated minibus.

→ AVENUE services addressing ON4: None Vehicle capabilities and additional functionalities needed to be able to safely remove the safety driver from the vehicle are identified as gaps.

3.1.5 ON5: Premium service

1. As an operator, I want to be able to offer premium / VIP service for special occasions where rides wouldn't be shared.

→ AVENUE services addressing ON5: Ridesharing can be enabled and disabled by the operator through the configuration settings available in the Bestmile Dashboard.

3.1.6 ON6: High-quality on-demand service

1. As an operator, I want to offer a flexible on-demand service that allows me to transport passengers from any given point A to any given point B in a pre-defined area.
2. As an operator, I want to be sure that the trip request is matched optimally to a vehicle.
3. As an operator, I want the fleet orchestration software to be able to route the vehicles to ensure optimization.
4. As an operator, I want to be able to pool passengers at any point in time if this is the optimal solution.
5. As an operator, I want to be sure that two AVs on a bidirectional route won't get into a deadlock.

¹ More on supervision needs for the operator see ON9

→ AVENUE services addressing ON6: Aspects 1 and 2 of this need are part of the core functionality of the AVENUE platform. Deadlock avoidance (point 5) is an improvement that is currently still in discussion. Points 3 and 4 represent known gaps which are also included in the Final Gap Analysis in deliverable D2.3: (3) Prescribing the route to the vehicle is already supported by the fleet orchestration platform but not by the vehicle. (4) It is currently not possible to cancel or overwrite an ongoing mission. This means that if a new booking is created, which should ideally reroute the vehicle on its ongoing ride (or stop on the way to pickup the new passenger), this is not currently possible with the vehicle software (while already fully supported by the fleet orchestration platform).

3.1.7 ON7: Optimised infrastructure at the stops

1. As an operator, I want to reduce infrastructure at stops to a minimum in order to reduce costs and efforts and increase flexibility → moving towards virtual bus stops.
2. As an operator, I want to ensure that the bus stops have the necessary infrastructure in place to allow usage of the service for all types of users (braille, wheelchair access, etc.).

→ AVENUE services addressing ON7: The AVENUE platform allows to create and configure services both as coordinate-based services (= “door-to-door” (D2D)) and as station-based services. As for point 2 since this is infrastructure-related, this is up to the local implementation by the operator running the service.

3.1.8 ON8: Comprehensive booking system

1. As an operator, I want users to be able to place bookings via different means, in particular via a user-oriented app and via a call center. See more on booking in PN5.
2. As an operator, I want passengers to be able to place prebookings.
3. As an operator, I want passengers to be able to place recurring bookings.

→ AVENUE services addressing ON8: AVENUE out-of-vehicle services “On-demand booking” and “Trip planning via call center”. Bookings being created via a large range of tools is part of the core functionality of the AVENUE platform. Thanks to Bestmile’s Booking API, many different booking interfaces can be integrated to create bookings for a service, such as the AVENUE Traveler App. Call center bookings are possible to be created via the Bestmile Dashboard available to the operators and supervision teams. Prebookings are part of the core functionality too, and can be enabled and disabled for any service. Recurring bookings are not currently supported by the AVENUE platform.

3.1.9 ON9: Service monitoring and supervision

1. As an operator, I want to be able to monitor the service in real-time: position of all vehicles, vehicle telemetry data, bookings, etc.
2. As an operator, I want to be able to use live video streams of the inside and surrounding of my vehicles to supervise the service.

→ AVENUE services addressing ON9: Real-time supervision of the vehicles and service is part of the core functionality of the AVENUE platform and is available to the supervision team via the Bestmile Dashboard. Live video streams are currently not available via the vehicle API.

3.1.10 ON10: Customized access rights and permissions for supervision tool

1. As an operator, I want to be able to give different levels of access rights for the supervision of my services, depending on the staff member or stakeholder and their role (e.g., an authority might need access only to certain processed data and analytics).

→ AVENUE services addressing ON10: This is fully supported by the AVENUE platform. To grant access to the supervision of the service via the Bestmile Dashboard, the operator can define custom roles with custom sets of permissions and then assign these roles freely to his users.

3.1.11 ON11: Data gathering and reports

1. As an operator, I want all live data gathered from the vehicle telemetry and bookings to be stored.
2. As an operator, I want to be able to extract all data stored.
3. As an operator, I want to be able to conduct analysis of my service thanks to comprehensive data visualization and representation available.

→ AVENUE services addressing ON11: This is part of the core functionality of the AVENUE platform. Bestmile stores all vehicle and booking data provides historic analytical reports and visualizations on this data in the Business Intelligence section of the Dashboard, and can additionally provide data exports of booking and vehicle data to the operator for further analysis, where needed.

3.1.12 ON12: Customized configuration of on-demand service

1. As an operator, I want to be able to run a door-to-door or a station-based service.
2. As an operator, I want to be able to offer a flexible and easily adjustable service adapted to changing needs.
3. As an operator, I want to be able to make modifications to my service on a self-service basis, such as adaptation to the service area or bus stops.
4. As an operator, I want to be able to (temporarily) remove roads or routes from the network.

→ AVENUE services addressing ON12: This is part of the core functionality of the AVENUE platform. The platform allows to create and configure services both as coordinate-based services (= “door-to-door”) and as station-based services, allows for flexible configuration of service area, stops, as well as other configurations, such as service parameters. As for the modifications of the route network, this is also possible and can be done both temporarily and permanently. However, this last point is not a self-service option, the operator needs to contact the Bestmile team to apply these changes.

3.1.13 ON13: Ensurance that the right users are in the right vehicle

1. As an operator, I want to be sure that the vehicle opens the doors for the right vehicle.
2. As an operator, I want to be sure / receive a confirmation that the right traveler has boarded.
3. As an operator, I want to cross-check the number of passengers that should be on board (information from the bookings) against the actual number of passengers on board.

→ AVENUE services addressing ON13: None. Traveler identification is one of the aspects still to be further discussed and addressed in the framework of task 4.4 of the project. A workshop is to be planned for Q2 / Q3 2021 with the technical partners to discuss potential solutions and their feasibility.

3.1.14 ON14: Passenger feedback

1. As an operator, I want to collect passenger feedback in a standardised format and as a standard part of the booking process.

→ AVENUE services addressing ON14: AVENUE in-vehicle service: Smart feedback system and AVENUE out-of-vehicle service: User feedback.

3.1.15 ON15: Safe service / ensure the safety of users in an AV without staff on board

1. As an operator, I want to ensure the safety of my passengers during operations, including
 - Ensuring that passengers sit down and buckle up during a ride,
 - Ensuring that harsh braking does not put passengers at risk.
2. As an operator, I want to allow the passenger to communicate with the operator intervention team for safety or security concerns, who will then be able to establish the nature of the problem and contact the respective external service needed, such as police, fire brigade, technical services.
3. As an operator, I want to be able to share certain data live and automatically with these external services, such as the position of the automated minibuss and live videos.
4. As an operator, I want to be the supervision team to be alerted in security or safety-critical certain events, such as accidents, health issues of a passenger, aggression, bag-snatching, etc.

