AVENUE

Autonomous Vehicles to Evolve to a New Urban Experience

DELIVERABLE

D2.18 Final Trials use cases specification and evaluation plan

Co-funded by the Horizon 2020 programme of the European Union

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 769033

Disclaimer

This document reflects only the author's view and the European Commission is not responsible for any use that may be made of the information it contains.

Document Information

Grant Agreement Number	**769033**
Full Title	Automated Vehicles to Evolve to a New Urban Experience
Acronym	AVENUE
Deliverable	D2.18 Final Trials use cases specification and evaluation plan
Due Date	31.04.2021
Work Package	WP2
Lead Partner	Bestmile, École Centrale Lyon (ECP)
Leading Author	Lisa Labriga (Bestmile), Sylvie Mira Bonnardel, Fabio Antonialli (ECP)
Dissemination Level	Public

Document History

Version	**Date**	**Author**	**Description of change**
1.0	24.02.2021	Lisa Labriga (Bestmile)	First draft
1.0	24.02.2021	Quentin Zuttre (Keolis)	Review and update of chapter 2.4 (I)
2.0	03.03.2021	Lisa Labriga	V2.0
2.0	03.03.2021	Quentin Zuttre	Review and update of chapter 2.4 (II)
2.1	04.03.2021	Lisa Labriga	V2.1
2.2	08.03.2021	Maud Simon (Bestmile)	V2.2 Terminology Update
2.3	12.03.2021	Lisa Labriga	V2.3 Integration of first inputs PostBus
2.3	15.03.2021	Jeroen Beukers (TPG), Sylvie Mira Bonnardel & Fabio Antonialli (ECP)	Update of chapters 2.2. (TPG) and 3 (ECP)
2.4	16.03.2021	Lisa Labriga	V2.4 Integration of inputs TPG & ECP
2.4	16.03.2021	Steve Marrafa, Simone Branco De Vera (SLA)	Update of chapter 2.3
2.5	16.03.2021	Lisa Labriga	V2.5 Integration of inputs SLA
2.5	23.03.2021	Christian Zinckernagel (AM)	Update of chapter 2.1
2.5	24.03.2021	Steve Marrafa, Simone Branco De Vera	Update of chapter 2.3

2.5	01.04.2021	Martin Neubauer (PostBus)	Update of chapter 2.5
2.6	09.04.2021	Lisa Labriga	V2.6 Integration of updates
2.6	13.04.2021	Steve Marrafa, Simone Branco De Vera	Additional inputs to chapters 2.3.4, 2.3.7.2, and 5.2.4.3.
2.7	15.04.2021	Lisa Labriga	V2.6 Integration of updates
2.7	22.04.2021	Lionel Binz (EtatGe)	Quality review deliverable D2.18
2.8	26.04.2021	Lisa Labriga	V2.8 Integration of review comments and suggestions
2.8	26.04.2021	Christian Zinckernagel, Steve Marrafa, Simone Branco De Vera	Clarification on questions from review on chapters 2.1 and 2.3
2.9	27.04.2021	Lisa Labriga	V2.9 Integration of clarifications
2.9	29.04.2021	Maud Simon, Jelena Alonso (Bestmile)	Final internal review
Final	30.04.2021	Lisa Labriga	Final version
3.0	18.01.2022	Laurent Helfer	Revision for Reviewer comments

Table of Contents

Table of Figures

Table of Tables

Acronyms

ADS	Automated Driving Systems
AM	Automated Mobility
API	Application Protocol Interface
AV	Automated Vehicle
BM	Bestmile
BMM	Business Modelling Manager
CAV	Connected and Automated Vehicles
CB	Consortium Body
CCAM	Cooperative, connected and automated mobility
CERN	European Organization for Nuclear Research
CO_2	Carbon dioxide
D7.1	Deliverable 7.1
DC	Demonstration Coordinator
DI	The department of infrastructure (Swiss Canton of Geneva)
DK	Denmark
DMP	Data Management Plan
DSES	Department of Security and Economy - Traffic Police (Swiss Canton of Geneva)
DTU test track	Technical University of Denmark test track
EAB	External Advisory Board
EC	European Commission
ECL	École Centrale Lyon
ECSEL	Electronic Components and Systems for European Leadership
EM	Exploitation Manager
EU	European Union
EUCAD	European Conference on Connected and Automated Driving
F2F	Face to face meeting
FEDRO	(Swiss) Federal Roads Office
FOT	(Swiss) Federal Office of Transport
GDPR	General Data Protection Regulation
GIMS	Geneva International Motor Show
GNSS	Global Navigation Satellite System
HARA	Hazard Analysis and Risk Assessment
HSPF	Hochschule Pforzheim
IPR	Intellectual Property Rights
IT	Information Technology
ITU	International Telecommunications Union
KPI	Key Performance Indicator
LA	Leading Author
LIDAR	Light Detection And Ranging
M	Month
MEM	Monitoring and Evaluation Manager
MT	MobileThinking
NO	Norway
NPS	Net Promoter Score
OCT	General Transport Directorate of the Canton of Geneva
ODD	Operating Design Domain
OEDR	Object And Event Detection And Response
OFCOM	(Swiss) Federal Office of Communications
PC	Personal Computer
PC	Project Coordinator
PEB	Project Executive Board
PGA	Project General Assembly
PRM	Persons with Reduced Mobility
PSA	Group PSA (PSA Peugeot Citroën)
PTA	Public Transportation Authority
PTO	Public Transportation Operator
PTS	Public Transportation Services
Q	Quarter
QRM	Quality and Risk Manager
QRMB	Quality and Risk Management Board
RN	Risk Number
SA	Scientific Advisor
SAE Level	Society of Automotive Engineers Level (Vehicle Autonomy Level)
SAN	(Swiss) Cantonal Vehicle Service

SDK	Software Development Kit
SLA	Sales Lentz Autocars
SMB	Site Management Board
SoA	State of the Art
SOTIF	Safety Of The Intended Functionality
SWOT	Strengths, Weaknesses, Opportunities, and Threats.
T7.1	Task 7.1
TM	Technical Manager
TPG	Transport Publics Genevois
UITP	Union Internationale des Transports Publics (International Transport Union)
URR	User Retention Rate
USAT	User Satisfaction Score
V2I	Vehicle to Infrastructure communication
V2X	Vehicle-to-everything
WP	Work Package
WPL	Work Package Leader

Executive Summary

Deliverable D2.18, Final Trials use cases specification and evaluation plan, consists of two main parts: the demonstrator roadmaps that details the action plan and roadmap for each of the demonstration sites of the AVENUE project (Copenhagen, Geneva, Luxembourg, and Lyon) as well as the replication sites, and the evaluation plan of the overall AVENUE services, technologies, and functionalities.

The **demonstrator and replicator roadmaps** contain a baseline description of automated minibuses running under the supervision of the transport operators and compare this to the vision outlined for the AVENUE project and related needs. The vision is then broken down into concrete goals for the four-year project, which are outlined in detail in the action plan. The action plan describes the pilot site chosen, the use cases and the roadmap, including operation details, technical requirements, objectives and milestones (with the underlying steps, a list of actions to achieve them and an associated timeline) and Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis per use case. It furthermore provides details on integrations planned and special needs to be addressed. Lastly, the demonstrator roadmaps contain some details on the evaluation plans for the use cases. While mainly referring to the comprehensive evaluation, which forms the second part of this deliverable, each demonstrator details out the Key Performance Indicators (KPIs) to determine the success of the pilot as well as the data that they would like to collect in order to evaluate the demonstration of the different use cases.

The **evaluation plan** details the evaluation process to be established throughout the project and that will iteratively be refined. During the operation of the services, the needs of the different user groups based on different classifications (age, activity, gender, special needs) and the barriers in the adoption and acceptance of automated vehicle transport services will be identified. A detailed evaluation of the service acceptance will be performed, measured both by subjective and objective KPIs: questionnaires for active and potential users, semi-structured interviews, number of new users in the service, number of users changing behavior, etc. The evaluation of the costs and benefits will be done with the Total cost of ownership method, taking into account not only service operation costs, but also quantify the indirect societal and environmental benefits like parking cost savings or efficient land development benefits, change of modal transfer, working hour gains and waiting time reductions, energy savings, carbon footprint and air pollution reduction and even changes in passenger habits resulting from the public service personalization.

Evaluation is taking place during Phase four (M12-M48) and Work Package (WP) 8. The economic analysis of the used automated electric vehicles will first focus on business viability and then on possible economic impacts for users and cities. The social impact analysis will study the user experience, the user acceptance and the potential changes in mobility behavior in the use of public transport systems.

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 minibuses will ensure safe, rapid, economic, sustainable and personalized 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 behavior, 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 behavior 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 to in the AVENUE project as a Fully Automated Vehicle (AV), also referred to 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 27th of 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
- A "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.

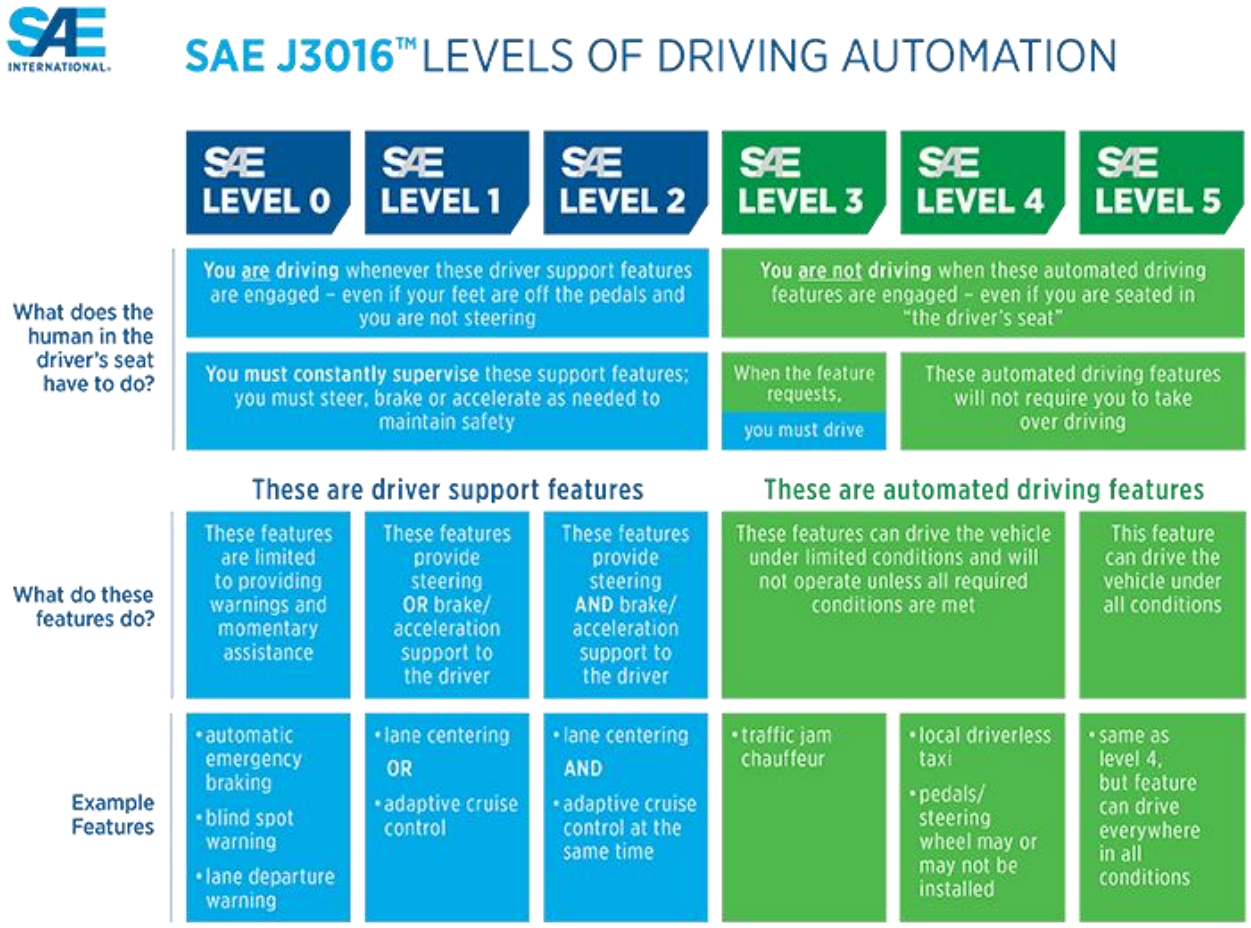


Figure 1: SAE Levels of Driving Automation

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 behavior 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 in 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 of 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 behavior, in an open street environment. The vehicles are automatically capable to recognize 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 minibuses are 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 a round-about in the presence of other fast running cars, stop in zebra crossings, communicate with infrastructure via Vehicle to Infrastructure communication (V2I) (ex. red light control).

The automated minibuses used in the AVENUE project can technically achieve speeds of more than 60 km/h. However, this speed cannot be used in the project demonstrators for several reasons, ranging from regulatory to safety. Under current regulations, the maximum authorized 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 100 meters and the obstacle identification is done for objects no farther 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 braking and stop with 40 meters in higher speeds (40-50 km/h), but then the brake would be too harsh putting in risk the vehicle passengers. The project is working on finding an optimal point between the passenger and pedestrian safety.

Due to legal requirements, a **Safety Operator** must always be present in the vehicle and be able to take control at 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 an 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 knowhow and best practices will be surveyed, assessed and analyzed. The work of 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 conducted.

Task 2.5 targets the use case scenarios that will be developed and will reflect detailed realistic situations, behavior of the end-users in their regular automated vehicles' service requests. For all types of services and user groups, this task will develop and pre-study the user experiments per demonstrator city (initially) and (at a later stage) per replicator city. The provisional list of AVENUE services will be further enriched, while at least 10 services will be selected for demonstration. Those services will be further detailed in line with the needs and feedback from the demonstrator and replicator cities. Each of those cities will define a baseline and an ambitious vision with corresponding goals for the realization of the respective AVENUE large-scale demonstrators. Different actions/measures and services may be defined and selected. A SWOT analysis will be performed per city that could affect the implementation and the success level of the respective action plan for large scale demonstrations. This includes the type of experiment (focus group or user study), the number of expected participants, the study design, the data to be collected, as well as the evaluation method (an evaluation plan will be elaborated). The functional specifications will be defined for the usage scenarios, with focus on passenger and operation security, service quality and taking into account the business development needs. All technical functionalities (hardware and software) will be identified in link with the defined user requirements. Specifications concerning end-user behavioral patterns and relevant triggers will also be integrated into the functional specifications. The use case scenarios will be used for WP4, WP5 and WP6. Part of the work in task feeds into deliverables 2.13-2.15, while the work of T2.5 that feeds into this deliverable focuses on the demonstrator roadmaps.

In this Deliverable D2.18 we describe the final use cases specifications for each site of the four AVENUE Public Transportation Operators (PTOs), as well as the two new replication sites from PostBus and Sales-Lentz. In addition, the evaluation plan for the demonstrator and replicator sites is outlined.

2 Demonstrator and replicator roadmaps

2.1 Copenhagen: Action plan and roadmap

2.1.1 Baseline description

Until today (March 2021), Amobility has been running, outside of the AVENUE project, automated minibus pilot projects in Denmark, Finland, Norway, Sweden and Estonia, gaining experience and using this experience in the AVENUE pilots and demonstrations The pilot project will be further elaborated in the following section. In March 2021, one pilot project is running, one pilot project is approved and being tested to start in June 2021 and one has been approved to start in September 2021. In the following we present and overview of the different pilots operated by Amobility, indicating which are part of the AVENUE project.

Tallinn (Estonia) 2019 (Done) (not AVENUE site)

The route that is operated in Tallinn is part of the Sohjoa Baltic project that researches, promotes and pilots automated driverless electric minibuses as part of the public transport chain, especially for the first/ last mile connectivity. The operation started at the end of August 2019 and lasted five months.
Details:

- Vehicle: 1 Navya Autonom Shuttle
- Route: Fixed route and fixed stops, 1 km one way
- Passengers: Students, university employees and local commuters
- Operating hours: Tuesday-Friday: 10:00 – 16:00, Saturday-Sunday 09:00 – 20:00
- With a Safety operator on board (required by Estonian Road Authorities)
- Pricing: Free of charge

Oslo (Norway) 2019-2021 (Done) (partly AVENUE site)

The pilot project in Oslo has been running for three years now and is a collaboration between Oslo Municipality, the Norwegian Public Roads Administration, Ruter[1] and Amobility. Oslo and Akershus wish to have 0% emissions across their public transportation and this project will test if the self-driving buses can support these ambitions for a sustainable public transport system.

The first route was launched in May 2019 in Akershusstranda. It runs on a route from Vippetangen, to the town hall city square and back again. This takes the minibus service past the cruise-terminal and along the harbor front.

Details:

- Vehicles: 4 Navya Autonom Shuttle
- Route: Fixed route and fixed stops, 1.3 km one way
- Passengers: Local commuters, tourists

[1] The public transport authority for Oslo and Akershus counties.

- Almost 19'000 passengers during the first four months
- Operating hours: Monday-Sunday 8:20 – 21:15
- With a Safety operator on board (required by Norwegian Road Authorities)
- Services: Fully integrated with the public transport in Oslo e.g., in the RuterReise App and digital time schedule at the two major bus stops
- Pricing: Same tickets as for other public transport in Oslo are needed to use the service

Helsinki (Finland) 2019 (Done) (not AVENUE site)

The route that is operated in Helsinki is part of the Sohjoa Baltic project that researches, promotes and pilots automated driverless electric minibuses as part of the public transport chain, especially for the first/ last mile connectivity. The operation took place from June to September 2019.

Details:

- Vehicle: 1 Navya Autonom Shuttle
- Route: Fixed route and fixed stops, 2.5 km one way
- Passengers: Students, university employees and local commuters
- Operating hours: Monday-Friday: 09:00 – 15:00, Saturday-Sunday: 12:00 – 18:00
- With a Safety operator on board (required by Finnish Road Authorities)
- Pricing: Free of charge

Gothenburg (Sweden) 2018-2019 (Done) (not AVENUE site)

The pilot project in Goteborg is divided into two phases. The first phase of the pilot project took place from May until September 2018 in the Chalmers university area for a duration of 6 weeks.

Details:

- Vehicle: 1 Navya Autonom Shuttle
- Route: Fixed route and fixed stops, 1.8 km one way
- Passengers: Students, university employees and local commuters
- Total passengers: Approx. 1'500
- Operating hours: Monday-Friday 07:00 – 18:00
- With a Safety operator on board (required by Swedish Transport Agency)
- Pricing: Free of charge

The second phase took place from April until October 2019 at Lindholmen Science Park. Around 25'000 people travel through the area daily. At one end of the route is a parking area, where the monthly parking permit fee has been reduced, in order to encourage motorists to park there and take the automated minibus for the last part of their journey.

Details:

- Vehicles: 2 Navya Autonom Shuttle
- Route: Fixed route and fixed stops, one roundabout, 1.8 km one way
- Passengers: employees at international companies and national authorities, students, scientists and residents
- Operating hours: Monday-Friday 7:00 – 18:00
- With a Safety operator on board (required by Swedish Transport Agency)
- Pricing: Free of charge

Learnings: Driving in mixed traffic provides many learnings regarding how the other road users act and what obstacles and challenges occur due to this. How much interference with the service arises when a cyclist or a car overtakes an automated minibus? Does the interest in this technology keep interests among citizens; how long does it take for the locals to accept the service as a natural integrated part of the transport services, etc.? Furthermore, many technical details regarding operation and the Safety operator's functions are obtained.

Movia project: Køge Hospital (Denmark) 2018 (Done) (not AVENUE site)

The pilot project at Køge Hospital is divided in three phases. The first phase of the project took place from May until August 2018 in the Køge Hospital for a duration of three months.

Details:

- Vehicle: 1 Navya Autonom Shuttle
- Route: Fixed route and fixed stops
- 1 km of private road commissioned
- Passengers: Patients, relatives and hospital staff. Total passengers: > 6'500
- Operating hours: Monday-Friday 7:30 – 15:30
- With a Safety operator on board
- Services: In the non-peak hours, on-demand stops on the fixed route were tested, based on the fixed bus stops. The visitor could order an automated minibus through the screen at the bus stop sign post, and then the automated minibus would come to pick them up, without stopping at the other stops, unless others had made a demand
- Pricing: Free of charge

Learnings: We gained important learnings about passengers with special needs, e.g., walking frames, wheelchairs, and elderly. The users expressed gratitude and relief due to the service provided, and the hospital experienced the impact of the service and the size of the need among their patients. The on-demand trials indicated the need to find the common denominator when communicating the how-to messages - so that all types of users are able to interact with the service. Furthermore, many technical details regarding operation and the Safety operator's functions were obtained.

Aalborg East (March 2020 - December 2021) (Active**)** (not AVENUE site)

The pilot project in Aalborg East is a two-year project designed to show how automated minibuses can provide public transport services in a rapidly developing area. The route is on an enlarged bike lane where only self-driving vehicles are allowed to drive alongside with the bikes and the pedestrians. The operation is still active.

Details:

- Vehicles: 3 (2 in operation, 1 spare) Navya Autonom Shuttle
- Route: Fixed route and fixed stops
- 2 km of semi-public roads commissioned
- Passengers: People in the area around Astrupstien.
- Operating hours: Monday-Friday 7:00 – 21:00
- With a Safety operator on board
- Pricing Free of charge

Learnings: The project is still running and learnings have not been evaluated at the moment.

Ski (Norway) (June 2021 - June 2023) (Approved and in testing) (not AVENUE site)

The pilot project is deployed in collaboration with Ruter in Norway. The pilot project is the first pilot project where Amobility is using a non-Navya vehicle. The pilot deploys Toyota ProAce vehicles retrofitted with Sensible 4 sensors and software systems. The vehicle is developed to drive in all weather conditions, being snow the main focus.

Details:

- Vehicles: 2 TOYOTA minivans (on-demand driving only – 30 km/h)
- 8 km of public road commissioned
- Route: Dynamic driving (no fixed order of stops or routes to drive) in a residential area
- 9 virtual stops where patients can be picked up or delivered to
- 30 km/h driving zones
- Operating hours: 10 – 12 hours of operation per day (longer operational hours are approved and can be implemented as needed)

Learnings: The project has not begun yet and the learnings have not been evaluated.

Movia project: Slagelse Hospital (Denmark) (September 2021 - May 2022) (Approved) (AVENUE site)

The pilot project at Slagelse Hospital is the second and third phase of the Movia project, where Køge Hospital was the first phase.

Details:

- Vehicles: 2 automated minibuses (on-demand driving only)
- 5.5 km of public road commissioned
- Route: Dynamic driving (no fixed order of stops or routes to drive)
- Stops: 6 stops where patients can be picked up or delivered to
- Operating hours: 10 hours of operation pr day (longer operational hours are approved and can be implemented as needed)
- 30 km/h driving zones (purpose is to push Navya to deliver)
- Need: Patients and relatives are missing a transport option within the hospital area

Learnings: The project has not begun yet and the learnings have not been evaluated.

2.1.2 Vision, needs, and goals

Vision

The city of Copenhagen has an overall goal to become the World's first Carbon dioxide (CO2)-neutral capital by 2025. Amobility and the AVENUE project will support this goal by implementing and operating automated electric minibuses in Copenhagen as a green initiative to last mile public transport.

The overall goal for Amobility is to implement and test services under the Amobility Cloud on the Copenhagen site. In order to do so, Amobility aims at deploying four vehicles during the project, while working towards expanding the route to multiple routes in the Nordhavn area. These routes will create a better connection between the selected areas of Copenhagen and existing public transport solutions. During the AVENUE project, Amobility wants to further expand the portfolio of vehicles and vessels to

create more advanced features and integrations with the Mobility Cloud. The whole system is planned to integrate with the existing PTO solutions in the Copenhagen area.

Our services should be experienced as "Helpful, Simple & Seamless": When automated vehicles become an integral part of the cityscape, the users will be able to define their transport needs – and order their solution via Amobility's Amobility Cloud. Shortly after, the user will get picked up exactly at his/her location and will be transported to the end destination chosen. The cloud will also be shaped so that it can move goods and parcels - all in various shapes and sizes - around when needed.

At the end of this project, Amobility had planned to have:

- Developed and implemented automated Mobility Cloud in Nordhavn, to the extent the technology and vehicles allow it. Due to issues in Nordhavn the Mobility Cloud cannot be developed and tested in Nordhavn. The core parts of the platform and the components are now further developed at the new site in Slagelse. Many of the parts of the cloud have to be developed first before the bigger picture can be created. Integrating with Google maps and developing internal platforms for monitoring, ordering of trips and mission control are part of this development.
- In an on-demand (door-to-door) automated transport system without fixed routes to the extent that the technology and vehicles allows for it. On-demand testing is very much related to the vehicle's ability to receive, handle and edit missions from Public Transportation Authorities (PTAs). As a part of testing, this on-demand between stops is the first step, followed by on-demand between visual stops. Driving in the not mapped areas is currently not possible. Again, here the possibility to develop and test in Nordhavn is not possible and the developments will be moved to the Slagelse site - where on-demand will be developed and implemented in collaboration with the PTA Movia.
- With the whole zone mapped & geo-fenced, to the extent the technology and the vehicles allow it. Currently this is seen as a very difficult task with the Danish legislation since the test law prohibits that every road is assessed given the vehicle behavior and traffic patterns. Furthermore, the technology available on the market and the pricing structures are seen as major barriers for this to happen within the next 2-3 years.

Needs

By deploying automated minibuses in Nordhavn we address the following needs:

- Transport solution for the Nordhavn area: in the area and connecting to the existing public transport hubs to the extent possible, also taking into account that there is no other means of transport in the area apart from the Metro.
- Lowering the CO2 emissions for the Nordhavn area, to the extent possible.
- Lowering the number of vehicles used in the Nordhavn area, to the extent possible.

Corresponding goals

- Provide AV services that were actually needed.
- Demonstrate that AVs are safe, sustainable, economical and can provide personalized transport.
- Test a fleet operation with multiple AVs, on-demand in a mapped area, off route, with a speed up to 50 km/h, in mixed traffic, without Safety operators on board - to the extent possible given the technology and the vehicles. Currently speed of above 18 km/h is not possible and driving off route is not possible or allowed according to the Danish test law. As the vehicles are still defined as SAE level 3 vehicles, taking out the Safety operator is not possible. There are too many safety

jobs included in the job descriptions, such as approving priority fields (allowing the vehicle to proceed) and much more.

- Enhance the traveling experience in Nordhavn by connecting the area better, making sure that local residents and workers can move around easier and connect them to existing public transport stations.
- Take part in shaping a future neighborhood by solving transport issues in smarter and more sustainable ways.
- Lower the CO2 emission in Nordhavn by deploying public transport shuttles, driven by 100% electric engines.
- Demonstrate automated shared transport in Nordhavn and lower the number of vehicles.

Status

- Given some heavy construction works, the Nordhavn site was closed down at the end of February 2021. The construction work in the area demanded some of the streets to be closed, meaning that the vehicles could not drive in longer periods. This could not be justified in the project and the site was closed down.
- A new site has been submitted and approved for the AVENUE project. The site is a seven stop on-demand route with two vehicles on a hospital site in Slagelse, Copenhagen.

2.1.3 The pilot site: Nordhavn (2020-2021)

The Copenhagen test site was situated in an area of the city called Nordhavn. Nordhavn is an active industrial port that is undergoing a transformation – turning into Copenhagen's new international waterfront district offering residential and commercial buildings. When the development of Nordhavn is done, the area will house more than 40'000 residents and 40'000 employees.

Nordhavn aims at being an eco-friendly neighborhood and contributes to boosting Copenhagen's image as an environmental metropolis. Renewable energy and new types of energy, optimal use of resources, recycling of resources and sustainable transport will help make Nordhavn a model for sustainable development and sustainable design. A vibrant city: Nordhavn should vibrate with life as a versatile urban area with a multitude of activities and a wide range of shops, cultural facilities and sports facilities. The area is becoming more and more populated, and the need for local transportation is expected to keep growing.

Currently the Nordhavn area is serviced by a nearby S-train station and bus stops located near the station. There are however no buses or trains running directly in the area – creating a great opportunity for the automated vehicles to function as a new public transport solution, connecting the area much better than it is today. In 2020, two new metro stations have been built – opening in the middle of the neighborhood, close to the route.

The main expected users of the automated minibuses service will be the residents of Nordhavn (including families, children, and elderly), commuters working in Nordhavn, and visitors to the area. Several usage scenarios can thereby be anticipated:

- Ease the mobility within the area for the residents and commuters working in the area.

- Used for the first/ last mile from the main road/ entry point to the area to the different stops within the area for residents and commuters working there.
- Provide easier access from the main road to e.g., the harbor pool, restaurants, cultural facilities for visitors and families.

2.1.3.1 Shutting down Nordhavn before time

The Nordhavn area is under heavy construction work as the new smart city is still not fully developed. The area should have originally been finished in 2020, but due to major delays in construction plans, the area is now set to be finished in 2024. Because of the construction being delayed, parts of the Nordhavn route (streets) will be closed down for longer periods of time during the remainder of the AVENUE project.

Therefore, Amobility has decided to close down the site as the potential learnings from the route can no longer be realized. Expanding the route is not possible, hence on-demand door-to-door services cannot be tested either. Because of this, Amobility could not justify the cost related to the project and the site was closed down in February 2021.

In the process of continuing the work and development of the AVENUE project, Amobility has been looking into other options to continue contributing to the project.

In that process, Amobility made arrangements with Copenhagen area PTA Movia on introducing an AVENUE automated minibus into a two-minibus project on Slagelse Hospital, with the main learnings being on-demand driving and integrations with public transport PTA Movia and their client systems etc. The new site has interesting customer requirements, as the distances between the departments in the hospital are too long for patients to walk.

For more information about learnings and data see chapter for Nordhavn in D7.8: H2020-AVENUE_Second iteration Copenhagen Large Scale Pilot Use Case.

2.1.4 The pilot site: Ormøya, Norway (end 2019 - end 2020)

Amobility currently collaborates with Oslo Municipality, the Norwegian Public Roads Administration and Ruter on a three-year self-driving trial project. The project is an important milestone in the process of getting self-driving buses to the Oslo area. Oslo and Akershus wish to have 0% emissions across their public transportation and this project will test if self-driving buses can support these ambitions for a sustainable public transport system. The end goal is for automated buses to be part of Ruter's regular offer in a few years' time frame.

While waiting for the approvals in Denmark, two of Amobility's AVENUE automated minibuses will be integrated into the second route "Ormøya" in Oslo. The route was approved end of 2019 and started operation in the beginning of 2020. The project was running until the end of 2020.

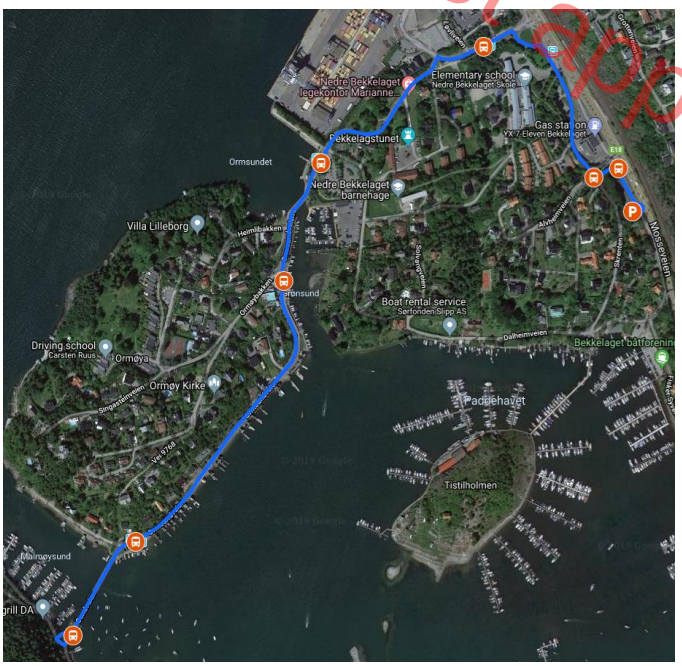


Figure 2: Route at Ormøya, Norway

The aim of the Ormøya route is to provide a mobility service in an area of Oslo that is not covered that well today and connect the service to the existing public transport. Thereby, test how suitable AVs are as a feeder service to the existing public transport and if it will reduce the usage of private cars.

Details:

- Vehicles: 3 Navya Autonom Shuttle max speed 18 km/h
- Route: Fixed route and fixed stops, 1.7 km one way
- Passengers: local citizens
- Operating hours: Monday-Sunday between 6:00 – 22:00
- With a Safety operator on board (required by the Norwegian Road Authorities)

- Services:
  - The service is fully integrated into the travel plan "RuterReise" showing the stops, time schedule and connections
  - There are bus stop signs at the bus stops
  - The bus requires tickets, like the rest of the public transport in Oslo

Learnings:

- Test of Vehicle-to-everything (V2X) integration with traffic light systems
- Hacking and cybersecurity test of V2X
- Around 7'000 people carried over around 23'000 km
- Low speeds caused dangerous situations in traffic. Problems with snow.
- User experience test with "no Safety operator"

For more information about learnings and data see chapter for Ormøya in D7.8: H2020-AVENUE_Second iteration Copenhagen Large Scale Pilot Use Case.

2.1.5 Slagelse Hospital Copenhagen, Denmark

The route is located at Slagelse Hospital connecting the parking areas and the different departments with each other. The Slagelse route will start at the beginning of September 2021.

Facts about the route:

- Route is already approved (no extra work required as part of the AVENUE project)
- Patients and relatives are missing a transport option within the hospital area
- 5.5 km of public road commissioned
- Two shuttles (on-demand driving only)
- 30 km/h driving zones (purpose is to push Navya to deliver)
- Dynamic driving (no fixed order of stops or routes to drive)
- 6 stops where patients can be picked up or delivered to
- 10 hours of operation per day (longer operational hours are approved and can be implemented as needed)

The following picture shows the 5.5 km roads that are commissioned (yellow) and the 6 stops.

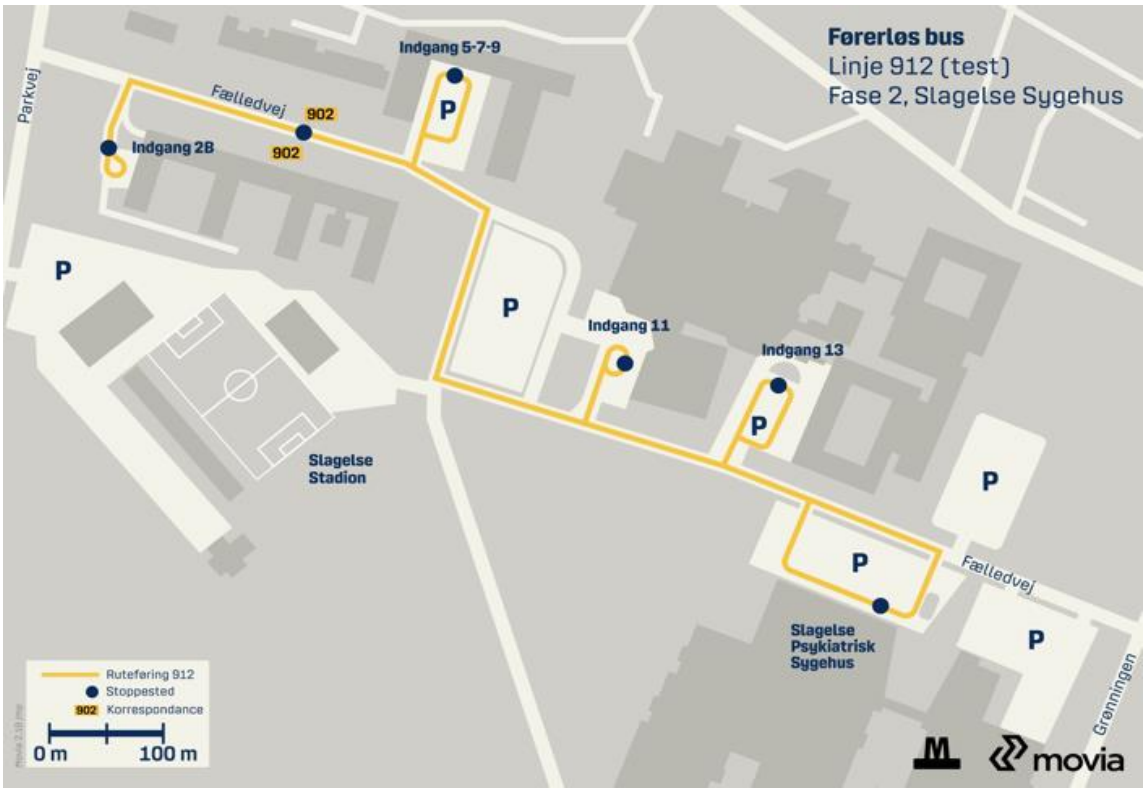


Figure 3: Planned route and stops at the Slagelse site

The stops are located at department entrances or near parking areas connecting the patients and relatives to the hospital site. The route is not seen as a circle route as the automated minibuses will be able to drive any given way in the commissioned area, meaning that the automated minibuses can drive directly from Entrance 2B to Entrance 13 and then from Entrance 13 to Entrance 11 and there back from Entrance 11 to Entrance 13. The automated minibuses can therefore drive in both directions and in/out from both right and left.