→ AVENUE services addressing ON15: Point 1: Currently, the only option for operators to share such information is via stickers in the automated minibusses: PTOs do not have the possibility to add any customized information to the display in the automated minibuss (used for troubleshooting by the safety operator and Navya only), neither is it possible to configure automated announcements in the automated minibuss. Point 2: It is currently not possible to use any of the available tools and functionalities in the automated minibuss for communication between the operator intervention team and passengers. However, a direct communication to the PTO is already integrated into the AVENUE Traveler App: via a “Call shortcut” in the application, PTOs can set a specific phone number. Point 3: limited access to vehicle supervision can be provided by the operator to external partners too; see ON9 and ON10. Live video streams are currently not available (see gap identified at ON9). Point 5 see AVENUE In-vehicle service: Enhance the sense of security and trust.

3.1.16 ON16: Implementation of new routes

1. As an operator, I want to be able to evaluate new routes remotely based on new map data and existing knowledge.
2. As an operator, I want to be able to be independent in the process of mapping and commissioning a new route and not be dependent on the vehicle manufacturer to come on-site and perform the required actions.

→ AVENUE services addressing ON16: This is currently not possible and has been identified and also described in the Final Gap Analysis in deliverable D2.3.

3.1.17 ON17: Flexibility in equipment and tools used

1. As an operator, I want to be able to add additional equipment to my vehicles, such as additional sensors or cameras.
2. As an operator, I want to be able to consume and use the data collected via the additional equipment in a convenient manner. Ideally, I want all data and analytics to be accessible via the same supervision tool.

→ AVENUE services addressing ON17: In-vehicle service: Enhance the sense of security and trust. Currently, automated minibusses are being prepared to test this service at the Slagelse site in Copenhagen.

3.2 Service needs as a user (passenger)

This chapter describes service needs identified for users of the transport services, the passengers. References to the user needs and requirements identified in Deliverable D2.6 Final Passenger needs analysis and specifications have been added where applicable.

3.2.1 PN1: Seamless and pleasant ride experience

1. As a user, I want to be transported directly from my departure point to my destination.
2. As a user, I want to be transported in a comfortable way (not too crowded, comfortable ride, clean vehicle, etc).
3. As a user, I want to experience a fast, reliable, and seamless transport service.
4. As a user, I want to get value for money.

→ AVENUE services addressing PN1: The AVENUE platform, as well as all AVENUE services, are ultimately intended to fulfil these general needs, it is thus not possible to pick only 1-2 specific services. Point 1 refers back to door-to-door services; see ON12.

3.2.2 PN2: Personalised travel assistance

1. As a user, I want to receive personalised travel assistance when having issues with booking.
2. As a user with special needs, I want to receive personalised travel assistance to board and alight the independent vehicle access isn't possible (e.g., only a manual wheelchair ramp).

→ AVENUE services addressing PN2: AVENUE out-of-vehicle service: Trip planned via call center for point 1. Point 2 depends on the local implementation by the operator and is thus listed in the chapter on gaps and open questions.

3.2.3 PN3: Security and safety

1. As a user, I want to be transported in a secure way and feel safe while using the service.
2. As a user, I want to be able to reach out easily to the operator if I feel unsafe.
3. As a user, I want to be informed about the measure taken to ensure my safety and security, such as
 - knowing a supervision team on-site,
 - knowing that the vehicle is monitored via live video streams,
 - knowing the supervision team will be alerted for any aggression, accident or health issue in the vehicle.

As a visual or hearing-impaired user, I still want to have access to this information.

→ AVENUE services addressing PN3: Point 1: AVENUE in-vehicle service: Enhance the sense of security and trust. Point 2: Gap, see also ON15. Point 3: AVENUE out-of-vehicle service: Digital or human information points. The adaptation of this service to visually impaired or hearing-impaired users remains an open question.

3.2.4 PN4: Service information

1. As a user, I want to have access to information about the policies of the transportation service, such as age restrictions, if animals are allowed in the vehicle, etc.
2. As a user, I want to have access to information about the ecological footprint of the service and how it benchmarks against other transport options.
3. As a user, I want to have comprehensive information about the service, such as
 - Is a public transport option available for the trip I want to make?

- Is the trip I'm planning a direct ride with one service, or will I need to change?
 - What routes does this service serve, and where are the stops?
 - How can I book a ride? How does it work? What do I need to do?
4. As a user, I want to be able to access information about the transport options going beyond this service, such as seeing timetables for connecting fixed-line busses, etc.
 5. As a wheelchair user, I want to know if I can use all stops and, if not, which stops are wheelchair accessible.
 6. As a user, I want to know where I can find additional information and whom I can contact for additional questions.
 7. As a visually or hearing-impaired user, I want to be able to consume all types of information listed above.

→ AVENUE services addressing PN4: AVENUE out-of-vehicle service: Digital or human information points. The adaptation of this service to visually impaired or hearing-impaired users remains an open question.

3.2.5 PN5: Booking my ride

1. As a user, I want to be able to book a trip via an app in an easy, logical, and fast manner. I want to be able to do that in all local languages as well as in English. Thereby, I want to be able to
 - select the origin and destination from a list,
 - select the origin and destination on a map,
 - select the origin and destination from points of interest,
 - select the origin and destination from the type of access, e.g., accessibility for wheelchair users.
2. As a user with special needs, I want to be able to make a booking independently via an application.
3. As a user, I want to be able to make a booking even when I am not (yet) on site.
4. As a user, I want to be able to make a prebooking.
5. As a user, I want to be able to make a recurring booking.
6. As a user, I want to be able to make a booking that copies the details from one of my past bookings.
7. As a user, I want to be able to make a booking via a call center.
8. If there are different types of services, as a user, I want to be able to choose the service during booking.

→ AVENUE services addressing PN6: Many of the aspects listed here are part of the core functionality of the AVENUE platform, such as supporting prebooking (3), bookings via the Traveler App (1) or via a call center (6 – see also AVENUE out-of-vehicle service: Trip planning via a call center), accessibility concerns for bookings via the Traveler App (2) or choosing a service from different service options (7). Several points are also possible to be implemented in the AVENUE TA (3, 4, 5, 6), but this has not happened yet as it depends on having user profiles in the Traveler App, which is not currently the case. This has been identified as a gap. Recurring bookings (5) are not currently possible in the AVENUE platform, and this has been listed as a gap.

3.2.6 PN6: Managing my ride

1. As a user, I want to be able to cancel my booking before the ride.
2. As a user, I want to be able to change my booking:
 - Change the destination (before or during the ride),
 - Change the origin (before the ride),
 - Edit the number of passengers for whom I've booked (before the ride),
 - Edit my transport options, such as if I carry big luggage (before the ride).

→ AVENUE services addressing PN7: Point 1: Cancellation of a ride that has not yet started is possible via the Traveler App, see AVENUE service On-demand booking. Point 2: Modifications to bookings already created are not currently supported by the AVENUE platform. Users will have to cancel their booking and create a new booking.

3.2.7 PN7: Information about my ride(s)

1. As a user, I want to know when I will be picked up.
2. As a user, I want to know when I will arrive at my destination.
3. As a user, I want to know when there is a change to my ride or an issue that affects my ride, its consequences as well as next steps.
4. As a user, I want to know where the pickup point is and how I get there.
5. As a user, I want to see the vehicle that will pick me up live on a map.
6. As a user, I want to know how to identify the vehicle I booked in order to ensure that I'm boarding the right vehicle.
7. As a user, I want to receive travel information during the journey, such as
 - changes to the itinerary or ETA,
 - live vehicle location on a map,
 - when and where do I need to alight,
 - any intermediate stops planned.
8. As a user, I want to receive a price estimation at booking.

→ AVENUE services addressing PN8: Most of these aspects are included in the booking flow of the AVENUE Traveler App as textual information (1-5, 7) or will be implemented as a next step (6). Point 8 has not been implemented as all AVENUE services are free services, or the standard PT prices will be applied, which will be paid for via the standard payment methods. The adaptation of this service to visually impaired users remains an open question.

3.2.8 PN8: Information about best practices for boarding and alighting

1. As a user, I want to know how I can enter the vehicle.
2. As a user, I want to know if there's a specific seat I should sit on, e.g., due to policies linked to the Covid pandemic.
3. As a user, I want to know if attaching the seatbelt is obligatory / recommended as well as how to attach it.
4. As a user, I want to know that I should wait for the vehicle is come to a complete stand-still before getting off.
5. As a visually impaired user, I want to receive an audio signal when I have reached my destination, as well as guidance on how to alight safely and independently, and general rules on-board (see points 1-4).²

→ AVENUE services addressing PN9: Points 1-4 are addressed by the AVENUE out-of-vehicle service: Digital or human information points. The adaptation of this service to visually impaired or hearing-impaired users remains an open question, especially as the in-vehicle telecommunication system is not available for operators to use for communication with passengers, neither for automated messages nor for direct bilateral communication. Point 5: The Traveler App sends push notifications for the most

² See also user needs #16 - #18 of D2.6.

important status change of the booking, such as arrival at pickup, vehicle departure, arrival at dropoff. These notifications can be set with an audio signal on mobile devices.

3.2.9 PN9: Profile settings

1. As a user, I want to be able to set specific user needs in my profile, such as being a passenger in a wheelchair, needing additional space for my lead dog, cane, or walking frame, usually traveling as a family with X family members.

→ AVENUE services addressing PN9: None. This requires having user profiles in the Traveler App, which is not currently the case. This has been identified as a gap.

3.2.10 PN10: No-trouble payment experience

1. As a user, I want to be informed about the pricing policies for the service as well as all payment options.
2. As a user, I want to be informed about the pricing for all different public transport and service options for my ride, and I have to be able to consider this when making a decision on which service to use.
3. As a user, I want to be able to pay for the service in several convenient ways.
4. As a user, I want to be able to access my historic traveling data to see, for example, all trips taken over the past month as well as the total cost associated with these trips.

→ AVENUE services addressing PN10: Point 1 and 2 are addressed by the AVENUE out-of-vehicle service: Digital or human information points. Since none of the mobility services in the framework of the AVENUE project are paid mobility services, no payment options have been developed or integrated into the AVENUE Traveler App and AVENUE platform deployments for the different sites.

3.2.11 PN11: Special needs users are able to use the service freely and independently

Several accessibility aspects are already covered in the other user stories, and this section aims to list all remaining needs that haven't been covered yet:

1. As a user, I want to know about the capacity of assistive devices (lead dog, cane, walking frame, etc.) and wheelchair.
2. As a user in a wheelchair with heavy luggage or a big stroller, I want to know which services, stops, and vehicles are wheelchair accessible and how to book them.
3. As a visually impaired user, I want to be able to safely find the stops.³
4. As a visually or hearing-impaired user, I want to be able to safely board and alight the vehicle.⁴

→ AVENUE services addressing PN11: Point 1 is partially addressed with one of the next improvements planned as work in task 4.4, linked to an expanded capacity model. This will allow users to book not only for additional people but also allow them to indicate if they are, for example, in a wheelchair or come with a stroller, large luggage, etc. As for the information aspect of points 1 and 2, this could be addressed in the AVENUE out-of-vehicle service: Digital or human information points. The adaptation of this service to the specific needs of visually impaired or hearing-impaired users remains an open question and is listed in chapter 4. Point 3 could be addressed through infrastructure on-site, audio announcements of busses arriving, or auditive guidance through the TA, but none of this has been implemented so far. It has been listed as a gap in chapter 4. As for point 4, possible needs linked to this

³ See also user needs #1 - #8 of D2.6.

⁴ See also user needs #9 - #15, #25 of D2.6.

are detailed in user needs #9 - #15 as well as #25 of D2.6. These are not currently addressed by an AVENUE service and are thus listed as open questions/gaps in chapter 4.

4 AVENUE services

This chapter describes the final AVENUE services as well as identified gaps or open questions linked to the operator and passenger needs identified by the PTOs and described in chapter 3.

4.1 AVENUE services

This chapter briefly describes the AVENUE services as selected by the PTOs and developed in WP4 since the beginning of the project. Each service is briefly described but not further detailed, as details about the technical implementation, iterations, testing, and evaluation are outlined in detail in deliverables D4.5 and D4.8, to which final versions are to be delivered by August 2021 (D4.6 and D4.9).

Services that have been listed in the project proposal but weren't selected throughout the project are not listed or described in this deliverable, as this subject has been thoroughly covered in D2.13 and D2.14.

4.1.1 In-vehicle services

4.1.1.1 Enhance the sense of security and trust

This service addresses the timely, accurate, robust and automatic detection of various petty crime types or misdemeanors, as well as the assistance of authorized end-users towards the re-identification of any offenders via video and audio sensing and depth imaging. It addresses the following use cases:

- Unaccompanied Luggage Monitoring
- Bag Snatch Detection
- Vandalism Detection
- Sound Events Detection

Find details about this service in deliverable D4.5, chapter 2.4. A final version of this deliverable is expected as D4.6 by August 2021.

4.1.1.2 Automated passenger presence

The service addresses the timely, accurate, robust, and automatic counting of the passenger number within the automated minibus via video sensing, as well as appropriate notifications and/or instructions to its passengers. The main goal is to monitor the number of passengers on board at all times so that the shuttle's capacity is not exceeded at any time. It addresses the following use cases:

- Passenger Counting
- Route Optimization
- Passenger Awareness

Find details about this service in deliverable D4.5, chapter 2.5. A final version of this deliverable is expected as D4.6 by August 2021.

4.1.1.3 Follow my kid/grandmother (In-vehicle solution)

The service and scenario propose a full-fledged solution that allows designated “guardians” to follow the APT journeys of more vulnerable people, since the guardians can check the trip via a dashboard or mobile app, receive notifications via mobile app, add people to their “guarded” list, and share trips/position and Estimated time of arrival (ETA) with others. It addresses the following use cases:

- Vulnerable person traveling at night
- Kids Monitoring
- Patients Monitoring

Find details about this service in deliverable D4.5, chapter 2.6. A final version of this deliverable is expected as D4.6 by August 2021.

4.1.1.4 Shuttle environment assessment

The service is responsible for the timely, accurate, robust, and automatic detection of any change in the air quality and the presence of smoke or fire inside the vehicle. In cases there will be an alert on the system, notifications and instructions will be sent to the passengers to the operators and/or to the suitable authorities. It addresses the following use cases:

- Lighting a Cigarette
- Exposure to Carbon Dioxide
- High Temperature on the Automated minibus

Find details about this service in deliverable D4.5, chapter 2.7. A final version of this deliverable is expected as D4.6 by August 2021.