Development on the Slagelse site

Before and during the deployment of the Slagelse Hospital site, Amobility will be working on multiple development tasks that can benefit the AVENUE project:

- Prototype testing with Amobility and CERTH
  - Testing and developing a technical setup in Amobility offices
    - Equipment, connections, power supply etc.
  - Testing on Amobility test track starts in week 10
    - Automated passenger counting (critical for all operators)
    - Detection of unwanted behavior
    - Smart feedback
    - Forgotten belongings
  - Preparation for a full-scale demonstration on Slagelse Hospital
- Ongoing testing and improvements of the automatic ramp and Q-straint function for people in wheelchairs and people with disabilities.
- On-demand development with integration to Movia[2]
  - Integration with PTA Movia (booking of trips, client interface)
    - Amobility API endpoint integrations
    - Development of communications and data sharing
    - Data security
  - Mission ordering between Movia (client), Amobility (operator) and Navya (vehicle)
    - Testing and development of cancellation of a trip (before and ongoing)
    - Testing of dynamic rerouting
    - Testing of best route from A to B
- Data dashboard development (continues the development on the current foundation)[3]
  - Including on-demand data for daily operational improvement
  - Mission-data visualization
  - Data driven rerouting improvements

2.1.6 User groups: Personas

Task 2.2 in WP2 focuses on passenger needs and thus provides an important content to the development of the action plans and roadmaps of the PTOs. Based on the analysis and specifications of passenger needs through surveys conducted in task 2.2, a series of personas have been developed, as well as use cases based on these personas. For more information on this approach, its characteristics, purposes, limitations, and other background elements such as how personas were developed (and multiple details on the profiles), see the deliverable D2.5 "Second Passenger needs analysis and specifications".

[2] Concrete implementation of the AVENUE platform for this deployment is still in discussion, as the current project description and the contract with Movia does not foresee the inclusion of the AVENUE platform with Bestmile and MobileThinking as software providers.
[3] See footnote above

In this chapter, all these users' personas have been evaluated by Amobility with respect to their relevance for each of the pilot sites. You can find the results here below:

Passengers

		Nordhavn (DK)		Ormøya (NO)	
		Y/N	*Comment*	*Y/N*	*Comment*
Alex	31yo, Businessman, PT to go to work	YES & NO	Possibly, but not under normal conditions	NO	The route is only for local people
Helena	74yo, Retired, Limited mobility, PT to go for treatment	YES	Common user	YES	Common user
Henry	70+yo, Retired, Motor disability, PT to go shopping for daily needs	YES	Common user	YES	Common user
Carolin & John	77&79yo, Retired, No smartphone, Remote living, PT not often used yet	NO	Route in city center	YES	Local route in local area
Lilly & Lou	33&2yo, Maternity leave, Buggy needed, To go to daycare	YES	Common users	YES	Common user
Fabio	21yo, PT to/from clubs (at night only)	NO	Not a night service	NO	Not a night service
Charlotte	18yo, Student, Afraid at night when taking PT	NO	Not a night service	NO	Not a night service
Hanna	14yo, Student, PT to go to school	YES	Common user	YES	Common user
Bill & Clara	71&70yo, Retired, PT to go to excursions and hiking places	YES	Common users (local tourists)	YES	Common users (local tourists)
Erik	11yo, Student, PT to go to school	YES	Local user	YES	Local user
Philippe	20yo, Student, PT to go to university	YES & NO	Possibly, but not under normal conditions	YES & NO	Possibly, but not under normal conditions

Table 1: User group persona analysis Amobility - Passengers

Other road users

		Nordhavn (DK)		Ormøya (NO)	
		Y/N	*Comment*	*Y/N*	*Comment*
Cristina	38yo, Hotel manager, always busy, Hates traffic	NO	Not a passenger but as another road user in car	NO	Not a passenger but as another road user in car
Richard	84yo, Retired,	NO	Highly unlikely	YES	As a pedestrian

	Physical handicap, Feels not secure in the traffic				
Manuel	22yo, Bike courier, Feels not safe	NO	Not a passenger but as another road user on bike	NO	Not a passenger but as another road user on bike
Marcus	53yo, Taxi driver, Enjoys driving	YES	As pedestrian or another road user in car	YES	As pedestrian or another road user in car

Table 2: User group persona analysis Amobility - Other road users

Original personas

		Nordhavn (DK)		**Ormøya (NO)**	
		Y/N	*Comment*	*Y/N*	*Comment*
Carlo	60yo, Retired, Visually impaired, Use PT for daily drives	YES	Common user (local tourists)	YES	Common users (local tourists)
Mary	Use PT to go shopping with friends	YES	Common user	YES	Common user
Ned	Motorically impaired, PT to go to his office	NO	Route in city center	YES	Common local user
Katie	Feels insecure in PT	NO	As pedestrian	NO	Suburban route

Table 3: User group persona analysis Amobility - Original personas

2.1.7 Use cases and roadmap

Amobility has set up its AVENUE pilot project in the Nordhavn area of Copenhagen. Initially, the project consisted of one route, with other potential routes and route options being added throughout the project (if approved by the authorities). The operation of the first route (see map below) started in 2020, after the authorities' approval. The pilot route consists in mixed traffic with cars, pedestrians, bicycles, etc. The area is in general a low-speed area. The site was finally approved in August 2020, with delays due to COVID-19. The site ran for 5 months until the end of February 2021. A new site was approved for the AVENUE project, Slagelse Hospital (see above). The use cases for Amobility will continue on that site from September 2021 until April 2022. The new route will be in collaboration with PTA Movia in Copenhagen and some of the user services will be developed via integrations with the PTA.

Planned services provided for the end users:

- The automated minibuses are free of charge during the pilot project in Denmark, so there is no ticketing yet.
- There are bus stops providing the position of the bus, relative to the given stop. Real time estimations are under development and will be tested during the initial driving phases of the Slagelse project.

- Besides the bus stop sign, users can find information about the pilot project at Amobility website and Mobile App and via the PTAs: Movias user interfaces.
- It is the aim to test the services developed through the AVENUE project e.g., real-time position of the bus, on-demand booking, accessibility for disabled persons. Wheelchairs are allowed on the shuttle and will be strapped with Q-straint. Automatic ramps are active, but the operator can also activate the manual ramp. On-demand driving and ordering of trips (mission control) will be developed with the PTA and included in the integration between Amobility and Movia. This way the users can also order the trips via PTA interfaces.

	Use case 1	**Use case 2**	**Use case 3**	**Use case 4**	**Use case 5**
Time	Q3 2020 - Q1 2021	Q3 2021 - Q4 2021	Q1 2022 - Q2 2022	Not in the project[4]	Not in the project
description / objectives	Implementing an autonomous shuttle system on a fixed route with pre-established schedules in a dense urban context in which regular passengers get on and off the vehicle at pre-established stops	Developing and testing the on-demand system and proving its feasibility. Passengers can now ask the vehicle to pick them up at a fixed stop; no more schedules	The on-demand is no longer in its test phase, it is now functional and available to everyone. New routes are added and passengers can now use the pre-booking feature	An entire area is now covered by a multitude of mapped routes. The shuttles respond dynamically to customers' requests throughout this area. Much higher speeds are now possible	The objective here is to increase the number of vehicles but also to test the live mapping feature.
Approved?	Done	Yes	Yes	Not happening	Not happening
Safety operator?	Yes	Yes	Yes[5]	Yes	Yes
Route	Fixed-route, timetable or headway based, metro mode, loop line	Fixed route, on call stops, on-demand trials, loop with	Fixed route service, on-demand, introduction of new routes	Geo-fenced area with multiple mapped routes,	Multiple types of shuttles, dynamic routing,

[4] The technology and the legal framework in Denmark do not allow for this step or the next.

[5] Safety operators will be slowly removed from the automated minibuses. They will stay present on-site in an on-site office, always in max. 5 min reach from the automated minibus. It is assessed by Amobility that the safety operator cannot be taken out of the vehicle before the vehicles are approved as SAE level 4 vehicles. But Amobility will try to prove the decreasing interaction from the Safety operators as the foundation for moving forward. But currently the vehicles are not there yet.

		with multiple fixed stops, mixed traffic	multiple fixed stops	and dynamic routing on these routes	dynamic routing, coordinate-based, testing of Mobility Cloud service (D2D)	coordinate-based, further testing of Mobility Cloud service(D2D), live mapping process[6]
Booking		None	Instant booking	Instant booking and pre-booking	Instant booking and pre-booking	Instant booking and pre-booking
Vehicles[7]		2-4 automated minibuses adjusting to demand			Introduction of new types of AVs[8]	
Vehicle speed		Max 18 km/h, with an average speed of 10 km/h. The vehicles are not able to drive faster due to sensor software and documentation in Denmark.			20-50 km/h speed limit routes; AV at max. 50 km/h expected 30-50 km/h)	20-60 km/h speed limit routes; AV at max. 60 km/h; expected 30-60 km/h)
Operation times		The automated minibus will run Mon-Fri. Exact timetables can change given demands from the PTA..				
Steps *schedule*	*1*	Obtaining all the necessary infrastructure	Make the app available to the public (Q3 2021)	Mapping of all the new routes (Navya)	Mapping of all the new routes.	Obtaining the new vehicles
	2	Designing the routes	Test phases (Q3 2021)	Including the new routes in the dynamic routing network	Including the new routes in the dynamic routing network	Mapping of all the new routes
	3	Obtaining the needed local authorizations	Practical implementation (Q4 2021)	Practical implementation (Q2 2022)	Including pre-booking in existing booking management system and implementing it in the customer application.	Test phases

[6] If technology and regulations allow for that.

[7] Until use case 4 (incl.) only Navya Autonom Shuttles

[8] Allowing the vehicle to drive into new streets. If technology and regulations allow for that.

	4	Mapping of the routes (Navya)			Test phases	Practical implement-ation
	5	Test phases/ implementation (Q1 2021)				

Table 4: Use cases and roadmap - Slagelse Hospital

*This particular use cases template was established in the framework of the AVENUE project and is, apart from a few modulations, identical for every demonstration. Its general layout has been established to match the needs and peculiarities of the of the autonomous public transit system and, more specifically, those of the AVENUE project.

For all use cases:

The focus throughout the whole project lies for Amobility in passenger and operation security. Next comes the service quality provided, followed by business development needs

In the annexes, you can find an illustration of the routing for the use cases 1-5 as well as the SWOT analysis for the first, second and third use case.[9] No SWOT analysis can be prepared yet for the use cases 4-5 since they are not happening in the project due to technical and legal obstacles. This is further elaborated on in D7.8 and D.2.3.

2.1.7.1 Technical requirements

Use case 1	Use cases 1-5	Use cases 2-5	Use cases 4-5	Use case 5
Mobile app (optional)	● Bus stop signs ● Amobility webpage	An app or another solution to make the on-demand requests	Fleet management system	Amobility 's Mobility Cloud

Table 5: Use cases and their technical requirements

2.1.7.2 Objectives and milestones per use case

	Objectives	Milestones
Use case 0 (05/18 02/20)	● Approvals from authorities. ● Ensuring stakeholder acceptance and support prior to operation.	● Baseline user surveys to be conducted and analyzed. ● Introducing stakeholders to the AV, the route and stops.
Use case 1 (09/20 02/21)	Fixed route, loop line, fixed stops, in mixed traffic.	● Input from user surveys to be analyzed and implemented. ● Input from safety operator to be analyzed and implemented. ● Learning regarding traffic patterns and interaction between trucks, cars, bicycles and pedestrians.
Use case 2	The automated shuttles are expected to run on-demand trials - on fixed route.	● On-demand on fixed route. ● Integrations with PTA. ● Mission control. ● Sending, receiving and cancelling a mission. ● Booking at stop, via hospital department and on stop.

Use case 3	Fixed route service, on-demand, introduction of new routes and dynamic routing on these routes. Will be operational on demand - with increased speeds - if possible, by the vehicle vendor.	● Dynamic routing between stops, driving in both directions in and out from both directions. ● Increase in speeds if possible. ● Instant booking and pre-booking via PTA interface. ● Testing with faster commissioning processes. ● Further expansion of on-demand on route. ● Possible extensions of route.
Use case 4	Multiple AV's will be operational on demand - off routes, without Safety operators on board. Plan to have a geo-fenced area mapped - and have permission to drive here.	● Not happening in the project due to technical and legal obstacles.
Use case 5	New types of Autonomous AV's will be introduced in Nordhavn, meeting more needs of the local travelers and commuters - if the technology and regulations allow it. The speed of the AV's is expected to rise, and the transport should become more efficient. The goal is to provide on-demand services outside the route - meaning not dependent on a route - given that the technology and regulations allows it. The Mobility Cloud will be tested during the fourth year in combination with potential new services, meeting the needs of the users.	● Not happening in the project due to technical and legal obstacles. ● Amobility is introducing Toyota vehicles in Norway, learnings can be implemented in AVENUE. Toyota vehicles can drive between 25-35 km/h. Retrofitted ProAce vehicles with Sensible 4.

Table 6: 2.1.7.2 Objectives and milestones per use case

2.1.8 Evaluation plans for the use cases

Amobility does not yet work with a local company on evaluating the automated minibuses. For the AVENUE project, they will follow the evaluation plan proposed by ECL in this deliverable as well as the evaluation done by Hochschule Pforzheim (HSPF) in the framework of WP8. According to these two frameworks, the study design will be decided, as well as the details of the evaluation (such as the number of expected participants in the evaluation).

Below are **Key Performance Indicators** used by Amobility to determine the success of the pilot are the following (non-exhaustive list). These KPIs are inspired by the list of indicators described in chapter 3.2.1, but are more specifically established on the basis of Amobility's internal discussions and reflections (in close connection with Bestmile), taking into consideration the needs related to the context and the specificities of the project. For measurement, most of the indicators can be visualized in the Amobility dashboards as static data, via the referenced safety drivers' observations and findings, but also through field observations, interviews or any other methods often fruit of AVENUE partners' collaboration.

- Passenger satisfaction (use cases 1-5)
- Number of passengers (use cases 1-5)
- Number of trips/ km done by the automated minibus (use cases 1-5)
- Punctuality of the automated minibus (use cases 1-5)
- Uptime of the automated minibus (use cases 2-5)
- App downloads/ on-demand system usage (use cases 2-3)
- Uptime of the fleet management system (use cases 4-5) (not possible)
- Uptime Mobility Cloud (use case 5) (not possible)

In order to evaluate the demonstration of the different use cases but also the global service, Amobility would like to collect the following data (exhaustive list):

- Number of passengers (use cases 1-5)
- Types of passengers (use cases 1-5)
- Number of repeat passengers (use cases 1-5)
- Acceptance and support from passengers (use cases 1-5)
- User perception of the service (use cases 1-5)
- Customer satisfaction (use cases 1-5)
- Uptime/ downtime of service - specified into subcategories e.g., hard resets, times manual overtake, time in automated mode, operational time (use cases 1-5)
- Impact from the weather conditions on the uptime/ downtime (use cases 1-5)
- Quality of the information send to customers (e.g., waiting time, reloading time of the app) (use cases 1-5)
- Quality and usability of the Safety operator app/ webpage/ system (use cases 1-3)
- User experience of the on-demand service and support system (e.g., app) (use cases 2-5)
- Quality and usability of the fleet management system (use case 4-5) (not possible)
- User experience and acceptance of the Mobility Cloud (use case 5) (not possible)

2.1.9 Integrations and special needs

Integrations needed

Amobility has already evaluated an integration with existing PTOs in Denmark, particularly a traveler application called Rejseplanen that allows to look for connections throughout different PTOs.

Amobility will be integrating with the largest PTA Movia as a part of the Slagelse Hospital site. The integrations will allow the two systems to collaborate on missions (receiving, handling and cancelling), dynamic routing and user interfaces. The Slagelse project is further described in section 2.1.5.

Special needs

Amobility is interested in testing all the services that are being discussed in the framework of WP2 and developed in WP4. In particular, Amobility would like to provide a possibility to accommodate all types of passengers, including for example passengers with reduced mobility. Furthermore, Amobility is interested in testing on-demand if technically possible and approved by the authorities.

Amobility has installed Q-straint in all automated minibuses including an automatic ramp allowing passengers in wheelchairs or people with strollers to easily access the automated minibuses. As long as the Safety operator is present in the automated minibuses, he/ she can accommodate the travelers. Testing of people with special needs without a Safety operator will be conducted during the Slagelse Hospital project.

2.2 Geneva: Action plan and roadmap

2.2.1 Baseline description

Transport Publics Genevois (TPG) started with one automated project set up in the canton of Geneva. On 2nd of July 2018, one Navya Autonom Minibus started driving on an urban route in the neighborhood of Meyrin. The "Line XA" connected the Meyrin train station with Meyrin village and provided a transport solution for residents in a zone that was not served by standard bus lines. The automated minibus drove around on a 2.1 km long fixed route with 4 fixed stops. The roads are public and urban in a zone with a speed limit of 30 km/h. All traffic is possible in the area since it combines a residential area with an industrial zone. No lanes had been predefined for the automated minibus and many obstacles increased the complexity of the use case. The track was therefore very difficult and represented a real-world urban driving test. The automated minibus ran Monday to Saturday during the rush hour in the morning (06:15 – 08:30) and in the late afternoon (17:15 – 19:00), providing transport mainly to commuters going to and coming from work. Around 60 passengers were transported with the minibus each day. A pool of 12 Safety operators took turns in the minibus, under the supervision of two "super operators".

During the sanitary situation in 2020, the TPG had to stop its fully automated service as of the 13th of March. In the meantime, the two-year project authorization we received from the FEDRO (Federal Roads Office, OFROU in French) came to an end. The TPG was able to receive a six-month's extension of the authorization due to the COVID-19 crisis with the possibility to prepare a new extension file for a two-year renewal. Unfortunately, during the six months extension, it was announced by the township of Meyrin, that they were planning to install another 14 more speedbumps on the track, which made a total of 17 obstacles to overtake on a circuit of 2.1 km. The TPG therefore decided to discontinue the "Line XA" and to further concentrate on the Belle-Idée project.

2.2.2 Vision, needs, and goals

Vision

TPG's primary objective is to be able to offer transport services for everyone, everywhere, on time and in an environmental way. With our current fleet of buses, it is too expensive and technically not possible to achieve such goals. A 12-meter bus is too large to enter a village road and smaller buses with a driver aren't cost effective.

In fact, it would be good to replace one large bus with four automated minibuses and to have the former bus driver oversee all four automated minibuses as an external operator. One example could be to offer internal transport in a smaller town. People who want to visit Geneva can take a regional bus or tram; people who want to visit the grocery store take the automated minibus.

Another important argument to move towards automated, electric minibuses are the objectives of a climate-neutral public transport. In future green villages, a vehicle with a combustion engine has no place. The pilot site in the AVENUE project is a real-world use case that can be used as a solution and add on to our existing bus and tram network.

Need

Able to offer transport services for everyone, everywhere, on time and in an environmental way.

Corresponding goals

- On-demand
- On-time
- Personalized transport
- Full automated robotized small-scale public transport network

2.2.3 The pilot site: Meyrin

The core objective was to be able to connect the Meyrin train station with the main TPG tram lines. Commuters, who live in suburban areas or in the neighboring France and who arrive by train, have to change their mode of transport in order to be dispatched around the center of Geneva city. Up until the beginning of the project a public transport solution to connect both hubs did not exist. The distance between the Meyrin train station and the tramlines in Meyrin Village is around one kilometer, which is a 10-15 minutes' walk. The TPG transport solution served the sparsely populated area of Meyrin and connected both hubs during the morning and evening rush hour while taking into account the connecting timetables related to in- and outgoing trains and trams. The vehicle circled around in the clockwise direction.