4.1.1.5 Smart feedback system

The “smart feedback service” will allow travellers to give their feedback by a hand gesture to the cameras inside the shuttle. It addresses the following use cases:

- Giving a thumbs up/down in light settings
- Giving a thumbs up/down in dark settings
- Giving a thumbs up/down in crowded settings
- Giving a thumbs up/down in empty settings (or few passengers)

Find details about this service in deliverable D4.5, chapter 2.8. A final version of this deliverable is expected as D4.6 by August 2021.

4.1.2 Out-of-vehicle services

4.1.2.1 Passenger presence

This service allows the safety operator to count the number of passengers on board via a mobile application for the safety operator, called Driver App.

Find details about this service in deliverable D4.8, chapter 3.1. A final version of this deliverable is expected as D4.9 by August 2021.

4.1.2.2 Visualization in real-time of minibus location

This service allows to visualize in real-time the location of the automated minibus on a map on the Traveler App.

Find details about this service in deliverable D4.8, chapter 3.2. A final version of this deliverable is expected as D4.9 by August 2021.

4.1.2.3 On-demand stop

This service allows the traveler to request the minibus to stop at a certain stop via his Traveler App. The safety operator then receives the stop request on the Driver App and can take the necessary actions in the minibus to stop at the requested stop.

Please note that this service is relevant only for fixed-route open-access deployments and such where mission control of the automated minibuses is not implemented.

Find details about this service in deliverable D4.8, chapter 3.3. A final version of this deliverable is expected as D4.9 by August 2021.

4.1.2.4 Trip planned via call centers

This service is implemented by the PTOs. It allows travelers to place a booking via a call center. The supervision team receiving the call in the call center can then create the booking via the Bestmile Dashboard.

Find details about this service in deliverable D4.8, chapter 3.5. A final version of this deliverable is expected as D4.9 by August 2021.

4.1.2.5 Digital or human information points

This service is mainly implemented by the PTOs through digital and human information points, which provide comprehensive information about the service and how to use it. Depending on the local choices done by the PTO, it can be implemented via information displays on-site, via call center, or via digital means, for example, with the information provided on a website or the Traveler App.

Find details about this service in deliverable D4.8, chapter 3.6. A final version of this deliverable is expected as D4.9 by August 2021.

4.1.2.6 On-demand zone

This service aims at informing the passenger via the Traveler App when he is in a zone where he can order an on-demand service or when he enters this zone.

Find details about this service in deliverable D4.8, chapter 3.7. A final version of this deliverable is expected as D4.9 by August 2021.

4.1.2.7 Single-button vehicle calls and help request

This service allows passengers to call the PTO service center/emergency hotline through a button in the Traveler App.

Find details about this service in deliverable D4.8, chapter 3.8. A final version of this deliverable is expected as D4.9 by August 2021.

4.1.2.8 On-demand booking

This service allows the traveler to book a ride in an on-demand service via the Traveler App.

Find details about this service in deliverable D4.8, chapter 3.10. A final version of this deliverable is expected as D4.9 by August 2021.

4.1.2.9 User feedback

This service allows passengers to provide feedback about their ride experience via the Traveler App after a ride is completed.

Find details about this service in deliverable D4.8, chapter 3.11. A final version of this deliverable is expected as D4.9 by August 2021.

4.1.2.10 Follow my kid/grandmother (Out-of-vehicle solution)

The initial version of this service is to allow a trusted person to “follow” another followed person on Global Positioning System (GPS) based technology. The goal is to display on the caregiver’s application the position of the followed person. On top of the GPS position, the follower can also see the booking status, just as if they were the one using the AV service.

Find details about this service in deliverable D4.8, chapter 3.12. A final version of this deliverable is expected as D4.9 by August 2021.

4.2 Identified gaps or open questions

This chapter focuses on the gaps and open questions identified in chapter 3 when comparing the operator and passenger needs with the AVENUE services provided. Since these are linked to different service and ecosystem aspects, the chapter is split into three sections, infrastructure and on-site service, vehicle, as well as software.

This deliverable will not outline the AVENUE services implemented and planned since this is covered in detail in deliverables D4.5 and D4.8, to which final versions are to be delivered by August 2021 (D4.6 and D4.9).

4.2.1 Infrastructure and on-site service

This section focuses on the gaps and open questions linked to the infrastructure and on-site services provided by the PTOs.

Need	Need: detailed description	Gap or open question
ON7	As an operator, I want to ensure that the bus stops have the necessary infrastructure in place to allow usage of the service for all types of users (braille, wheelchair access, etc.).	Open question linked to the accessibility of the bus stops on the AVENUE sites.
PN2	As a user with special needs, I want to receive personalised travel assistance to board and alight the vehicle independent access isn’t possible (e.g., only a manual wheelchair ramp).	Open question linked to personal assistance provided as a special service to passengers with special needs by the PTOs.
PN3	As a visual or hearing-impaired user, I want to be informed about the measure taken to ensure my safety and security, such as <ul style="list-style-type: none"> knowing a supervision team on site, 	Open question linked to the adaptation of the AVENUE out-of-vehicle service: Digital or human information points to visual or hearing-impaired users.

	<ul style="list-style-type: none"> knowing that the vehicle is monitored via live video streams, knowing the supervision team will be alerted for any aggression, accident, or health issue in the vehicle. 	
PN4	As a visually or hearing-impaired user, I want to be able to consume all types of information listed above.	Open question linked to the adaptation of the AVENUE out-of-vehicle service: Digital or human information points to visual or hearing-impaired users.
PN8	As a visually impaired user, I want to receive an audio signal when I have reached my destination, as well as guidance on how to board and alight safely and independently, and general rules on-board (seatbelt, on which seat to sit down, etc.).	Open question linked to the adaptation of the AVENUE out-of-vehicle service: Digital or human information points to visual or hearing-impaired users, especially as the in-vehicle telecommunication system is not available for operators to use for communication with passengers, neither for automated messages nor for direct bilateral communication.
PN11	As a user, I want to know about the capacity of assistive devices (lead dog, cane, walking frame, etc.) and wheelchair.	Open question linked to the adaptation of the AVENUE out-of-vehicle service: Digital or human information points to visual or hearing-impaired users.
PN11	As a user in a wheelchair with heavy luggage or a big stroller, I want to know which services, stops, and vehicles are wheelchair accessible and how to book them.	Open question linked to the adaptation of the AVENUE out-of-vehicle service: Digital or human information points to visual or hearing-impaired users.
PN11	As a visually impaired user, I want to be able to safely find the stops.	Gap / Open question: This could be addressed through infrastructure on-site or audio announcements of busses arriving at the stop.
PN11	As a visually or hearing-impaired user, I want to be able to safely board and alight the vehicle.	Open questions linked to possibilities of improving the boarding and alighting experience for such users; see also user needs #9 - #15 as well as #25 of D2.6.

Table 1: Identified gaps / open questions – infrastructure and on-site service

As this summary shows, the key topic of the identified gaps and open questions for infrastructure and on-site service is linked to the adaptation of the AVENUE services to the needs of visually- or hearing-impaired users or those with reduced mobility.

4.2.2 Vehicle

This section focuses on the gaps and open questions linked to the vehicle.

Need	Need: detailed description	Gap or open question
ON3	As an operator, I want to reach higher speeds with my AVs, at least 30 km/h, in order for the AV service to be a competitive solution.	Gap also identified in D2.3
ON3	As an operator, I want a smooth operation of my public transport service with an AV, regardless of the weather conditions and the	Gap also identified in D2.3

	road behaviour of other vehicles on the road. This requires <ul style="list-style-type: none"> • More intelligent sensory systems, • Better braking calculation, • Better safety zones, • Overtaking ability, • Closed corridor overtaking. 	
ON4	As an operator, I want to ensure that the AV service is running smoothly without a Safety Operator onboard: specific manual interventions need to be possible to be done remotely / by teleoperation, such as pull to curb, use the horn, overtaking a vehicle that is illegally parked etc.	Gap also identified in D2.3
ON4	As an operator, I want to ensure that the remote supervision team can perform certain actions at distance, such as door opening and stopping the automated minibuses.	Gap also identified in D2.3
ON15	As an operator, I want to ensure the safety of my passengers during operations, including <ul style="list-style-type: none"> • Ensuring that passengers sit down and buckle up during a ride, • Ensuring that harsh braking does not put passengers at risk. 	Currently, the only option for operators to share such information is via stickers in the automated minibuses: PTOs do not have the possibility to add any customized information to the display in the automated minibuses (used for troubleshooting by the safety operator and Navya only), neither is it possible to configure automated announcements in the automated minibuses.
ON15 / PN3	As an operator, I want to allow passengers to communicate with the operator intervention team for safety or security concerns, who will then be able to establish the nature of the problem and contact the respective external service needed, such as police, fire brigade, technical services.	It is currently not possible to use any of the available tools and functionalities in the automated minibuses for communication between the operator intervention team and passengers.
ON16	As an operator, I want to be able to evaluate new routes remotely based on new map data and existing knowledge.	Gap also identified in D2.3
ON16	As an operator, I want to be able to be independent in the process of mapping and commissioning a new route, and not be dependent on the vehicle manufacturer to come on site and perform the required actions.	Gap also identified in D2.3

Table 2: Identified gaps / open questions – vehicle

This overview shows that most of the gaps linked to the vehicle have already been identified in D2.3. Key aspects here are the wish for an increased speed and weather-independent driving capabilities of the vehicle, gaps linked to the possibility to remove the safety operator, and more independence for the operator from the vehicle manufacturer.

4.2.3 Software

This section focuses on the gaps and open questions linked to the software: vehicle software, fleet orchestration, and Traveler App.

Need	Need: detailed description	Gap or open question	Software
ON4	As an operator, I want to ensure that the remote supervision is able to observe the automated minibus movement and events inside the automated minibus thanks to a live video stream.	Gap also identified in D2.3: live video streams are currently not available via the vehicle API.	Vehicle
ON6	As an operator, I want the fleet orchestration software to be able to route the vehicles to ensure optimization.	Gap also identified in D2.3: Prescribing the route to the vehicle is already supported by the fleet orchestration platform but not by the vehicle software.	Vehicle
ON6	As an operator, I want to be able to pool passengers at any point in time if this is the optimal solution.	Gap also identified in D2.3: It is currently not possible to cancel or overwrite an ongoing mission. This means that if a new booking is created, which should ideally reroute the vehicle on its ongoing ride (or stop on the way to pickup the new passenger), this is not currently possible with the vehicle software (while already fully supported by the fleet orchestration platform).	Vehicle
ON6	As an operator, I want to be sure that two AVs on a bidirectional route won't get into a deadlock.	Open question if deadlock avoidance for AVs can still be tackled until the end of the project.	Fleet orchestration platform
ON8 / PN5	As an operator, I want passengers to be able to place recurring bookings. As a user, I want to be able to make a recurring booking.	Recurring bookings are not currently supported by the AVENUE platform.	Fleet orchestration platform
ON9	As an operator, I want to be able to use live video streams of the inside and surrounding of my vehicles to supervise the service.	Gap also identified in D2.3: live video streams are currently not available via the vehicle API.	Vehicle
ON13	As an operator, I want to be sure that the vehicle opens the doors for the right vehicle. As an operator, I want to be sure / receive a confirmation that the right traveler has boarded.	Gap / open question around traveler identification. Traveler identification is one of the aspects still to be further discussed and addressed in the framework of task 4.4 of the project. A workshop is to be planned for Q2 / Q3 2021 with the technical partners to discuss potential solutions and their feasibility.	Fleet orchestration platform & Traveler App

	As an operator, I want to cross-check the number of passengers that should be on board (information from the bookings) against the actual number of passengers on board.		
PN5	As a user, I want to be able, via the Traveler app, to make a <ul style="list-style-type: none">• booking even when I am not (yet) on-site,• prebooking,• recurring booking,• booking that copies the details from one of my past bookings.	Gap: While this could be implemented in the AVENUE TA, it hasn't been done so far in the project as it depends on having user profiles in the Traveler App, which is not currently the case. This requires integration to the PTOs user database, which is not something for which the AVENUE PTOs have shown an interest. It remains an open question if this will be done on any of the AVENUE sites before the end of the project.	Traveler App
PN6	As a user, I want to be able to change my booking: <ul style="list-style-type: none">• Change the destination (before or during the ride),• Change the origin (before the ride),• Edit the number of passengers for whom I've booked (before the ride),• Edit my transport options, such as if I carry big luggage (before the ride).	Gap: It is currently not possible to modify an already created booking. Instead, the passenger needs to cancel the booking and create a new booking with the desired changes. This is only possible ahead of pickup.	Fleet Orchestration platform
PN9	As a user, I want to be able to set specific user needs in my profile.	Gap: This depends on having user profiles in the Traveler App, which is not currently the case. This requires integration to the PTOs user database, which is not something for which the AVENUE PTOs have shown an interest. It remains an open question if this will be done on any of the AVENUE sites before the end of the project.	Traveler App
PN7	All information is provided as textual information in the Traveler App.	The adaptation of this service to visually impaired users remains an open question.	Traveler App
PN11	As a visually impaired user, I want to be able to safely find the stops.	Gap / Open question: This could be addressed through auditive guidance through the TA.	Traveler App

Table 3: Identified gaps / open questions – software

Regarding the software, gaps and open questions have been identified for vehicle software, the fleet orchestration, as well as for the Traveler App.

For the vehicle software, identified gaps are:

- Live video stream,
- Prescribing the route to the vehicle,
- Overwriting / cancelation of an ongoing mission.

For the fleet orchestration software, identified gaps are:

- Recurring prebookings,
- Traveler identification,
- Deadlock avoidance,
- Modification of an already created booking.

For the Traveler App, identified gaps are:

- Traveler identification,
- User profiles in the TA and everything that depends on it,
- The adaptation of the TA for visually impaired users.

5 Conclusions

This Deliverable D2.15 outlines the service needs and requirements as expressed by the AVENUE PTOs, maps them to the available AVENUE services, and identifies any outstanding gaps and open questions linked to the service needs.