During the first operations of the "Line XA", we rapidly noticed the importance of further developing the vehicle and fine-tuning its behavior on the road.

Figure 4: Route at Meyrin with stops

Driving direction	Clockwise
Route length	2.1 [km]
Speed limit all traffic	30 [km/h] area
Usage / Road	Open to all passengers for their daily commuting needs Urban open road
Number of bus stops	4
Number of vehicles	1
Timetable	07:00 – 09:00 and 16:00 – 18:00

Table 7: Facts about the route

2.2.4 The pilot site: Belle-Idée

In order to deploy a fleet of automated minibuses as part of the AVENUE project, an agreement was reached with the Belle-Idée site in Thônex, in the Canton of Geneva. The Belle-Idée site is a Psychiatric as well as elderly Hospital and part of the University Hospital in Geneva (HUG). The HUG is committed in the development of green mobility initiatives. The Belle-Idée site offers:

- Private property
- Visitors do not need a badge to enter the site
- Main entrances closed by barriers
- Only accessible by motor vehicle after invitation
- Always accessible by foot or bicycle
- Bus line (1) and (31) through the main axe of the site
- Speed limit: 30 km/h in the whole zone

From the start of the project, three vehicles will be running on the site, on a network of routes with 75 bus stops. The picture below provides an idea of possible routes.

Figure 5: Network of possible routes at the Belle-Idée site in Geneva

Other facts about the route:

- 38 hectares
- 9km of route
- 30 buildings deserved
- 3 Shuttles
- Speed up to 25 km/h
- Significant road traffic: all types of vehicles but also pedestrians and cyclists
- Opening hours: 07:30 - 19:30

The expected main users of the services in the area will be the employees and visitors to the hospital, as well as passers-by. The following usage scenarios can be imagined[9]:

Hospital employees

- Regular bus stop to workplace
- Parking to workplace
- Workplace to restaurant
- On site transport to visit patients
- On site transport of patients
- On site transport maintenance workers

Hospital visitors

- Regular bus stop to patient
- Parking to patient
- Parking to restaurant

[9] Lists inconclusive.

- Building to building

2.2.5 User groups: Personas

Task 2.2 in WP2 focuses on passenger needs and thus provides an important content to the development of the action plans and roadmaps of the PTOs. Based on the analysis and specifications of passenger needs through surveys conducted in task 2.2, a series of personas have been developed, as well as use cases based on these personas. For more details and the full background, see deliverable D2.5 "Second Passenger needs analysis and specifications".

In this chapter, all user these personas have been evaluated by TPG with respect to their relevance for each of the pilot sites. You can find the results here below:

Passengers

		Meyrin		**Belle-Idée**	
		Y/N	*Comment*	*Y/N*	*Comment*
Alex	31yo, Businessman, PT to go to work	Y	Common user	Y	Common user
Helena	74yo, Retired, Limited mobility, PT to go for treatment	Y	Common user	Y	Common user
Henry	70+yo, Retired, Motor disability, PT to go shopping for daily needs	Y	Common user	Y	Common user
Caroline & John	77&79yo, Retired, No smartphone, Remote living, PT not often used yet	Y	Village route	Y	Common User
Lilly & Lou	33&2yo, Maternity leave, Buggy needed, To go to daycare	Y	Common user	Y	Common user
Fabio	21yo, PT to/from clubs (at night only)	N	Not a night service	N	Not a night service
Charlotte	18yo, Student, Afraid at night when taking PT	N	Not a night service	N	Not a night service
Hanna	14yo, Student, PT to go to school	Y	Common user	Y	Common user

Bill & Clara	71&70yo, Retired, PT to go to excursions and hiking places	Y	Common user	Y	Common user
Erik	11yo, Student, PT to go to school	N	Unaccompanied children not allowed	N	Unaccompanied children not allowed
Philippe	20yo, Student, PT to go to university	Y/N	Maybe once	Y/N	Maybe once

Table 8: User group persona analysis TPG - Passengers

Other road users

		Meyrin		**Belle-Idée**	
		Y/N	*Comment*	*Y/N*	*Comment*
Cristina	38yo, Hotel manager, always busy, Hates traffic	N	Car user	Y	Car user
Richard	84yo, Retired, Physical handicap, Feels not secure in the traffic	Y	Pedestrian	Y	Pedestrian
Manuel	22yo, Bike courier, Feels not safe	N	Cyclist	N	Cyclist
Marcus	53yo, Taxi driver, Enjoys driving				

Table 9: User group persona analysis TPG - Other road users

Original personas

		Meyrin		**Belle-Idée**	
		Y/N	*Comment*	*Y/N*	*Comment*
Carlo	60yo, Retired, Visually impaired, Use PT for daily drives			Y	Employee
Mary	Use PT to go shopping with friends			Y	Employee
Ned	Motorically impaired, PT to go to his office			Y	Visitor
Katie	Feels insecure in PT			Y	Visitor
*Family**				Y	Visitor
*Pets / Animals**		Y		Y	Accompanied only

Table 10: User group persona analysis TPG - Original personas

Other non-identified persona profile?

	Meyrin		Belle-Idée	
	Y/N	*Comment*	*Y/N*	*Comment*
Mister X*	N		Y	Mentally disabled people
Family*	N		Y	Migrant from refugee camp
Student*	N		Y	College student

Table 11: User group persona analysis TPG – Other personas

*These are personas used only in the TPG specific context

2.2.6 Use cases and roadmap

First, as for all the other demonstrations in this deliverable, we need to specify that the roadmap is here considered as a tool that aim to compare a baseline situation (see chapter 2.2.1) with the one that is envisioned within the framework of the AVENUE project and that are described in this section, but also to identify and split the related needs into a series of concrete goals.

TPG will set up its AVENUE pilot project in the zone of the Belle-Idée hospital in Thônex.

In June 2020, TPG received the formal authorization from the Swiss authorities to start deploying the project. Due to the high level of complexity of the project, a deployment period of 6-9 months covering three main phases had to be foreseen.

Every phase was divided into mapping, the deployment of a vehicle on a number of smaller routes and the creation of bus stops as well as an extensive testing period. The fully automated on-demand system was also configured and tested throughout the deployment. This has resulted in the capability to drive on 99% of all available routes within the Belle-Idée site with three vehicles and to be able to stop at 75 predefined, mostly virtual bus stops.

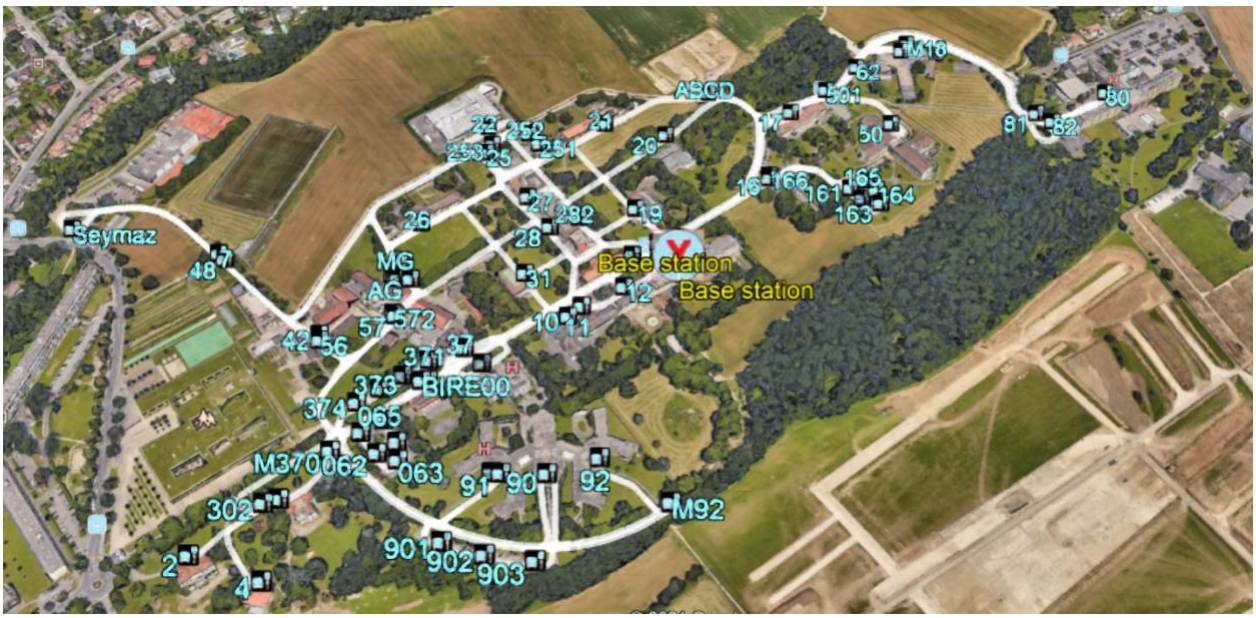


Figure 6: Stops created at the Belle-Idée site

	Use case 1	Use case 2	Use case 3
Time	Q1 2021	2021-2022	2022

Objective / Description		Offering an "on-demand" service with an operator inside every vehicle	Gradually introducing process automation to control, measure and manage	Deploying three fully automated driverless minibuses, with an operator nearby
Safety operator?		Yes	Yes/No	No
Route		Directly start a full on-demand, dynamic route, predefined virtual minibus stop based service, mixed traffic		
Booking		Instant booking and pre-booking		
Individual rides?		For specific patients, a "VIP reservation" would be interesting to have		
Operation times		06:00-19:00 on-demand with expected peak hours at 08:00, 12:00, 16:00, 18:00		
Technical requirements		- solutions for disabled people necessary -		
Steps	*1*	Obtaining the full needed infrastructure	First trials without safety drivers	Generalization of safety drivers free riding
	2	Designing the routes		
	3	Obtaining the needed local authorizations		
	4	Mapping of the routes (Navya)		
	5	Test phases/ implementation (Q1 2021)		

Table 12: Use cases and roadmap - Belle-Idée

Increasing the speed of the automated minibus is of less importance on this site. The highest priority is to be able to remove the Safety operator. Safety is of utmost importance and development of object identification needs to be the first priority. The focus throughout the whole project lies for TPG in passenger and operation security as well as in the service quality, since the acceptance of Fully Automated Vehicles completely depends on the user experience. Business development needs are of less importance than the former two points.

2.2.6.1 SWOT analysis for this use case

Strengths	Weaknesses
• Real life use case. When successful definitely to be copied.	• No choice of automated minibus manufacturer or comparison between several others. • Potential lack of dynamic infrastructure information to avoid blockages in order to operate a flexible on-demand service.
Opportunities	**Threats**
• Possibility to attain project goals with easy-to-understand technology.	• No agreement regarding project objectives by authorities (regarding the homologation route etc.), also because of a personnel change in December 2018. • Stagnation of hardware/software development. • Bankruptcy/out of business hardware/software partner. • Safety-related: with an on-demand service with dynamic route many road users are not used to encountering the automated minibus in specific areas. • Safety-related: challenge for the automated minibus provider to ensure safe behavior without predefined lanes. • Safety related: development of road behavior minibus: positioning, braking, acceleration/deceleration etc. • Safety related: stationary and moving object identification (not detection).

Table 13: SWOT analysis Belle-Idée

2.2.7 Evaluation plans for the use cases

TPG does not yet work with a local company on evaluating the automated minibuses. For the AVENUE project, they will follow the evaluation plan proposed by ECL in this deliverable as well as the evaluation done by HSPF in the framework of WP8. According to these two frameworks, the study design will be decided, as well as the details of the evaluation (such as the number of expected participants in the evaluation).

Below are **Key Performance Indicators** used by TPG to determine the success of the pilot are the following (non-exhaustive list). These particular KPIs are inspired by the list of indicators described in chapter 3.2.1, but are more specifically established on the basis of TPG internal discussions and reflections, taking into consideration the needs related to the context and the specificities of the project; then even if they are quite similar to those mobilized in the other project sites, these indicators are specific to this particular demonstration site. To measure these indicators, some information can be gathered through the safety drivers' observations that are carefully referenced on a daily basis but also in the shuttle dashboard logs or via passengers' interviews or surveys. Qualitative inputs can also be extracted from informal conversations that local teams may have with customers or staff members.

The list has been segmented by considering the respective objectives of the different KPIs:

- See if the results match the objectives defined
  - Number of hours travelled
  - Number of passengers carried
  - Number of press articles published
  - Autonomous mode rate
  - Number of breakdowns
- Determining if TPG is able to deliver the kind of services they had in mind
  - User satisfaction
  - Safety drivers' feedback
  - Other road users' feedback
  - Number of passengers per trip
  - Number of routes available
  - Delay rate
  - Number of breakdowns
- Determine how the user experience is
  - Punctuality/Delay rate
  - Rate of aborted trips
  - Mobile app efficiency/user satisfaction
  - Average waiting time
  - Number of unnecessary stops
  - Number of routes

In order to evaluate the demonstration of the different use cases, TPG would like to collect the following data (exhaustive list):

- Number of instances where the driver must take manual control (Heatmap)
- Number of emergency stops/ decelerations (Heatmap)
- Minimum accepted gap at intersections or in lane changes
- Average speed vs. average speed of the rest of traffic flow
- Variance in journey time
- Driver frustration/ aggressiveness in the presence of AVs
- Number of handovers from automated to manual driving at the vehicles' request
- Down time frequency for mechanical servicing/ cleaning
- Cost-per-vehicle-kilometer
- Operating efficiency
- Rider comfort
- Reliability
- Affordability
- Integration
- Satisfaction

2.2.8 Integrations and special needs

Integration

Integration with different operation systems for scheduling and traveler information. To be further defined in the project.

Special needs to be addressed?

TPG's primary objective is to be able to offer transport services for everyone. Therefore, and even more so because of the location of the pilot site at the hospital, passengers with special needs will certainly be included in the use case definitions, such as passengers with reduced mobility. TPG organizes a half yearly audit with the association of disabled persons in Geneva. We will also invite them to test fully automated public transport in Belle-Idée.

2.3 Luxembourg: Action plan and roadmap

2.3.1 Baseline description

Before the start of the AVENUE project, Sales-Lentz Autocars (SLA) did not have any automated minibuses projects running. In the framework of the project, pilot projects have started in September 2018 on two pilot sites, see chapter 2.3.3 and 2.2.4.

2.3.2 Vision, needs, and goals

Vision

By the end of the AVENUE project, Sales-Lentz Autocars vision is to set up an on-demand service with a fleet of Fully Automated Vehicles running in level 4 (without a Safety operator onboard) and with a speed of around 45 km/h, and for which a seat in the automated minibus during a trip can be booked.

In Luxembourg, public transport has been for free since April 2020. All vehicles that are subcontracted for the "Régime Général des Transports Routiers" (RGTR) must be integrated into the Mobilitéit.lu platform, as the government does not want a platform per operator and by type of service.

SLA wants to deploy the automated minibuses for several tasks:

- First and last mile solutions to bring people from their location to a public transport stop, or from the public transport stop to a destination of their choice (e.g., their workplace).
- Offer a mobility solution in city centers, urban areas, residential areas etc. where there is currently no mobility solution available due to several reasons (e.g., pedestrian zones, narrow streets, etc.).
- Connect different areas that are close to each other but where no mobility solution is available today.

Needs

- First & last mile transportation
- An environmentally friendly, on-demand mobility solution available and accessible for everyone
- Providing local mobility solutions for low passenger volumes
- Offering public transportation (in collaboration with our Transport Ministry) in areas where no public transport is available at the moment

Corresponding goals

- Operating the automated minibus with a safety operator between two points on an open road and without passengers on a trial basis
- Operating the automated minibus with a safety operator between two points on an open road with passengers

- Gradually increasing the speed of the minibuses up to 45 km/h
- Operating the automated minibuses on-demand on different routes
- Operating automated minibuses without a safety operator
- Operating a fleet of automated minibuses on-demand on different routes

2.3.3 The pilot sites

Since September 2018, Sales-Lentz Autocars is running 3 automated minibuses on two sites:

- Pfaffenthal, a valley in the city of Luxembourg, where two automated minibuses run on a short track connecting the residential area of Pfaffenthal to the panoramic lift in Pfaffenthal that goes up to the city of Luxembourg. Services on this line started on 24th of September 2018.
- Contern, an industrial area located around 10 km east of Luxembourg city, where one automated minibus connects the train station of Contern-Sandweiler with "Campus Contern", a real estate development company. Services on this line started on 19th of September 2018.

Both pilot sites will be described in more details here below. Please note that the services described apply to the beginning of the project but can still change by the time the project ends. It is also possible that the services will not be maintained on both sites by the end of the project, and efforts might rather focus on one site only.

2.3.3.1 Pfaffenthal

Two NAVYA Autonom Minibuses are running on the site of Pfaffenthal between two stations: the train and funicular station of Pfaffenthal, as well as the panoramic lift in Pfaffenthal that leads up to the city of Luxembourg. The track has four stops and the depot and charging station for the minibuses are close to the station at the Pfaffenthal lift, see map below (figure 7 & 8).
The speed limit on the whole route has been reduced to 30 km/h. In order to avoid massive overtaking by cars, SLA is challenging Navya as minibus manufacturer to increase the maximum minibus speed from the current 18 km/h to 25 km/h as soon as possible, with a mid-term objective of 30 km/h and a long-term objective to 45 km/h.
The main problem in Pfaffenthal was to find a mobile depot where they could park the minibus during the night. The depot is especially important during winter and bad weather conditions.

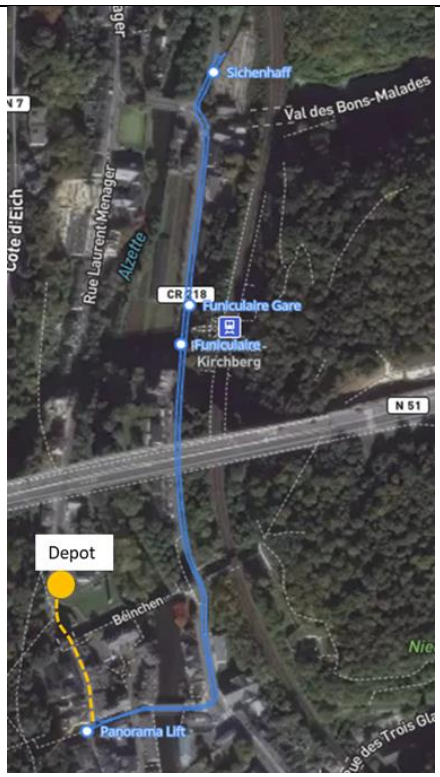
Today, the automated minibuses drive back and forth on the same streets. The goal of the route extension is to drive a closed loop as shown in the picture. This allows for a smoother operation without the need of a complex turning maneuver at the end of the route as well as for an implementation of another stop in the residential area of Pfaffenthal.
Many types of user groups have been identified in Pfaffenthal, from local residents, tourists, to work commuters, pupils and students, all ages and all socio-economic groups.