The input for the needs has been gathered since the start of the project (see for details also D2.13 and D2.14) and was most recently updated throughout a series of workshops with the AVENUE operators. The objective of the workshop series was to gather the service needs and requirements for each AVENUE PTO until the end of the project as well as (optionally), with an outlook to the future, beyond the end of the AVENUE project. The outcome of the workshops is the main input to this deliverable.

The AVENUE service needs and requirements as expressed by the PTOs have been grouped by the “requester” – is it a need for the operator or for the end-user, the passenger? – and are formulated as user stories. The service needs are numbered and named following the same logic: “ON” stands for an operator need, “PN” stands for a passenger need. Each service need contains several aspects, which are listed in a bullet-point list under the need description. For each service need, a reference is given to AVENUE services addressing this need, both for services already developed as for services currently still in development and/or testing. Where no AVENUE service applies, the gap is identified.

Next, the available AVENUE services are briefly described, and open gaps and questions are listed. The gaps and open questions are split into three sections, infrastructure and on-site service, vehicle, as well as software.

For infrastructure and on-site services, the key topic of the identified gaps and open questions is linked to the adaptation of the AVENUE services to the needs of visually- or hearing-impaired users or those with reduced mobility.

Most of the gaps linked to the vehicle have already been identified in D2.3. Key aspects here are the wish for an increased speed and weather-independent driving capabilities of the vehicle, gaps linked to the possibility to remove the safety operator, and more independence for the operator from the vehicle manufacturer.

Regarding the software, gaps and open questions have been identified for vehicle software, the fleet orchestration, as well as for the Traveler App. For the vehicle software, the identified gaps are the live video stream, prescribing the route to the vehicle, and overwriting / cancelation of an ongoing mission. For the fleet orchestration software, identified gaps and open questions are linked to recurring prebookings, traveler identification, deadlock avoidance, and the modification of an already created booking. For the Traveler App, identified gaps are: traveler identification, user profiles in the TA and everything that depends on it, the adaptation of the TA for visually impaired users.

As a next step, the findings summarised in this deliverable D2.15, especially gaps and open questions, will be feeding into WP4, where final decisions about possible improvements will be taken, and, if time allows, still implemented until the end of the project.

6 Appendix A: Individual PTO service needs and requirements

This chapter contains the outcomes of the workshop series organised in Q4 2020.

6.1 TPG requirements/service needs

6.1.1 General

Priority is a fully automated, fluid on-demand service where people are fully independent and don't need to ask questions.

6.1.2 Requirements – As a user, I want to

The following use cases are applicable for all kinds of customers, including reduced mobility, with strollers, wheelchairs, buggies, pets, carrying luggage, non-native speakers, etc.

6.1.2.1 General

- Be transported directly from my departure point until my destination
- Be transported in an environmentally friendly way
- Be transported in a comfortable way (not too crowded, comfortable ride, clean vehicle, etc.)
- Be transported in a secure way, in security and feeling safe
- Experience a fast and seemingly transport experience
- Experience a reliable service
- Get value for money
- Have access to information about policies
- Have access to information about eco-footprint

6.1.2.2 Public transport available

- Know if public transport is available where I am (or where I start) and where I want to go?
- Know if this is a direct service or divided into several connections
- Know if this mode of public transport is suitable for me?
- Know what I need to do to be transported?
 - Where is the bus stop, if any?
 - When will a bus arrive, if ever?
 - What are the options to order a bus?
 - How does it work?
 - What do I need to do?
 - How can I find information?
 - etc

6.1.2.3 Booking

2. Be able to book a vehicle by the use of an app
 - Logically

- Quickly
- Following usability and accessibility conventions
- Supporting Fr, De, It and En languages
- 3. Be able to cancel my booking (before the ride)
- 4. Be able to change my booking (even during the ride)
 - Change destination
 - Change pickup point
 - Add/remove passengers/options
- 5. Be able to book on-site and directly
- 6. Be able to book off-site
- 7. Be able to make a prebooking
- 8. Be able to make a recurring booking
- 9. Be able to make a booking from my history file
- 10. Be able to make a booking from my last bookings
- 11. Be able to book via a helpdesk (telephone operator)
- 12. Be able to select a destination from a list
- 13. Be able to select a destination on a map
- 14. Be able to select destination from points of interest
- 15. Be able to select destination from the type of access (building wheelchair entrance)
- 16. Be able to book regarding service (quick/slow, waiting time, alone/full house, women only.)
- 17. Be able to see transfer hubs with live timetable connections
- 18. Be able to select from several travel options
- 19. Be able to make several client profile configurations (myself, as a family, etc.)
- 20. Being informed about scheduled pickups and drop-offs during my ride

6.1.2.4 Receive travel information

- 9. Know how long it takes for my vehicle to arrive at pickup
- 10. Know how long it takes to arrive at destination
- 11. Know when something is wrong, why, and the consequences
- 12. Know where the virtual bus stop is where I need to wait and how to go there
- 13. See the vehicle live on a map
- 14. Know how I can identify the vehicle I booked (picture of the vehicle, vehicle name, ID number)
- 15. Receive travel information during the journey
- 16. See where I drive on a map
- 17. Receive information when I need to go out
- 18. Receive information that this is not my stop when the bus is halted before for another client
- 19. Receive crucial notifications but not too many notifications either

6.1.2.5 Board and alight

- Know how I can enter the vehicle
- Know where I'm supposed to sit (Covid seat people by family, single traveller?)
- Know how to attach the seatbelt
- Receive general information, sit, attach seatbelt, other
- Know when to stand up (vehicle standstill) and go out
- Know how to leave the vehicle

6.1.2.6 Assistance & Security

- Receive personalised travel assistance
 - Booking
 - Accompanied travel (children, aged, special needs)

- Wheelchair assistance: No TPG automated minibus has a ramp, thus passengers in a wheelchair should be able to request assistance from the team on-site. Optionally only a couple of stops could be accessible by wheelchair (those that have a platform or ramp, thus where these passengers could enter without assistance)⁵
- Be able to live speak with a TPG person (vehicle button/App?)
- Emergency button
 - in the vehicle: yes (to supervisor)
 - in the TA: why not (to supervisor)
- Knowing someone is within reach
- Knowing that crime is being monitored
- Accident / Health issue in the vehicle: Alert through CERTH service, operator reacts correctly
- Aggression in the vehicle: Alert through CERTH service, operator reacts correctly

6.1.2.7 Entertainment

- **Not a priority**
- TPG infotainment via app?

6.1.2.8 Pricing and Payments

- Know that I can travel Pay as you go
- Know the pricing of the proposed travel options and ability to select a preferred option
- Know the total amount of money spent so far this month
- Receive a total travel invoice at the end of the month (every mode of transport used)
- Or for a single ticket user, be able to acquire a single ticket (from the TPG webshop?)