The main usage scenarios are:

- Tourists going from the old town to Kirchberg or the other way round.
- People commuting to work by different means of transportation that are arriving or departing in Pfaffenthal (trains, busses, individual cars, bicycles, scooters, etc.). The automated minibuses are connecting different transportation hubs (bus stations, train station, funicular station, bicycle sharing station) so that the commuters can use the automated minibuses to get their next transport connection, or to get to the different areas of Luxembourg city (e.g., the public elevator

to get to the upper city center, the funicular station to get to the business district Kirchberg or to the residential area of Pfaffenthal).

- Many types of user groups have been identified in Pfaffenthal, from local residents, tourists, to work commuters, pupils and students, all ages and all socio-economic groups.

Current route:	Possible route extension:
 **Figure 7: Current route Pfaffenthal**	 **Figure 8: Possible route extension Pfaffenthal**

The main usage scenarios are:

- Tourists going from the old town to Kirchberg or the other way round.
- People commuting to work by different means of transportation that are arriving or departing in Pfaffenthal (trains, busses, individual cars, bicycles, scooters, etc.). The automated minibuses are connecting different transportation hubs (bus stations, train station, funicular station, bicycle sharing station) so that the commuters can use the automated minibuses to get their next transport connection, or to get to the different areas of Luxembourg city (e.g., the public elevator to get to the upper city center, the funicular station to get to the business district Kirchberg or to the residential area of Pfaffenthal).
- Local residents taking the minibus to get to the public elevator to reach the city center, reaching the funicular station to get to the shopping malls in Kirchberg or to the residential area of Pfaffenthal.
- Residents from a nearby retirement home located on the city center site taking the elevator down to Pfaffenthal, then the automated minibus to reach the funicular station to go either up to the Kirchberg area or taking a train to southern or northern Luxembourg.

2.3.3.2 Contern

Since 2020, we started with phase 2. Only 2 stops are foreseen in this phase: one at Campus Contern and another one at the train station of Contern. During the trial of the extended route, addition of more stops is possible, according to the passengers' needs. The depot stays in the same location.

The main users are mainly employees working at Campus Contern and the companies nearby, commuting by public transport. Consequently, the main expected usage scenarios are commuters arriving in the morning by train or bus at the train station of Contern/Sandweiler and taking the automated minibus as a first and last mile solution to reach their working place (in the evening, it is the other way round).

An extension to other parts of the industrial zone is currently being analyzed and must be approved by the mayor of Contern.

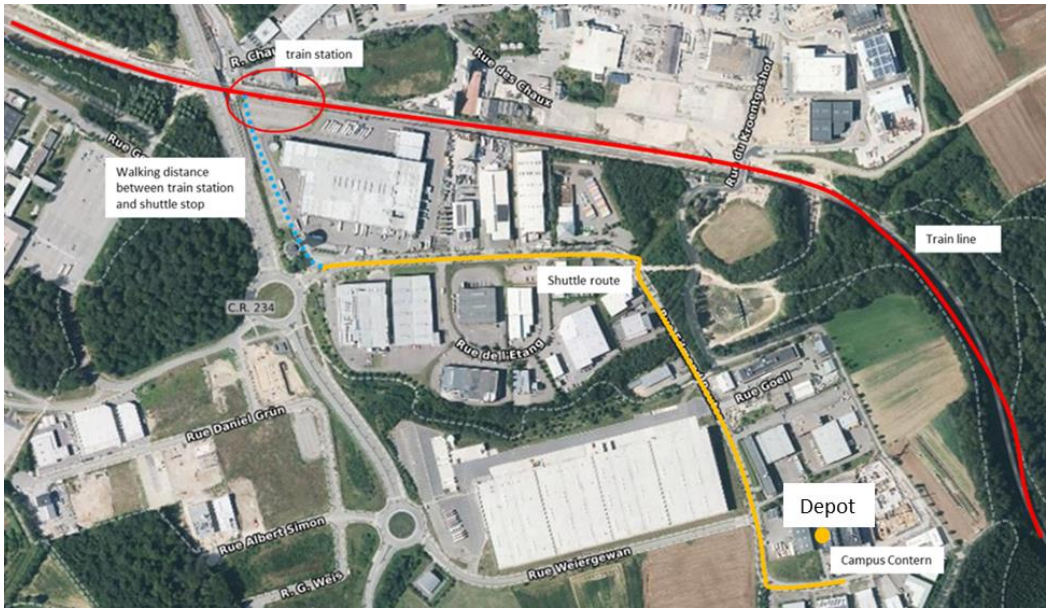


Figure 9: Map of the pilot site in Contern: original route

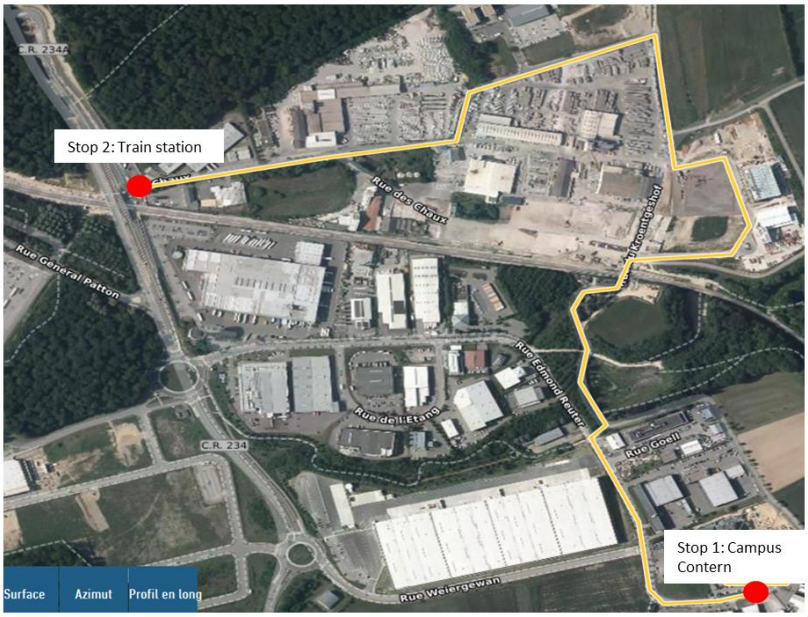


Figure 10: Map of the pilot site in Contern: extended route

2.3.3.3 Replicator Site Esch-sur-Alzette

Esch-sur-Alzette carries the title **"European Capital of Culture 2022"**. Eleven municipalities (known as the ProSud alliance) and 8 municipalities (CCPHVA, Communauté de communes du Pays Haut Val d'Alzette) from the French border are also involved in the "European Capital of Culture 2022". A cooperation with the city of Kaunas in Lithuania, which will be cultural city in 2022 as well, is also planned.

One automated minibus will be operating on a fixed route (rue de l'Alzette) and on a fixed time schedule during the opening hours of the shops. Outside of the opening hours, the automated minibus will be operating on-demand in the rue de l'Alzette.

Phase 1 : Route > Rue de l'Alzette

- The "Rue de l'Alzette" measures a little over 1'200 m. It starts at the "Place de l'Hôtel de Ville" and ends at "Boulevard Prince Henri".
- Pedestrian Street.

Figure 11: Route phase 1 Esch-sur-Alzette

Time plan for the deployment of the automated minibus(es)

Phase	Name of Phase	Start	End
Phase 1	Permissions / authorizations	01.01.2020	30.04.2022
Phase 2	Mapping, Deployment, Garage	01.04.2021	30.04.2021
Phase 3	Autonomous Network fixed stops	30.04.2021	30.10.2022
Phase 4	Autonomous Network door-to-door	01.12.2021	30.10.2022
Phase 5	Official mobility partner Esch 2022 European Capital of Culture	01.01.2022	30.10.2022

Table 14: Timeplan for the deployment at Esch-sur-Alzette

Ambitions and development plans

The long-term vision for an automated based, door-to-door service in Esch-sur-Alzette:

In the fourth quarter of 2021, the objective is to start the operation of an automated minibus with dynamic routing in a geographically defined area, without fixed bus lines or predefined timetables. In the first phase, predefined bus stops will be foreseen to board and alight passengers (phase 3). After validation of the automated minibuses' operation, the aim is to switch to a real on-demand, door-to-door operation mode without fixed bus stops (phase 4). The planned network for dynamic routing will be deployed inside a geo-fenced area in a residential area in the center of Esch-sur-Alzette. Figure 12 shows the boundaries of the planned site.

Figure 12: Boundaries of the site

In order to offer a mobility solution accessible to all the residents of this area, a complex network has been elaborated, which can be seen in red in Figure 13. The different colored lines represent the existing public transport lines, while the red lines represent the planned automated minibus route network.

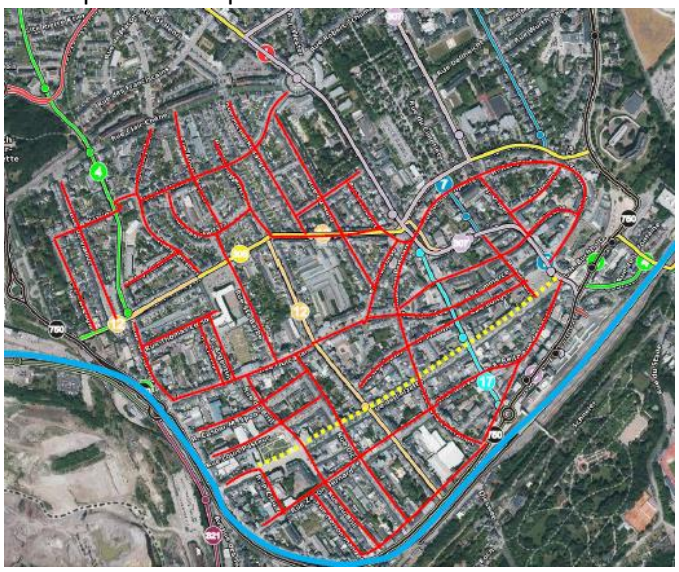


Figure 13: Planned route network

This layout of the minibus network enables to connect the residents of Esch-sur-Alzette to the center, as well as to the existing public transport stops. The yellow dotted line in Figure 13 represents the automated

minibus route in the main shopping street "rue de l'Alzette", which will be deployed in phase 1 of the project and which will stay in operation for the whole duration of the project.

The door-to-door automated minibus network will fill the current existing gap of public transport in the center of Esch-sur- Alzette. The automated minibuses will offer a connection between the existing public transport lines, the center of Esch-sur-Alzette and the residential and leisure areas.
The residential area is perfectly fitted as a testbed for an automated, on-demand, door-to-door mobility concept because this area is excluded from public transport and in most parts the legal speed is limited to 30 km/h. Furthermore, the layout of the residential area with the substantial number of intersections enables efficient dynamic-routing opportunities. The vision is to be the **official mobility partner for the European Capital of Culture Esch 2020.**

2.3.4 User groups: Personas

Task 2.2 in WP2 focuses on passenger needs and thus provides an important content to the development of the action plans and roadmaps of the PTOs. Based on the analysis and specifications of passenger needs through surveys conducted in task 2.2, a series of personas have been developed, as well as use cases based on these personas. For more details and the full background, see deliverable D2.5 "Second Passenger needs analysis and specifications".

In this chapter, all these user personas have been evaluated by SLA with respect to their relevance for each of the pilot sites. You can find the results here below:

Passengers

		Pfaffenthal		**Contern**		***Esch-sur-Alzette**	
		Y/N	Comment	Y/N	Comment	Y/N	Comment
Alex	31yo, Businessman, PT to go to work	Y	common user	Y	common user	Y	common user
Helena	74yo, Retired, Limited mobility, PT to go for treatment	N	Automated minibuses make the link between different means of transport in Pfaffenthal, so you are forced to take several connections. This person is no able to switch connections	N	Route in industrial zone, mainly commuters to work who are taking the minibus	N	No operation during the night (maybe in phase 3)
Henry	70+yo, Retired, Motor disability, PT to go shopping for daily needs	Y	common user	N	Route in industrial zone, mainly commuters to work who are taking the automated minibus	Y	common user
Caroline & John	77&79yo, Retired,	N	Inner city route	N	Route in industrial zone, mainly	N	Inner city route

	No smartphone, Remote living, PT not often used yet				commuters to work who are taking the automated minibus		
Lilly & Lou	33&2yo, Maternity leave, Buggy needed, To go to daycare	Y	Very common users but strollers not allowed inside the minibus	N	Route in industrial zone, mainly commuters to work who are taking the automated minibus	Y	Very common users but strollers not allowed inside the minibus
Fabio	21yo, PT to/from clubs (at night only)	N	No operation during the night	N	No night service + route in industrial zone, mainly commuters to work who are taking the automated minibus	N	No operation during the night
Charlot-te	18yo, Student, Afraid at night when taking PT	N	No operation during the night	N	No night service + route in industrial zone, mainly commuters to work who are taking the automated minibus	N	No operation during the night
Hanna	14yo, Student, PT to go to school	Y	Common user	N	Route in industrial zone, mainly commuters to work who are taking the automated minibus	Y	Common user
Bill & Clara	71&70yo, Retired, PT to go to excursions and hiking places	Y	Common users (a lot of tourists)	N	Route in industrial zone, mainly commuters to work who are taking the automated minibus	Y	Common user
Erik	11yo, Student, PT to go to school	Y	Common user	N	Route in industrial zone, mainly commuters to work who are taking the automated minibus	Y	Common user
Philippe	20yo, Student, PT to go to university	Y/ N	Not for now but once the on-demand system is available, then it would be possible	Y/N	Not for now but once the on-demand system is available, then it would be possible	Y	Not for now but once the on-demand system is available, then it would be possible

Table 15: User group persona analysis SLA - Passengers

Other road users

		Pfaffenthal		Contern		*Esch-sur-Alzette	
		Y/N	Comment	Y/N	Comment	Y/N	Comment
Cristina	38yo, Hotel manager, always busy, Hates traffic	N	Individual car user who gets annoyed by the presence of the automated minibus because of its slow speed	N		N	Individual car user who gets annoyed by the presence of the automated minibus because of its slow speed
Richard	84yo, Retired, Physical handicap, Feels not secure in the traffic	Y	As a passenger but also as an outside person (pedestrian)	N	Y & N: not for now but once the on-demand system is available, then it would be possible	Y	As a passenger but also as an outside person (pedestrian)
Manuel	22yo, Bike courier, Feels not safe	N	Not as a passenger but as another road participant	Y	Never happened up to now, but it could be that in future one of the companies in Contern is taking deliveries from a bike messenger, in this case yes, Manuel could be one of the other road participants	N	Not as a passenger but as another road participant
Marcus	53yo, Taxi driver, Enjoys driving	Y	As another road participant, very common	Y	As another road participant. Sometimes it is a taxi driver that is illegally parked and blocking the minibuses, other times there are trucks, vans, etc. blocking the road due to illegal parking	Y	As another road participant, very common

Table 16: User group persona analysis SLA - Other road users

Original personas

	Pfaffenthal		Contern		*Esch-sur-Alzette	
	Y/N	Comment	Y/N	Comment	Y/N	Comment

Carlo	60yo, Retired, Visually impaired, Use PT for daily drives	Y	Common user	Y	Sometimes	Y	Sometimes
Mary	Use PT to go shopping with friends	Y	Common user	Y	Sometimes	Y	Sometimes
Ned	Motorically impaired, PT to go to his office	N	Route in city center	Y	Sometimes	N	Route in city center
Katie	Feels insecure in PT	Y	As another road participant	Y	As another road participant	Y	As another road participant

Table 17: User group persona analysis SLA - Original personas

*These are expectations and are to be validated when the service starts.

2.3.5 Use cases and roadmap

The use cases and roadmap are confidential and can thus be found in the annex of this deliverable (chapter 5.2).

2.3.6 Evaluation plans for the use cases

The use cases and roadmap are confidential and can thus be found in the annex of this deliverable (chapter 5.2).

2.3.7 Integrations and special needs

2.3.7.1 Integration needs for all sites

An integration in Init and Trapeze has been put on standby this year.
Regarding the automated minibuses that will operate in the public transport service (therefore under RGTR subcontracting) must integrate the platform of our government Mobilitéit.lu. The Transport ministry procedure has not yet been predefined and it will not be written before the end of 2022

2.3.7.2 Special needs

One of SLA's key objectives is to provide transport services for everyone, including passengers with reduced mobility.

Special needs for both Pfaffenthal and Contern

- In Pfaffenthal, we still have not found an appropriate parking spot for the minibuses during the night.

  We made recommendations to the City of Luxembourg, including a recommendation letter, but unfortunately, due to COVID-19, restarting the operations of the automated minibuses is not a priority for the mayor of the City of Luxembourg

- Special services/ equipment for passengers with special needs (e.g., visual or hearing-impaired people). This is especially important for the future when no Safety operator is on board. For now, the Safety operator can help the passengers.

- Increasing the operational speed of automated minibuses. With a current maximum of 18 km/h, the minibus is slowing down traffic. Without this speed increase use case 3 and 4 will not be approved by our government.
- Safety operators are getting back and knee pains after operating the automated minibuses for several hours because the seats are too hard. A special seat for the safety operators is necessary.
- Safety operators are communicating with NAVYA technicians via WhatsApp. Sometimes a lot of communication between the two parties is necessary via the Safety operator's smartphone. A recharging possibility inside the minibus is lacking. A solution could be the installation of a USB port in the minibus (currently missing).

Special needs for Pfaffenthal:

Speed limit on the planned track varies between 30 km/h and 50 km/h. Currently the NAVYA Minibus is operating at 18 km/h. In order to avoid massive overtaking by cars, we would like a speed limitation of 30 km/h on the whole track. A new official speed reduction to 30 km/h was submitted to the responsible institution Ponts&Chaussées but was declined.

Special needs for Contern:

Stricter control of wrong/ illegal parking in order to avoid that the automated minibus stops due to the detection of obstacles (wrongly parked cars and trucks) on its path. In the industrial zone of Contern, a lot of trucks and cars are parked on the side of the road and partly reaching into the street. As soon as the automated minibus detects these vehicles as an obstacle it slows down or stops so that our Safety operator is forced to take over the minibus manually.

Special needs for Esch-sur-Alzette

In order to define the special needs, an analysis and a survey (TBC) will be made after the first phase of the project, in partnership with the commune of Esch.

2.4 Lyon: Action plan and roadmap

2.4.1 Baseline description

The Keolis Group runs various automated minibuses projects worldwide. Since 2016, Keolis was running an automated minibus project in Lyon, called "NAVLY". Navly consisted of two Navya Autonom Minibuses that ran on a fixed route with fixed stations in the area of Confluence in Lyon, an old harbor area that was revitalized 15 years ago and nowadays combines businesses, services, restaurants, event venues with a residential neighborhood. From 1st of December 2018 up until March 2020, the AVs run from Monday to Saturday, between 10:00 and 20:00. The service hours can be readapted during specific events. Since the start of the deployment in 2016, the two AVs ran around 36'000 km and were used by more than 55'000 passengers.

For the AVENUE project, Keolis Lyon has deployed a second itinerary in Lyon on a new rapidly growing area around Groupama Stadium. This new itinerary will provide to test AVs on 100% open road itinerary, with connected infrastructure that will help to go through very frequented crossroads and roundabouts.

2.4.2 Vision, needs, and goals

Vision

Keolis Lyon vision for the AVENUE pilot project is to have several AVs running all around the area of the Groupama Stadium (see next chapter 2.4.3 for more information on the pilot site) to provide a service for the residents and tourists.

The Stadium is the first step of all area development. A medical center, hotel, office building, and a recreation center are being built, and it will change the attendance to the area. Public transportation is an important part of the transformation of an area, and AVs will be a main player providing these changes and thus increasing attractiveness of the area.

The first stage of this project took place from the 15th of November 2019 to the 31st of January 2021, connecting Groupama Stadium to the T3 Décines Grand Large Tramway stop. With the inauguration of a new tramway line serving Groupama Stadium on the 1st of February 2021, the aim is to gradually deploy new routes, available to customers by transport on-demand.

Needs

- Increase the technical level of Navya's automated minibus with V2X technology in order to be more efficient with traffic light crossroads and roundabouts.
- Automated minibuses as a complementary transportation option to buses and trams.
- Integration of the automated minibus into the passenger information tools used in Keolis Lyon.
- Improve the reliability of Fully Automated Vehicles, which were regularly out of service during phase 1.

Corresponding goals

- Offer an on-demand service
- Fluid interaction between AVs and urban traffic
- Social acceptance of AVs
- Improve passenger information

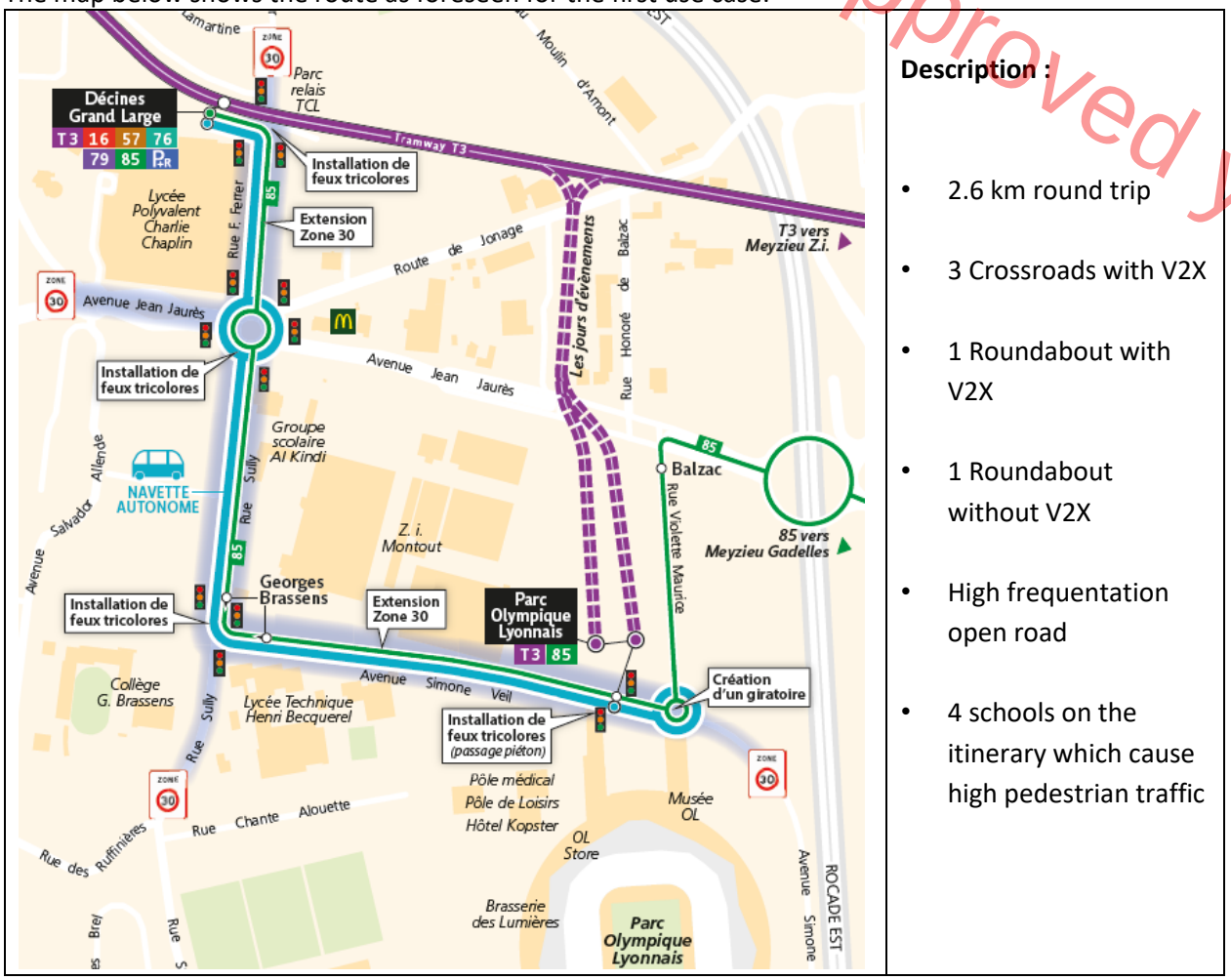
2.4.3 The pilot site

Since the initial inauguration on the 15th of November 2019, the Groupama Stadium district has evolved considerably. New generating poles are now open to the public. The district is now inhabited by:

- 1 professional building with offices
- 1 medical center
- 1 analysis laboratory
- 2 dormitories (bowling, bars, escape game, sports hall, etc.)
- 1 hotel/ restaurant
- 2 restaurants

These new travel generators will increase the number of visitors to the district. During phase 1 of the project, we noted that most of the visitors were Groupama Stadium employees, and gradually, visitors of the buildings and institutions that were opening in the area. We now expect to see a new flow of travelers who will be the users of these centers of attraction.

The map below shows the route as foreseen for the first use case:



Description :

- 2.6 km round trip
- 3 Crossroads with V2X
- 1 Roundabout with V2X
- 1 Roundabout without V2X
- High frequentation open road
- 4 schools on the itinerary which cause high pedestrian traffic

Figure 14: Route in Lyon, connecting the tram with the Groupama Stadium

On-demand service planned to start in Q3/Q4 2021

Figure 15: Routes of the planned on-demand service

Usage of service

- Visitors to the centers of attraction
- First and last mile solution between the mass transit system (T3 tram, T7 tram) and the stadium area

2.4.4 User groups: Personas

Task 2.2 in WP2 focuses on passenger needs and thus provides an important content to the development of the action plans and roadmaps of the PTOs. Based on the analysis and specifications of passenger needs through surveys conducted in task 2.2, a series of personas have been developed, as well as use cases based on these personas. For more details and the full background, see deliverable D2.5 "Second Passenger needs analysis and specifications".

In this chapter, all user these personas have been evaluated by Keolis with respect to their relevance for each of the pilot sites. You can find the results here below:

Passengers

		Groupama Stadium	
		Y/N	*Comment*
Alex	31yo, Businessman, PT to go to work	Yes	Hotel customer
Helena	74yo, Retired, Limited mobility, PT to go for treatment	Yes	Common User
Henry	70+yo, Retired, Motor disability, PT to go shopping for daily needs	Yes	Common user
Caroline & John	77&79yo, Retired, No smartphone, Remote living, PT not often used yet	Yes	Peri urban route
Lilly & Lou	33&2yo, Maternity leave, Buggy needed, To go to daycare	Yes	Common user
Fabio	21yo, PT to/from clubs (at night only)	No	Not a night service
Charlotte	18yo, Student, Afraid at night when taking PT	No	Not a night service
Hanna	14yo, Student, PT to go to school	Yes	Only rarely expected (museum visitor)
Bill & Clara	71&70yo, Retired, PT to go to excursions and hiking places	Yes	Common user
Erik	11yo, Student,	Yes	Professional seminary

	PT to go to school		
Philippe	20yo, Student, PT to go to university	Yes	Wheelchair passenger

Table 18: User group persona analysis Keolis – Passengers

Other road users

		Groupama Stadium	
		Y/N	*Comment*
Cristina	38yo, Hotel manager, always busy, Hates traffic	No	Pedestrian
Richard	84yo, Retired, Physical handicap, Feels not secure in the traffic	No	Biker
Manuel	22yo, Bike courier, Feels not safe	No	Cyclist
Marcus	53yo, Taxi driver, Enjoys driving	Yes	Scooter

Table 19 : User group persona analysis Keolis - Other road users

Original personas

		Groupama Stadium	
		Y/N	*Comment*
Carlo	60yo, Retired, Visually impaired, Use PT for daily drives	No	
Mary	Use PT to go shopping with friends	Yes	
Ned	Motorically impaired, PT to go to his office	No	
Katie	Feels insecure in PT	Yes	

Table 20: User group persona analysis Keolis - Original personas

2.4.5 Use cases and roadmap Groupama Stadium

	Use case 1	Use case 2
Time	Autumn 2019 – TBD	Q4 2021
Safety operator?	Yes	Slowly removing the Safety operator from the automated minibus[10]
Route	Fixed route, 2 fixed stops, metro mode.	• Extension of route to OL training center, OL museum, hotels

[10] After several months of operation, Keolis expects to have gathered enough feedback to be able to start the service, according to the decree 2018-211, with an operator outside the vehicle.

		First and last mile solution between the tram station Décines Grand Large (tram 3 & 5 buses) to the Olympique Lyonnais football stadium (Groupama Stadium); 2.5 km round trip, 100% open road	• Vehicles pass each other autonomously (without interference of the Safety operator) • On-demand transportation
Objective		• 100% automated driving • 100 km/day • Comfort of automated driving (without useless braking)	• Increase speed • Increase potential of V2X system • On-demand service
Stops		2	8 additional on-demand stops
Booking		None	Booking foreseen via mobile app, form tbd by PTA digital terminal at the entrance of the different buildings
Vehicles		2 Navya Autonom Minibuses	2 or more
Vehicle speed		20 km/h	20 km/h
Operation times		• Monday to Saturday from 8:30 am to 8:00 pm except during game day at the stadium. It might evolve regarding the evolutions of other modes of transport • 15 min frequency on peak hours and 30 min frequency on off-peak hours	• Booking application • Synchronization of AVs with tramway • Integration of AVs in global fleet management system of Keolis Lyon
VIP service?		No	No
Technical requirements		• Reliability of AVs • Provide communication V2X	Mission order for on-demand service
Special services to passengers		No	Provide a dynamic and real-time information on connections
Steps	*1*	Obtaining the vehicles	Adding of the new stops
	2	Designing the routes	On demand testing and final implementation
	3	Obtaining needed authorizations	Making the app available to the public
	4	Mapping of the routes (Navya)	
	5	Test phases/ implementation	

Table 21: Use cases and roadmap - Groupama Stadium

The focus throughout the whole project lies for Keolis in passenger and operation security. Next comes the service quality provided, followed by business development needs.

2.4.5.1 SWOT analysis for use case 1

Strengths	Weaknesses
• The itinerary choice is connected to tram station, so we can imagine offering an additional service to the standard service	• As the centers of attraction have only been open for a short time, we do not know the behavior of visitors. Sizing the offer is more difficult without prior knowledge of travel habits.
Opportunities	**Threats**
• The itinerary can level up in keeping with the new area development (2023 and after)	• The public will be difficult to reach in terms of advertising the service. A partnership with centers of attraction will be necessary to promote this service.

Table 22: SWOT analysis use case 1 – Keolis

2.4.5.2 SWOT analysis for use case 2

Strengths	Weaknesses
• The itinerary choice is connected to trams stations, so we can imagine offering an additional service to the standard service	• As the centers of attraction have only been open for a short time, we do not know the behavior of visitors. Sizing the offer is more difficult without prior knowledge of travel habits.
Opportunities	**Threats**
• The itinerary can level up in keeping with the new area development (2023 and after)	• The public will be difficult to reach in terms of advertising the service. A partnership with centers of attraction will be necessary to promote this service.

Table 23: SWOT analysis use case 2 - Keolis

2.4.6 Evaluation plans

Keolis does not yet work with a local company on evaluating the automated minibuses. For the AVENUE project, they will follow the evaluation plan proposed by ECL in this deliverable as well as the evaluation done by HSPF in the framework of WP8. According to these two frameworks, the study design will be decided, as well as the details of the evaluation (such as the number of expected participants).

Below are **Key Performance Indicators** used by Keolis to determine the success of the pilot are the following (non-exhaustive list). These KPIs are inspired by the list of indicators described in chapter 3.2.1, but are more specifically established on the basis of Keolis internal discussions and reflections, taking into consideration the needs related to the context and the specificities of the project. These indicators could be evaluated by several means ranging from the safety drivers and research teams' daily observations, to the information recorded in the vehicle's software or passenger feedbacks.

- Be able to increase the part of itinerary runs on open road

- Automatic run km/km total
- Km total/km expected
- Number of signal lost (with analysis of the reasons)
- Evaluate the efficiency of mobile app
- Number of passengers per trip
- Total number of passengers carried
- Number of km travelled
- Ease of use of the minibus
- Punctuality/Delay rate
- Rate of aborted trips
- Average waiting time
- Safety drivers' feedback
- Acceptance by other road users

In order to evaluate the demonstration of the different use cases, Keolis would like to collect the following data (exhaustive list):

- Reliability indicator
- Users' perception of AVs Service
- Reservation ratio, mobile app ratio, spontaneous use ratio, etc.
- Customer satisfaction measures
- Timekeeping
- Information treatment quality (specially to insure connection with tram)
- Quality of the information send to customer (ex: waiting time)

2.4.7 Integrations and special needs

Integrations

- 1st: Integrate with the tram schedule: One of the automated minibuses should be at the tram station when the tram arrives
- 2nd: Provide information on the app including the position of the minibus, ETA and ETD

Special needs

No special needs to be considered for this site.

2.5 Replication site Uvrier (PostBus) : Action plan and roadmap

2.5.1 Baseline description

PostBus, together with the Mobility Lab Sion-Valais (City of Sion, Canton Valais, HES-SO Valais-Wallis, EPFL, Swiss Post), launched a first SmartShuttle already in summer 2016 in the city of Sion in Valais, Switzerland. One of the first commercially deployed fleets in mixed urban transport, PostBus aimed at investigating if automated minibuses allow new services and forms of mobility in areas that are not currently accessed by public transportation, if the service of automated minibuses in the public sphere is technically and operationally feasible, and if it offers an added value to the customers. Working with Bestmile since the launch of the project, the service ran two automated Navya minibuses on a frequency-based, fixed-route

service in the very heart of the historic city of Sion. Passing through narrow allows, busy shopping streets and sections with mixed urban traffic, the SmartShuttle project took from its start the testing of automated minibuses for PostBus step by step further. The SmartShuttle project in Sion came to end in 2020 and will be continued with a revamped SmartShuttle project now in Uvrier as an AVENUE replication site.

2.5.2 Vision, needs, and goals

Thanks to the 4 years of exploitation in Sion, many possibilities for improvements were identified and, where possible, successively implemented. The deployment confirmed that AVs can be a suitable last mile solution.
With the SmartShuttle project in Uvrier, PostBus was mainly following two key objectives:

1. Access to public transport in areas that are not currently serviced. Especially in rural, not densely populated areas it is often-times difficult to set up an economic public transport service, still responding to the demands of local transportation. This leads, on the one hand, to a reduction of mobility for certain user groups, such as the elderly, children, or people with reduced mobility, and on the other hand, to an increased usage of private cars, which then in turn results in higher barriers for using public transport options elsewhere.
2. Demand-responsive public transport. Linked to the previous points, if public transport is offered in rural areas, it is mostly a fixed-route service with a reduced timetable due to the limited demand. This often does not fit the individual transport needs of the local population.

By offering a demand-responsive last-mile transportation option in Uvrier, to and from the train station, the above points shall be addressed.

Needs

By deploying automated minibuses in Uvrier we address the following needs:

- First & last mile transportation in lower-density suburbs
- High level of customer service
- Transport solution for connecting to existing public transport systems
- On-demand public transport solution

Corresponding goals:

1. Operation of an automated transport solution in Uvrier.
    a. Creating added value for passengers (target groups: commuters, families, mobility for people with a disability, elderly people, etc.) through a new, innovative transport offer and its connection to the rail transport system.
    b. Use of an "on-demand" offer, highlighting the advantages and limitations of such a function in terms of utilization, flexibility and expansion of the deployment scenarios.
2. Testing automated mobility in the Uvrier residential area.
    a. Development of the use case "automated vehicles in the residential area of Uvrier".
    b. Extensive implementation of integration with public transport (e.g., assuring the connection to train departures, first and last mile) and connection of other points of interest (e.g., school, shopping center, train station).
3. Improved customer experience with focus on people with special needs (elderly people, people with disabilities, etc.).
    a. Considering the special needs of, for example, elderly people or people with disabilities in the design of the service and analyzing the findings to improve future services.

2.5.3 The pilot site

The peri-urban village Uvrier lies far outside the city Sion on the eastern edge of the urban area. It is roughly five kilometers away from the nearest neighborhoods of the agglomeration of Sion. On the other side of the Lienne lies the municipality of Saint-Léonard in the district of Sierre, which together with Uvrier forms a closed settlement area.

Uvrier with its 1'400 inhabitants is an optimal test environment for automated driving.

When the Smart Shuttle project started in 2016 in Sion, the idea was mainly to guide tourist flows into the city center in a simplified way. On the other hand, the route in Uvrier, where the shuttles were relocated started operating in early 2021 replicating the Belle-Idee site (with initial plan to operate until end of 2021), is oriented towards the inhabitants of the suburb and is therefore more demand-oriented to the daily life of the people (trips to the station or supermarket, etc.). Moreover, Uvrier is a good reflection of many other Swiss suburbs. They all face the same challenges in the mobility sector that need to be solved.

In this respect, the findings can create added value specifically regarding social aspects. These include:

- Connectivity to the railway station and other points of interest
- Improved services for people with disabilities, elderly people and school children
- More flexible customer offer

The Uvrier deployment offers and connects:

- Train station
- Residential area
- School
- Shopping center
- Hotel

The expected main users of the services in the area will be the residents of Uvrier, as well as hotel guests arriving by train. The following usage scenarios can be imagined[11]:

- First mile to the train station
- Last mile from the train station
- Transport to the shopping center
- Transport to the school to pick up kids
- Transport to the hotel
- Visit of friends or family in the area

From the start of the project, between 2 and 4 vehicles will be running on the site, on a network of routes with around 18 stops. The map below shows the routes and stops of the deployment

Figure 16: Map of the Uvrier site, routes and stops

As can be seen from the map, the deployment at Uvrier aims at replicating the AVENUE Belle-Idée demonstration site with a network of virtual stops (partially using the existing bus stops), dynamic routing, and in general, the offer of a demand-responsive transportation option with AVs in an area which was underserviced before. As a replication site, it goes even beyond what is done at Belle-Idée in one aspect key to travelers, and therefore will allow the project to gather additional insights of high value: at Uvrier, PostBus will deploy a commercial Traveler App from an AVENUE project partner Bestmile, in addition to the AVENUE Traveler App developed in the project. With test users, both apps will be used and tested in parallel, allowing for a benchmark of the AVENUE app versus a production-proven commercial product.