6.1.3 Requirements – As a PTO, I want to

6.1.3.1 General

- Be able to transport everyone
- Be able to offer a flexible and easily adjustable service adapted to changing needs
- Encourage the use of public transport
- Offer service today where there is no public transport
- Offer an optimised service for our clients
- Offer a secure transport mode for customers and other road users
- Offer a 7/24 transport service
- Comply with legal terms and environment
- Offer an economical transport mode and spent less
- Receive passenger feedback (e.g., via feedback form in Traveler App)

6.1.3.2 Shuttle

- Ramps for wheelchairs, strollers, space for lead dogs, walking frames
- Special needs supporting tools, blind/deaf persons
- Higher speeds, at least 30 km/h
- More intelligent sensory systems
- Better braking calculation
- Better safety zones
- Overtaking ability

⁵ Notes from the workshop

- All-weather conditions
- Ability to drive driverless without operator aboard
- Display no travel information on the vehicle screen inside

6.1.3.3 On-demand

1. Offer on-demand and even door2door services
2. Pooling, ridesharing service to pickup additional passengers
3. Matching trip requests and vehicle availability
4. Routing vehicles to optimize route
5. Ability to receive trips automatically generated
6. User-oriented app (functionality see user needs)
7. Be able to change bus stop points
8. Be able to (temporary) remove roads from the network
9. Be able to configure the on-demand system to the different PTO needs
10. Remote supervision (stop automated minibus and open doors)
11. Real-time monitoring tools
12. Remote operator situational awareness (via Certh tools)
13. Possibility for a supervisor on-site to get alerts for certain events, in case of an incident, fire etc.; no constant live stream will be needed; alerting is key
14. Accident / Health issue in the vehicle: Alert through CERTH service, operator reacts correctly
15. Aggression in the vehicle: Alert through CERTH service, operator reacts correctly
16. Receive alerts to alert police etc
17. Passenger counting (floor space)
18. Speak with passengers via intercom
19. Video feed inside the automated minibus
20. Virtual bus stops without zigzag, traveller information screens, or bust stop request buttons

6.2 Keolis Lyon requirements/service needs

6.2.1 Background information

What is the interest for Keolis Lyon to integrate the automated minibus?

Economic model of public transport	New business model
<ul style="list-style-type: none"> • In France, public transport is an economic model heavily subsidized by local authorities (French average = 40% of ticket price covered by the sales price). • In Lyon, drivers' salaries represent 2/3 of operating costs. • Choices to develop new public transport lines depend on the number of users. • Below a certain expected number of passengers, the local authority can no longer bear the associated costs (the fewer passengers there are, the greater the local authority's share of funding). 	<ul style="list-style-type: none"> • PTOs will be able to offer new types of services that are not part of their current mission. • These new services can be thought of with a profitable economic model that would allow them to generate margins on sales prices. • The law on mobility is evolving to authorize these new uses • With a profitable offer, PTOs could provide mobility organizing authorities with a new source of funding. • This new source of funding could support investments to develop the public transport network.

<ul style="list-style-type: none"> • With the phenomenon of urban sprawl (in Lyon in 20 years, the metropolis has grown from around 200 to 500 municipalities), new, less dense peri-urban areas are developing. • The automated minibuses could make it possible to modify the eligibility criteria of areas for the development of public transport. 	<ul style="list-style-type: none"> • Automated minibuses could therefore make it possible to develop public transport and impact the ability of local authorities to invest in all modes of public transport.
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Table 4: Background information Keolis

What are the main services?

Economic model of public transport	New business model
<ul style="list-style-type: none"> • Type: Daily services • Objective: to encourage the use of public transport and to discourage selfish car users • Targets: Daily travellers using their cars today to get to work, drop off children at school, etc. • Perception of public transport: Non-users, reluctant, living in areas where the structuring lines of the network are not accessible on foot, lack of infrastructure that fascinates access to the public transport network (bicycle garage, self-service bicycle, relay parking, etc.). 	<ul style="list-style-type: none"> • Type: Weekend and holiday services according to the calendar for festivals, events, and tourist purposes • Objective: Offering transport services (public or not) currently offered by other operators (Uber) • Targets: Target transportation service users in geographic areas or times of the day when public transit is not available. Make value-added service proposals compared to traditional transit service, such as on-demand semi-transportation at prices higher than transit but lower than competitors offering door-to-door service. • Perception of public transport: pragmatic. Use of public transit based on efficiency and value for money

Table 5: Main services Keolis

6.2.2 Example 1: Economic model of public transport

- Semi-on-demand service (pickup only on defined portions, dropoff only at the tram/metro station)
- Reservation is available and free of charge. The application indicates when and where the automated minibuses will stop for pickup

Or

- Fixed line with automated minibuses every 10 minutes
- Reservation on smartphone or call center
- For any disabled person, this service is compatible with the general system of support by specialized teams.
- No ticketing system
- Ask the passenger for confirmation of care by the application (GPS ?)
- Consistency check between the number of passengers booked and the actual number on board (only for safety reasons).
- Pooling services only



Figure 2: Example - Economic model of public transport

6.2.3 Example 2: New business model

- Semi-on-demand service (pickup only on defined portions, dropoff only at the dedicated lane stops)
- Reservation is mandatory and payable according to supply and demand.
- Consistency check between the number of passengers booked and the actual number of passengers on board.
- Reservation on smartphone exclusively
- For any disabled person, the infrastructure of the dedicated bus lane will be available for boarding and alighting.
- Consider that the customer is on board thanks to the GPS positioning of the smartphone and/or ask for confirmation
- Knowing how long it will take me to catch the next automated minibuss if I book now. The calculator must take into account the walking time to get to the pickup area.
- The traveler must be able to book for more than one person
- Advance booking and premium service with non-shared automated minibuss available.

6.2.4 What functionality is required for each service?

Economic model of public transport	New business model
Passenger Counting: <ul style="list-style-type: none"> • Taking into account to manage reservations • Ensure the number of people inside the automated minibuss • Contact with Personal Computer (PC) Security in case of a discrepancy between the logical and actual number of people on board. 	Passenger Counting: <ul style="list-style-type: none"> • Taking into account to manage reservations • Ensure the number of people inside the automated minibuss • Contact PC Security in case of a discrepancy between the logical and actual number of people on board.

Assistance/Emergency : <ul style="list-style-type: none"> • Via a button on the inside, initiate communication with a person who will be able to establish the nature of the problem and direct you to the best service (Police, fire brigade, technical services). • In the contact between the emergency service and the police/fire brigade, certain information will be automatically transmitted and linked to the call (position of the automated minibus, etc.). 	Assistance/Emergency : <ul style="list-style-type: none"> • Via a button on the inside, initiate communication with a person who will be able to establish the nature of the problem and direct you to the best service (Police, fire brigade, technical services). • At the same time, live video communication is established and shared with the police, who will be able to judge whether or not an immediate intervention is necessary. The night service is considered to be a sensitive service with regard to aggression.
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Table 6: What functionality is required for each service? - Keolis

The two examples given are the simplest to use according to the regulations applicable to PTOs in France.

Do PTOs have to own the automated minibus fleet, or do they operate the fleet of the transport organizing authority (as is the case for the rest of the vehicle fleet)?

If the fleet is owned by the PTOs, then other cases may be considered, such as services to be provided at private sites. But this example is irrelevant because it is no longer public transport.