2.5.4 User groups: Personas

Task 2.2 in WP2 focuses on passenger needs and thus provides an important content to the development of the action plans and roadmaps of the PTOs. Based on the analysis and specifications of passenger needs through surveys conducted in task 2.2, a series of personas have been developed, as well as use cases based on these personas. For more details and the full background, see deliverable D2.5 "Second Passenger needs analysis and specifications".

In this chapter, all these user personas have been evaluated by PostBus with respect to their relevance for the replication site in Uvrier. You can find the results here below:

Passengers

		Uvrier	
		Y/N	*Comment*
Alex	31yo, Businessman, PT to go to work	Yes	Temporary disability (hearing and no hand free)
Helena	74yo, Retired, Limited mobility,	Yes	Reduced mobility and hard of hearing

	PT to go for treatment		
Henry	70+yo, Retired, Motor disability, PT to go shopping for daily needs	Yes	Reduced mobility
Caroline & John	77&79yo, Retired, No smartphone, Remote living, PT not often used yet	Yes	Elderly people
Lilly & Lou	33&2yo, Maternity leave, Buggy needed, To go to daycare	Yes	Temporary disability (no hand free)
Fabio	21yo, PT to/from clubs (at night only)	Yes	Temporary disability (no ability to drive due to party)
Charlotte	18yo, Student, Afraid at night when taking PT	Yes	First and last mile
Hanna	14yo, Student, PT to go to school	Yes	First and last mile
Bill & Clara	71&70yo, Retired, PT to go to excursions and hiking places	Yes	Disability (vision and mobility)
Erik	11yo, Student, PT to go to school	Yes	First and last mile
Philippe	20yo, Student, PT to go to university	Yes	On-demand mobility service

Table 24: User group persona analysis PostBus – Passengers

Other road users

		Uvrier	
		Y/N	*Comment*
Cristina	38yo, Hotel manager, always busy, Hates traffic	Yes	Car driver
Richard	84yo, Retired, Physical handicap, Feels not secure in the traffic	Yes	Pedestrian
Manuel	22yo, Bike courier, Feels not safe	Yes	Biker
Marcus	53yo, Taxi driver, Enjoys driving	Yes	Taxi driver

Table 25: User group persona analysis PostBus - Other road users

Original personas

		Uvrier	
		Y/N	*Comment*
Carlo	60yo, Retired, Visually impaired, Use PT for daily drives	Yes	Visually impaired

Mary	Use PT to go shopping with friends	Yes	Blind
Ned	Motorically impaired, PT to go to his office	Yes	Reduced mobility
Katie	Feels insecure in PT	Yes	First and last mile

Table 26: User group persona analysis PostBus - Original personas

2.5.5 Use cases and roadmap Uvrier

	Use case 1	Use case 2
Time	Q2 2021	Q1 2022
Objective Description	Running the on-demand service thanks to a Driver App, overcoming the limitation with the current software version installed on the automated minibuses.	Running a fully automated on-demand service where the automated minibus directly receives the missions from the Bestmile Fleet Orchestration platform.
Safety operator?	Yes	Yes
Route	Dynamic-route	Dynamic-route
Stops	17	17
Booking	Instant and prebooking	Instant and prebooking
Vehicles	2	2
Vehicle speed	Max. 20 km/h	Max. 20 km/h
Operation times	Monday until Friday from 7:00am to 10:00am and 1:00pm to 6:00pm	Monday until Friday from 7:00am to 10:00am and 1:00pm to 6:00pm
Individual rides ("VIP")?	Only exceptionally, for example for visits	Only exceptionally, for example for visits
Technical requirements	Driver App	Installation of software version 6.x on PostBus's automated minibuses
Special services to passengers	Booking rides using a touch display at the train station	• Provide a dynamic and real-time information on connections • Book rides using a touch display
Steps (+schedule) 1	Relocating the existing infrastructure from the former center Sion site	Implementing of the Navya 6.x software (Q4 2021)
2	Designing the new routes	Implementation of real time information on the shuttle within the touch display (Q1 2022)

3	Mapping of the new routes (NAVYA)	-
4	Implementing the service (Q2 2021)	-

Table 27: Use cases and roadmap - Uvrier

In Uvrier there is a long section of road where a speed limit of 60km/h is allowed. PostBus has taken a close look at the situation in this section because of the high speed differential between the shuttle and the rest of the traffic. The conclusion is that, with the overall low traffic volume and the area configuration that allows road users to have enough time and overview to overtake the shuttle, it is not a problem to use a shuttle that can only travel at 20km/h on this zone. PostBus teams have also discussed this issue with the Federal Roads Office (Fedro) and obtained their agreement; this governmental institution found very interesting to see how other road users react to the shuttle at such low speeds. Indeed, no problems on this section of the road were reported.

2.5.5.1 SWOT analysis for use case 1

Strengths	Weaknesses
• The customer can reach a variety of points of interest in the Uvrier area with the SmartShuttle, e.g., a school, a shopping center, a hotel, train station • The SmartShuttle is already known to the people from Sion and therefore, the acceptance rate to use this new service is most probably high	• The speed of the vehicles is too low • Safety operator still needs to take care of the booking process • The vehicles still initiate emergency stop mode too often. Good Safety operator training is extremely important here!
Opportunities	**Threats**
• Full automated service in urban environments • Driving force for a market ready solution	• The vehicles fail due to technical faults • Waiting times for customers are too high, which makes the service unattractive • Human intervention in the process leads to image damage

Table 28: SWOT analysis for use case 1 Uvrier

2.5.5.2 SWOT analysis for use case 2

Strengths	Weaknesses
• The customer can reach a variety of points of interest in the Uvrier area with the SmartShuttle, e.g., a school, a shopping center, a hotel, train station • The SmartShuttle is already known to the people from Sion and also accordingly. Therefore, the	• The speed of the vehicles is too low • The vehicles still initiate emergency stop mode too often. Good Safety operator training is extremely important here!

acceptance rate to use this new service is most probably high.	
Opportunities	**Threats**
• Full automated service in urban environments • Driving force for a market ready solution	• The vehicles fail due to technical faults • Waiting times for customers are too high, which makes the service unattractive • Human intervention in the process leads to image damage

Table 29: SWOT analysis for use case 2 Uvrier

2.5.6 Evaluation plans

The Uvrier project can essentially be described as a sensible and necessary continuation of the operation in Sion, with the difference that the operation will now run in a residential area. Testing the automated minibuses in contextual operation will take place in a peri-urban zone with connectivity to nearby points of interest. The project also entails integration of a complete digital on-demand solution in a peri-urban area

- Increased organizational effort, as two minibuses are in operation at the same time. This has an impact on the operational management. Staff deployment and vehicle maintenance (charging management, maintenance, cleaning) must be adapted. The simultaneous use of several vehicles is also a significant step towards scaling the operational organization.
- Further development of procedures and processes towards standardization. In this project we have the interesting case of the teleoperator staying in Sion, but the Safety operators do their work in Uvrier.
- The route in Uvrier, on the other hand, is particularly oriented towards the residents of the suburb and is therefore more demand-oriented towards people's daily lives (trips to the station or supermarket, etc.). In this regard, we are conducting a data analysis in collaboration with MobilityLab on how the new service is used by residents. The following points will be investigated:
    - Vehicle utilization, in order to investigate the use of the offer (What are the minibuses used for? How do people handle their luggage or shopping items?)
    - Target group analysis (Which population groups use the minibuses?)
    - Quality of service in terms of reliability of operation

Furthermore, PostBus is interested in carrying out a reporting, which should answer the following questions and points, among others:

- Quality and safety of unmarked stops:
    - How are unmarked stops perceived by other road users? Do they represent an obstacle?
    - Can there be precarious situations when braking or starting at unmarked stops, and if so, why?
    - Do they pose a safety risk, or can dangerous situations arise?
    - Is the position of these stops particularly suitable or are there better positions? If so, why?
    - Are passengers exposed to danger when getting on and off the bus?

Customer acceptance:

- What is the customer's attitude towards the "on-demand" concept?
- What is the customer reaction to pooling rides? What are the implications for the Safety operator?

- What level of acceptance can be expected from the customer and other road users to unmarked stops?
- What is the acceptance rate for electronic ordering (via smartphone, PC, etc.) of journeys in general and for people with special needs (elderly people, people with disabilities)?

Technology:

- Reliability of vehicle systems and demonstration of their limitations in "on-demand" operation.
- Speed behavior of the minibuses
- Functionality of data transmission and networking with regard to the control center and Safety drivers in "on-demand" operation

Here, KPIs were worked out together as a team. ThePostAuto operation of Sion, the University of Valais (HES-SO), the SmartShuttle project manager and the city of Sion were involved. Furthermore, the KPIs were subsequently discussed and finalized with the Federal Roads Office (FEDRO).

2.5.7 Integrations and special needs

Integrations:

- Bestmile implemented the departure times of the trains. The customer is informed about the train departures on the app.
- The customer has the possibility to book an automated minibus via touchscreen at the train station. An app is not required in this case.

Special needs:

No special needs to be considered for this site.

3 Evaluation plan

In order to perform the evaluation of the overall AVENUE services, technologies and functionalities at large scale demonstrations, the task 2.5 has to deliver an evaluation plan in D2.16. The evaluation should consider user experiences brought by AVENUE's fully automated urban transport systems and establish the framework for a detailed evaluation of the service acceptance, utilizing specific criteria and key performance indicators. Measuring both subjectively (questionnaires for active and potential users, semi-structured interviews) and objectively (number of new users in the service, number of users changing behavior, etc.).

This document presents the framework for an evaluation plan that will be conducted in the period from M25 to M48. The evaluation plan is linked to the task T2.2 Passenger needs (including Persons with Reduced Mobility (PRM)) and requirements specification that will deliver the D2.5 Definition of AVENUE services (R, PU, M6, M18, M36), enriching, updating and detailing the provisional list of services. The evaluation plan should be implemented in consistency with D2.5, i.e., following the human centered design process for interactive systems (ISO 9241-210) and ensuring that all the relevant stakeholders (including younger and older persons, their family and healthcare professionals) play an important role in the requirement and the evaluation phases throughout the project. Emphasis must also be put on the cultural and organizational differences within the user groups and member countries. This includes explorative, qualitative studies at the beginning of the project as well as the creation of personas to establish a common understanding among the project participants about the scope and basic ideas behind the user needs and expectations. To this end, user surveys will take place in all demonstrator cities and at least 10 additional ones among those expressing interest. So far, these surveys, performed with individuals

who have travelled on one of the project's shuttles has only been done in Copenhagen (n=70) and Sion (n=44) due to pandemic situation. In addition, two large scale surveys have also already been conducted among the general population, ordinary respondents who have essentially never tried autonomous public transport (let alone participated in an AVENUE demonstration), one in 2019 with 978 respondents and another in 2021 with 1816 respondents.

Given the size and complexity of the project, this evaluation framework proposal is divided into broad categories, which will be assessed based on availability of different data types and sources and classified into different Key Performance Indicators (KPIs). These will then be measured both objectively (e.g.: number of passengers per day, battery charging time, number of interventions.) and subjectively (e.g.: questionnaires for users, semi-structured interviews). Whenever possible, KPIs will be analyzed considering a time frame in order to measure their evolution during the project life-span.

The main objective is to evaluate and understand:

- the overall performance and quality of the automated minibuses;
- the overall performance and quality of the offered services;
- users' perceptions, satisfaction and attractiveness towards the services and the automated minibuses;
- the insertion of the automated minibuses services in their local environment.

It is worth noting that data protection and privacy issues will be resolved by the involvement of partners (under T1.4 and T6.3), before the beginning of the evaluation phase.

To have more information on how the components of evaluation plans will be measured and the results correlated to a level of goodness see the chapter 3.2 (for the KPIs) and the deliverable D.8 (for the survey and interviews). Some more information is also available in the deliverable D.2.6.

3.1 Summary description of the operating sites

For the purpose of the evaluation plan, a summary description of the operating sites is proposed. It responds to the standard of the Operating Design Domain (ODD) a taxonomy designed for automated driving systems. This particular summary table will be integrated into all deliverables starting from their upcoming iteration. This analysis could be done in two different moments in time ("*ex-ante*" and "*ex-post*") in order to measure the progress of operations throughout the project. All the demonstrators' sites will be evaluated on task 7.6 presents the overall proposition for the summary description of the operating sites.

In addition, with the overall ambition of the AVENUE project of offering on-demand mobility services and new business models for public transport, it is important to distinguish how close each operating site is to the ultimate goal of full on-demand offerings, that is, each site should be ranked on the levels of on-demand service (see Figure 17 for further details). It is important to highlight that the KPIs may vary according to the level of service that is offered by the public transport operator.

	Summary of AVENUE operating sites demonstrators						
	TPG		Holo		Keolis	Sales-Lentz	
	Geneva		Copenhagen	Oslo	Lyon	Luxembourg	
Site	Meyrin	Belle-Idée	Nordhavn	Ormøya	ParcOL	Pfaffental	Contern
Funding	TPG	EU + TPG	EU + Holo	EU + Holo	EU + Keolis	EU + SLA	EU + SLA
Start date of project	August 2017	May 2018	May 2017	August 2019	May 2017	June 2018	June 2018
Start date of trial	July 2018	June 2020	September 2020	December 2019	November 2019	September 2018	September 2018
Type of route	Fixed circular line	Area	Fixed circular line	Fixed circular line	Fixed circular line	Fixed circular line	Fixed circular line
Level of on-demand service*	Fixed route / Fixed stops	Flexible route / On-demand stops	Fixed route / Fixed stops	Fixed route / Fixed stops	Fixed route/Fixed stops	Fixed route / Fixed stops	Fixed route / Fixed stops
Route length	2,1 km	38 hectares	1,3 km	1,6 km	1,3 km	1,2 km	2,3 km
Road environment	Open road	Semi-private	Open road	Open road	Open road	Public road	Public road
Type of traffic	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed
Speed limit	30 km/h	30 km/h	30 km/h	30 km/h	8 to 10 km/h	30 km/h	50 km/h
Roundabouts	Yes	Yes	No	No	Yes	No	No
Traffic lights	No	No	No	No	Yes	Yes	Yes
Type of service	Fixed line	On demand	Fixed line	Fixed line	Fixed line	Fixed line	Fixed line
Concession	Line (circular)	Area	Line (circular)	Line (circular)	Line (circular)	Line (circular)	Line (circular)
Number of stops	4	> 35	6	6	2	4	2
Type of bus stop	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Bus stop infrastructure	Yes	Sometimes, mostly not	Yes	Yes	Yes	Yes	Yes
Number of vehicles	1	3-4	1	2	2	2	1
Timetable	Fixed	On demand	Fixed	Fixed	Fixed	Fixed	Fixed
Operation hours	Monday-Friday (5 days)	Sunday-Saturday (7 days)	Monday-Friday (5 days)	Monday-Sunday (7 days)	Monday-Saturday (6 days)	Tuesday & Thursday Saturday, Sunday & every public holiday	Monday - Friday
Timeframe weekdays	06:30 – 08:30 / 16:00 – 18:15	07:00 – 19:00	10:00 – 18:00	7:30 – 21:30	08:30 – 19:30	12:00 – 20h00	7:00 – 9:00 16:00 – 19:00
Timeframe weekends	No service	07:00 – 19:00	No service	9:00 – 18:00	08:30 – 19:30	10:00 – 21:00	No Service
Depot	400 meters distance	On site	800 meters distance	200 meters distance	On site	On site	On site
Driverless service	No	2021	No	No	No	No	No
Drive area type/ODD	B-Roads	Minor roads/parking	B-Roads/minor roads	B-Roads	B-Roads	B-Roads	B-Roads/parking
Drive area geo/ODD	Straight lines/plane	Straight lines/ plane	Straight lines/ plane	Curves/slopes	Straight Lines/ plane	Straight lines/ plane	Straight lines/ plane
Lane specification/ODD	Traffic lane	Traffic lane	Traffic lane	Traffic lane	Traffic lane	Traffic lane	Traffic lane
Drive area signs/ODD	Regulatory	Regulatory	Regulatory, Warning	Regulatory	Regulatory	Regulatory	Regulatory
Drive area surface/ODD	Standard surface, Speedbumps	Standard surface, Speedbumps	Standard surface Speedbumps, Roadworks	Frequent Ice, Snow	Standard surface, Potholes	Standard surface	Standard surface

Table 30: Summary of AVENUE operating site (+ODD components)

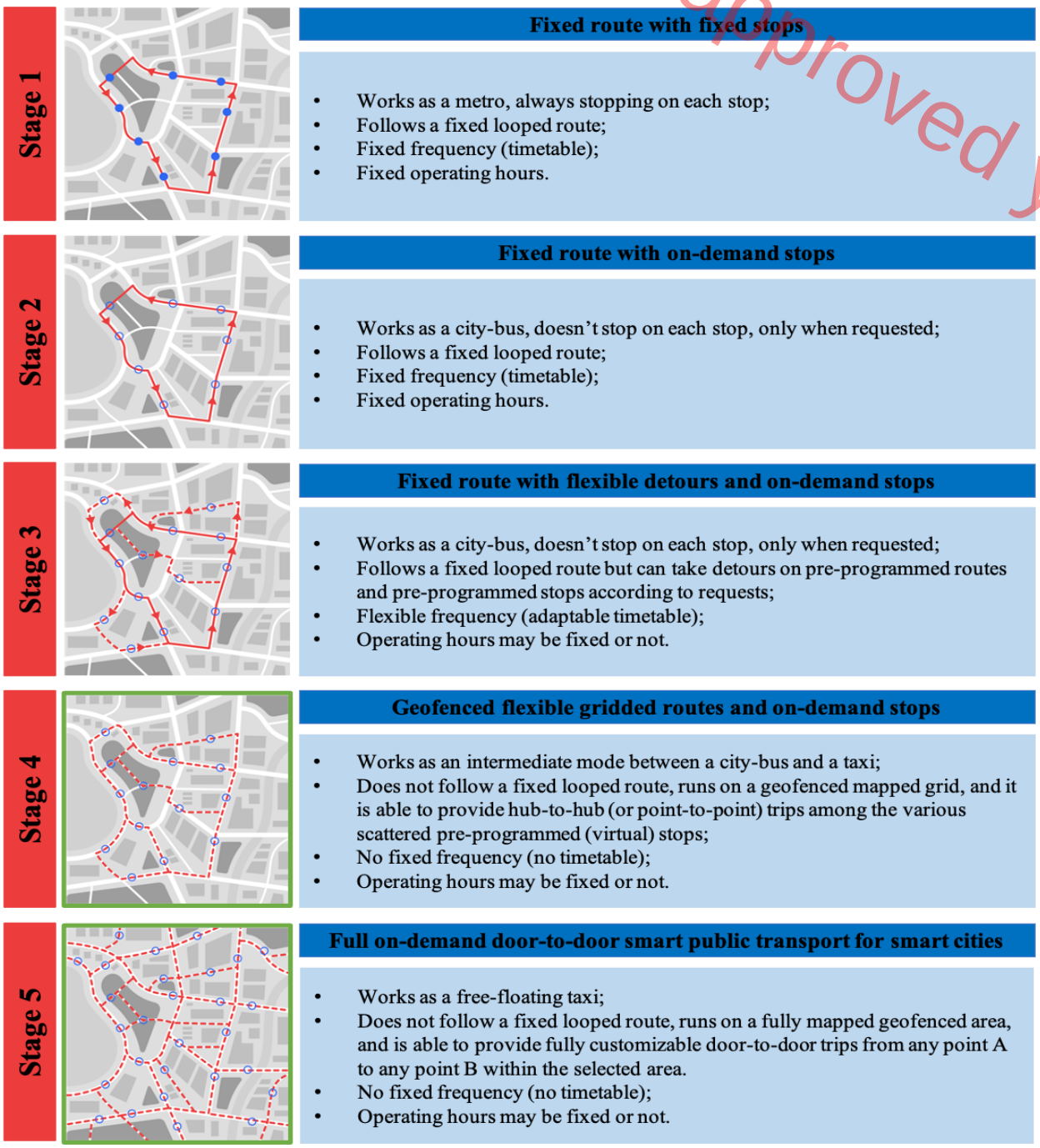


Figure 17: Levels of on-demand services for public transport with Automated minibuses (Antonialli, 2021b).