If the vehicle fleet belongs to the transport organising authority, new information system architectures will have to be devised with :

- 1 manufacturer
- 1 owner-manager of the fleet and its use
- 1 operator who supervises on a daily basis
- A set of stakeholders who will have to interact and benefit from back-office information

For new business models, services with longer distances must be considered. During the hours of operation of the public transit system, long distances are unnecessary because all modes are available. At night, it will be necessary to increase the distances to be covered for automated minibuses.

6.3 Amobility requirements/service needs

6.3.1 Operational requirements

6.3.1.1 Remote Control

- Real-time monitoring tools
 - Remote operator situational awareness
- Remote assistance tools
 - New trajectory
 - Pull to curb
 - Use horn
 - ..
- Remote service
 - Walky talky function between traveller and remote operator

6.3.1.2 Development of existing tools

- Better visualization tools. More advanced features
- Video feed inside and outside the automated minibus
 - Analysing video data autonomously
 - Video for manual monitoring
- Ability to evaluate new routes remotely based on new map data and existing knowledge
- Input from additional sensors that can be mounted on our vehicles

6.3.1.3 Shuttle functionalities

- Higher speeds, at least 30 km/h
- More intelligent sensory systems
- Better braking calculation
- Better safety zones
- Closed corridor overtaking
- All-weather conditions

6.3.1.4 On-demand

- Dispatcher
 - Matching trip requests and vehicle availability
 - Routing vehicles to optimize route
 - Routing vehicles to pickup additional passengers
- Vehicle
 - Ability to receive trips automatically generated
 - Ability to cancel an ongoing trip
 - Ability to change endstation without stopping
- User-oriented app
 - Request trip (pickup, dropoff, type of passenger, amount of passengers)

6.3.2 Regular user requirements

6.3.2.1 In-vehicle perspective

- Awareness about the location of automated minibus
- Awareness about route status
- Awareness about routing and virtual stops
- Information about policies
 - Animals, food, price, etc.
- Dynamic ETA
- Emergency call button
- Safety functionalities (feeling safe)
 - Knowing someone is within reach
 - Knowing that crime is being surveilled

6.3.2.2 Out-of-vehicle perspective

- Awareness of location of automated minibus
- Awareness about changes
- Awareness about delays
- Awareness about the price estimate

- Awareness about the capacity status
- Awareness about routing
- Booking of trips
 - Smartphones, phones, etc.
 - Confirmation
 - Book in advance
- Information about the eco-footprint
 - Better for the future?
- First mile, last mile
 - Door to door
 - Technical requirements

6.3.3 People with special needs requirements

6.3.3.1 In-vehicle perspective

- Mounting of wheelchairs
 - Automatic vs. manual
- Space for lead dogs
- Space for canes
- Space for walking frames
- Information about the trip status
 - Blind people
 - Deaf people
- Getting in and of the vehicle
 - Activate automatic ramp, or other supporting tools
 - Opening/closing doors
- Information about safety
 - How do we keep them safe?
 - Instructions in case of an incident, fire, etc.
 - Emergency call button

6.3.3.2 Out-of-vehicle perspective

- Information about capacity for assistive devices
- Ramps for wheelchairs, strollers, etc.
 - Automatic vs. manual
- Information systems
 - Blind people (Sound etc.)
 - Deaf people (Moving points)
- Booking of trip
 - Smartphone, phone, (flex taxi in Denmark as an example)
 - Confirmation
- Find the virtual stop
 - Blind people dots
 - Smartphone guidance

6.4 Sales-Lentz requirements/service needs

6.4.1 Luxembourg City – Pfaffenthal

6.4.1.1 Plans 2021

Beginning of the year 2021, we will propose an on-demand service to the city of Luxembourg and extend the current route.

Objectives:

- Offer a public transport to :
 - L'Hospice de Pfaffenthal (CIPA) (Rue Mohrfels)
 - Youth Hostel (Rue du Fort Olisy)
- Currently, no connection exists between the panorama lift and all these destinations. Therefore, most of the employees and visitors come by car, but there is a great lack of parking spaces.
- Offer public transport to:
 - SERVIOR (the parking is too small for employees and visitors)

6.4.1.2 Complication concerning the development of an on-demand application and needs

- Public transport in Luxembourg is free, and we cannot charge a person for a trip, even if it is an on-demand or VIP- service. The automated minibus service belongs to public transport, so no paid reservation is possible.
- The automated minibus will also have fixed stops and not on-demand stops. Luxembourg City is integrating the automated minibus in its public transport and does not want a „Taxi“ service.
- The only system that the ministry allows us is an „on-demand“ system with a touch screen on each stop (example > the order touch screen at Mc Donald's).
- The automated minibus will always remain parked near the Panorama Lift, but it will only run if someone calls it via this „on-demand“ screen. (A automated minibus-user must be able to to order the automated minibus at a specific pickup point and select his desired dropoff location, information about the estimated duration of the travel time should be given.
- On this on-demand screen there must also be an option for persons with reduced mobility to press a button to request the automated minibus to adapt when it arrives at the stop. The ramp should come out automatically.



Figure 3: Planned extension of route in Pfaffenthal (SLA)

6.4.2 Campus Contern

6.4.2.1 Extension of the current route (phase II)

Train station Contern ⇌ Campus Contern

Operating times:

Mo-Fr: 07h00-09h00

16h00-19h00

Passengers: mainly people going to work/coming from work

Connecting more companies

Operations started on this extension on 19/10/2020



Figure 4: Extended route at Contern

6.4.2.2 Service needs Contern

The automated minibus already has an on-demand service. In the morning, the automated minibus remains at the stop near the station and leaves only when there are passengers. In the evening it remains at the offices and leaves as soon as the employees leave to take the train.

The strongest need on this site is linked to traveler identification. Traveler identification has two aspects: (1) opening the doors for an authorized traveler and (2) confirmation that the authorized traveler has boarded. For SLA and SLA's customers, this is a top priority. Indeed, sometimes when Campus employees arrive in the morning to take the automated minibus to their offices, the automated minibus is already full because of non-employees passengers.

Campus Contern allows passengers external to the Campus to take the automated minibus but only when there are free places! Campus employees have priority and traveler identification will surely help to have a better organization and ensure priority to the Campus employees.

6.4.3 Replication site Esch-sur-Alzette

In phase 1, the automated minibus will be operating on a fixed-route, but with on-demand stops in the rue de l'Alzette. It is planned to possibly install on-demand touch screens at each stop.

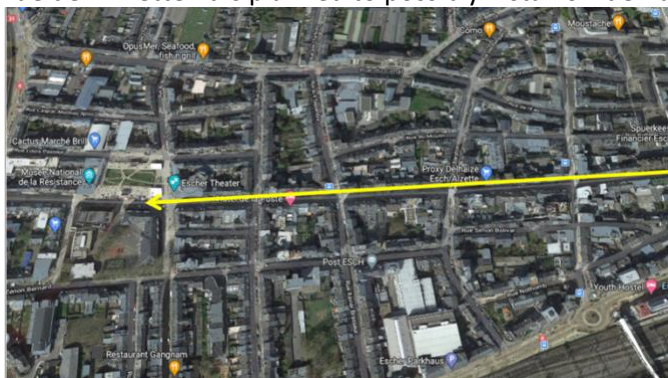


Figure 5: Planned route Esch-sur-Alzette Phase 1