3.2 Evaluation categories

The evaluation categories listed on the next pages follow the guidelines proposed on D.2.6, in a sense that the framework is built on a systematic comparison between the users and the service providers.

On the user side, the evaluation has to integrate the users' expectations and perceptions in the process in order to measure the gap between their cognitive perception and the tangible, measurable data.

On the service provider side, service specifications can be presented with objectives and quantitative KPIs. Nonetheless, there may be significant differences between targeted specifications and the concrete

realization of the service. Therefore, the evaluation must compare initial objectives given to a specific service and the actual performance, the effective performance as well as the perceived performance.

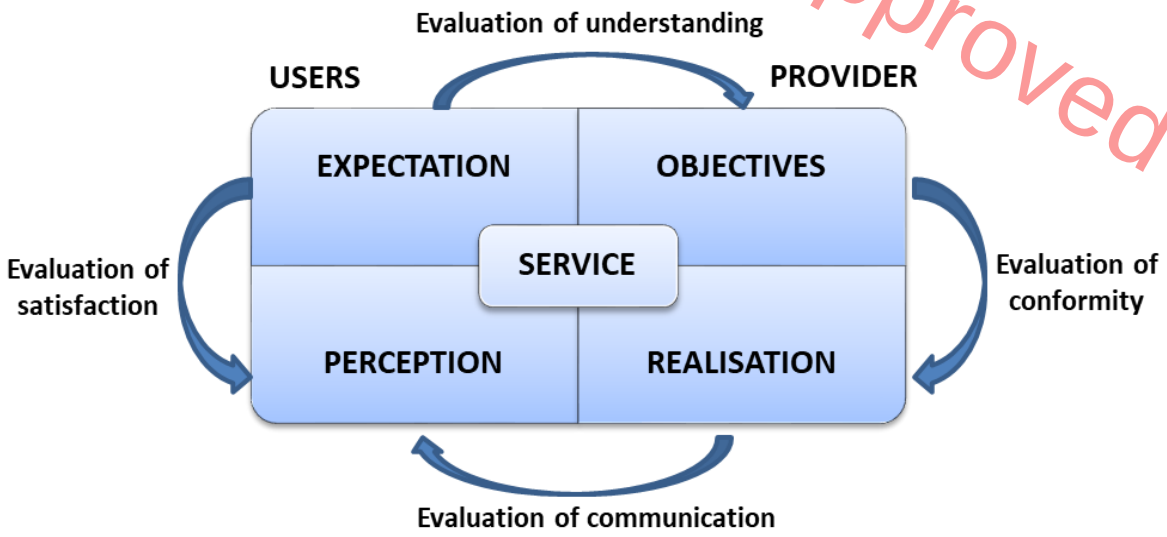


Figure 18: Evaluation process of a service

As shown in Figure 18, the evaluation process should be able to provide the following:

- **Understanding assessment:** to what extent did the service provider understand users' expectations and succeeded in specifying and providing an adapted service;
- **Conformity assessment:** the difference between the objectives identified by the provider through the KPIs and the realization measured by sensors and other objective indicators;
- **Communication assessment:** to what extent do users perceive and understand the range of proposed services;
- **Satisfaction assessment:** to what extent do users estimate that the service is reaching their expectations.

In the next sections, the evaluation categories are presented with their main guiding questions and the possible units of measures (KPIs) that we would like to evaluate.

The main evaluation points to be measured are divided into a set of KPIs which together will provide a global answer to a set of guiding questions. Results on each KPI will be collected on an "*ex-post*" fashion and will be compared to the overall goal set for each of them. This goal should be provided by the demonstrators as well.

These KPIs were established by ECL based on a triangulation of the data collection method, both on the basis of personal contacts and interviews with PTOs in the four AVENUE project cities as well as on the basis of the literature[11]. This list is being reworked and updated by ECL as the project evolves and as constraints caused by the pandemic evolve.

[11] Mainly this open access document: *Key performance indicators for assessing the impacts of automation in road transportation Results of the Trilateral key performance indicator survey (INNAMAA, Satu, 2018)*

3.2.1 Overall quality and performance of the minibus

This first category aims to measure the overall quality and performance of the automated minibus itself. The main evaluation points in this category are:

Guiding questions	KPIs	Evaluation	
		Objective (goal)	Ex-post evaluation
How does the minibus perform regarding safety and securty?	Number of emergencies stops - harsh brakes		
	Number of false positives where vehicle takes unnecessary collision avoidance action		
	Number of automatic stops		
	Number of manual takeovers		
	Number of mis- or dis-communication with other road users		
	Number of instances where other road-drivers abused the safety-first mechanisms in AVs		
	Number of mechanical/sensor failures		
	Number of down time hours due to maintenance or other issues		
	Number of requests for help from Navya §		
	Number of crashes/accidents		
	Number of other minor incidents		
How does the minibus perform regarding energy consumption?	Battery autonomy (kW.h/km)		
	Battery charging time (hours)		
How is the overall performance of the minibus regarding comfort and accessibility? (see WP4 and WP2)	Frequency of cleaning (times per week)		
	Temperature control – heating and AC (yes/no)		
	Is the wheelchair ramp available – working (yes/no)		
	Is the SOS button available – working (yes/no)		
	Audio-visual display of information (yes/no/partially)		
	Presence of in-vehicle wi-fi (yes/no)		
	Presence of in-vehicle infotainment system (yes/no)		

Table 31: KPIs for overall quality and performance of the minibus

3.2.2 Overall quality and performance of the service

This category entails the assessment of the overall quality and performance of the transportation service itself (offered by the PTOs to their local communities), as well as the complementary in- and out-of-vehicle services. The main evaluation points to be measured in this category are:

Guiding questions	KPIs	Evaluation	
		Objective (goal)	Ex-post evaluation
How is the overall performance of the transportation service?	Average time at stops – load and unload of other passengers (min)		
	Average operating speed (km/h)		
	Average detour time (min)		
	Average number of trips per day		
	Average distance covered per day (km)		
	Avg distance covered by autonomous driving (km)		
	Avg distance covered by manual driving (km)		
	Average occupancy rate – number of passengers per day		
	Average waiting time (min)		
	Total number of passengers (passengers / km)		
	Total mileage per vehicle (km)		
	Number of route cancellations – complete stop of the service		
How does the service perform regarding safety and security?	Presence of on-board operator (yes/no)		
	Surveillance system in the minibus (yes/no/partially)		
	Surveillance system in the operating site (yes/no/partially)		
How is the overall performance of the service regarding comfort and accessibility?	Ease-of-measure to PRM (yes/no/partially)		
	Integration with the city transport network (yes/no/partially)		
	Timetables at the stops/stations (yes/no/partially)		
	Timetable online (yes/no/partially)		
	Availability of on-line application (yes/no/partially)		
	Integration with route-planning apps (yes/no/partially)		
Is there a system in place to measure the economic perfor-mance of the service?	Total CAPEX costs (yes/no/partially)		
	Total OPEX costs (yes/no/partially)		
	Total of revenues (yes/no/partially)		
	Cost per minibus/km (yes/no)		
	Cost per passenger/km (yes/no)		

Table 32: KPIs for overall quality and performance of the service

3.2.3 Users' perceptions, satisfaction and attractiveness

A crucial part of the AVENUE services evaluation plan is to gather the feedback from users regarding their perceptions, satisfaction and attractiveness with regards to the minibus and the services. This category is aimed at evaluating the user's level of feedback and it relates to Task. 8.3 – Social impact evaluation, and Task 2.2 – Passenger needs (including People with Reduced Mobility – PRM). The main evaluation points to be measured are:

Guiding questions	KPIs	Evaluation	
		Objective (goal)	Ex-post evaluation
What is the retention rate of users?	Frequency of use of the service (times per week)		
	Intention to use the service again (5-point scale)		
How is the level of user satisfaction with the shuttle?	Comfort in the minibus (5-point scale) KPI can be the result of average scores of several items (e.g.: cleanliness, temperature, noise level, interior lighting, internal space, seats, handles, ramps for PRM, audiovisual information, etc.).		
	Feeling of safety and security in the minibus (5-point scale) KPI can be the result of average scores of several items (e.g.: presence of surveillance system, presence of on-board operator, presence of seatbelts, presence of handles, etc.).		
	Ease of use of the minibus (5-point scale)		
How is the level of user satisfaction with the service?	Reliability of the service (5-point scale)		
	Punctuality of the service (5-point scale)		
	Efficiency and effectiveness of the service (5-point scale) KPI can be the result of average scores of several items (e.g.: waiting time, minibus speed, frequency, information on timetables, etc.).		
	Location of the operating site (5-point scale)		
	Location of the stops (5-point scale)		
	Cost/benefit of the service (5-point scale)		
	Willingness to pay (value in Euros)		
	Ease of use of the service (5-point scale) KPI can be the result of average scores of several items (e.g.: minibus easily recognizable, stops are easy to find, ease of, connection to other transport modes, ease of measure to information about the service, etc.).		
	Importance of in-out additional services (5-point scale)		
What is the perception of impacts on other road users?	Road system usage safety: Are other road-user perceiving the minibus service as threatening (yes/no) or (5-point scale)		
	Road system usage efficiency: Are other road-user perceiving the minibus service as slowing down traffic (yes/no) or (5-point scale)		
	Are other road-user perceiving the minibus service as causing any other problems or inconveniences (yes/no) if yes: what are they?		

Table 33: KPIs for user's perception and attractiveness

Some of the results derived from tasks 8.3 and 2.2. can be analyzed using some well-known metrics present in the literature and better detailed in D2.6 and summarized below:

For the KPIs regarding satisfaction, the User Satisfaction Score (USAT) can be applied. The score is the average of all users' responses and it is recommended to be analyzed per users' segment and at least twice during the key phases of service delivery.

For the KPIs regarding intention to use and/ or indicate the automated minibus to others in the future, the Net Promoter Score (NPS) can be applied. Its advantage over the USAT is that it targets an intention and not an emotion. As a result, the answers are less influenced by the mood of the moment. Users' answers are placed into one of three categories: promoters (9 – 10), passives (7 – 8), or detractors (0 – 6). By taking the percentage of respondents who fall under the "promoter" category (10 – 9) and subtracting it from the "detractors" (0 – 6), the NPS is obtained.

Another interesting analysis to the PTOs and overall outcome of the AVENUE project is the User Retention Rate (URR). It refers to the ability to keep the user over a set period of time. The AVENUE service might attract a lot of users, but to which extent do they become regular users? The users' retention is an important indicator of the adequacy of the service to users' expectations and of the perceived quality of the service, and it can be calculated as follows:

$$URR = \left(\frac{E - N}{S}\right) \times 100$$

Where:

E = Number of users at end of period

N = Number of users acquired during period

S = Number of users at start of period

At last, with many questions regarding the Survey proposed in Task 8.3, being assessed on 5-point scales and having in mind that the survey will be applied in two different moments in time, the SERVQUAL method (Service Quality) can be used to assist in the evaluation of this category. The multi-dimensional KPI measures "service + quality" are considered as the most common method for measuring the subjective elements of the service quality. Users are asked to rate the service and their rating is compared to the expectations they previously expressed.

According to decision-making theory, it is easier to express judgements based on an anchor (the user's expectations). This allows the users to better understand and respond to abstract information (their satisfaction with a service). The questions cover 5 elements of service quality: RATER.

- **R**eliability: the ability to deliver the promised service in a consistent and accurate manner.
- **A**ssurance: the extent to which the service provider creates trust and confidence.
- **T**angibles: the appearance of the service (e.g., the minibus, website, equipment, etc.).
- **E**mpathy: the extent to which the service provider cares and gives individual attention.
- **R**esponsiveness: the delay needed by the service provider to rapidly provide an adapted service.

It is worth nothing that the KPIs and the proposed additional evaluation scores may not be all applied. Also, these data shall not be compared between the four demonstrator sites of the AVENUE project

because the four contexts are quite different. The important thing is to monitor each indicator over time in each site to measure their evolution.

Several actions will be undertaken to verify the validity of the results obtained through the evaluation plans (KPI-oriented but also survey plans). A test/retest posture could be adopted by making another evaluation to cross the results. The results also can be compared with those of the academic research, but also with the large-scale media/social media monitoring made by the AVENUE team ones. Concerning the surveys more specifically, this validity will be tested by assessing the statistical significance of the results in light of the surveyed sample size. There, the absolute minimum cohort size is 30 (minimum for the CLT theorem to hold), but to guarantee some very satisfactory conditions 150 respondents would be optimal (guaranteeing a 95% confidence level with an 8% margin of error). For the general population surveys (whose participants has a priori never used autonomous public transport), which counts 2794 respondents, the results will therefore provide extremely representative results statistically wise. Due to the pandemic situation, the second type of surveys, focusing on proper users, has only 114 respondents (from 2 sites only), although this offers a certain degree of significance, the goal is to increase this number in order to guarantee solid results. It is equally important to increase the number of sites where the surveys will take place because in the present situation the results would be biased by the influence of the cultural context but also of the very particular projects' conditions to be representative of the perceptions at a European scale.

Based on information gathered at the earliest stage of each particular survey procedure, the respondent panel will be divided into population groups based on age or other characteristics (more about it on the deliverable D.8) but also regarding to external/contextual specificities, such as the type of area served and the particular purpose of the shuttle in order to be able to make more refined distinctions within the results.

3.2.4 Urban environment of the deployments

The aim of this category is to measure the impact of the automated minibuses' implementation on their local environment, that is: to understand if and how the PTO has taken into account the local environment where the automated minibuses were deployed. The main evaluation points to be measured in this category are:

Guiding questions	**KPIs**	**Evaluation**	
		Desired objective (goal)	Ex-post evaluation
Were there meetings and discussions with the local stakeholders (public authorities, residents, local businesses, etc.) before the implementation of the service?	Number of stakeholders in the local area involved in the decision-making process to implement the services		
	Number of meetings between the PTO and each stakeholder		
	Number of interventions from each stakeholder during the deployment of the service		
Were there infrastructure works needed?	Number of constructions needed		
	Number of adaptations needed		

How was the communication and dissemination of the services with the minibus for the local population?	Number of posters put in place		
	Number of billboards put in place		
	Number of flyers (pamphlets) distributed		
	Number of posts on social media		
	Number of press/media coverages		
How was the level of integration to the city's transport network?	Itinerary integration with the city's transportation network (yes, no)		
	Integration of payment/ticketing with the city's transportation network (yes, no)		
Was there any opposition/resistance phenomena from the local stakeholders (public authority, residents, businesses)?	Level of opposition to the implementation of the service (5-point scale)		
Were there measurable local economic impacts after the implementation of the service?	Number of new real estate developments in the area		
	Number of vanished/disappeared jobs		
	Number of new jobs		

Table 34: KPIs for urban environment of the deployments

4 Conclusions

Deliverable D2.18 - Final Trials, uses cases specification and evaluation, consisting in two main parts: the demonstrator roadmaps that detail the action plan and roadmap for each of the demonstration sites of the AVENUE project (Copenhagen, Geneva, Luxembourg, and Lyon) as well as the replication sites (by PostBus and Sales-Lentz), and the evaluation plan of the overall AVENUE services, technologies, and functionalities.

4.1 Demonstrator and replicator roadmaps

The demonstrator and replicator roadmaps contained a baseline description of automated minibuses running under the supervision of the transport operators. This was compared to the vision outlined for the AVENUE project and related needs.

The vision was then broken down into concrete goals for the four-year project, which were outlined in detail in the action plan. The action plan described the pilot sites chosen, the use cases, the current status and past deployments, as well as the roadmap and next steps (including operation details, technical requirements, objectives and milestones and SWOT analysis per use case). It furthermore provided details on integrations done and planned and special needs addressed.

Lastly, the roadmaps contained some details on the evaluation plans for the use cases. While mainly referring to the comprehensive evaluation (see below), each operator detailed out the Key Performance Indicators to determine the success of the pilot as well as the data that they would like to collect in order to evaluate the demonstration of the different use cases.

4.2 Conclusion of the evaluation plan

Throughout the project, there is a continuous evaluation process established, and it will iteratively be refined to accommodate deficiencies detected during the demonstration phase.

During the operation of the services, we will evaluate the needs of the different user groups, based on different classifications (age, activity, gender, special needs), identify the barriers in the adoption and acceptance of automated vehicle transport services. A detailed evaluation of the service acceptance will be performed, measured both by subjective and objective KPIs: questionnaires for active and potential users, semi-structured interviews, number of new users in the service, number of users changing behavior, etc.

The evaluation of the costs and benefits will be done with the Total Cost of Ownership method, taking into account not only service operation costs, but also quantify the indirect societal and environmental benefits like parking cost savings, or efficient land development benefits, change of modal transfer, working hour gains and waiting time reductions, energy savings, carbon footprint and air pollution reduction and even changes in passenger habits resulting from the public service personalization.
Evaluation will take place during Phase four (M12 - M48) and WP8. The economic analysis of the used automated electric vehicles will first focus on business viability and then on possible economic impacts for

users and cities. The social impact analysis will study the user experience, the user acceptance and the potential changes in mobility behavior in the use of public transport systems.

The evaluation process will be implemented in 3 steps.

Step 1 – Plan and design the framework

- What is going to be evaluated
- Who are the specific users and the relevant number of inquiries?
- Which are the relevant KPIs to be measured
- How data are going to be collected
- What is the schedule for data collection (starting and closing dates, replication frequency)?

Step 2 – Implement the process accordingly with the framework

Step 3 – Data analysis

- Evaluation of the level of conformity
- Evaluation of social impact (satisfaction, communication, understanding)
- Evaluation of economic impact (TCO)

5 Appendix A: Confidential annexes to use case (confidential)[12]

5.1 Annexes Autonomous Mobility

5.1.1 Routing type in the Nordhavn/Slagelse area

5.1.1.1 Use case 1

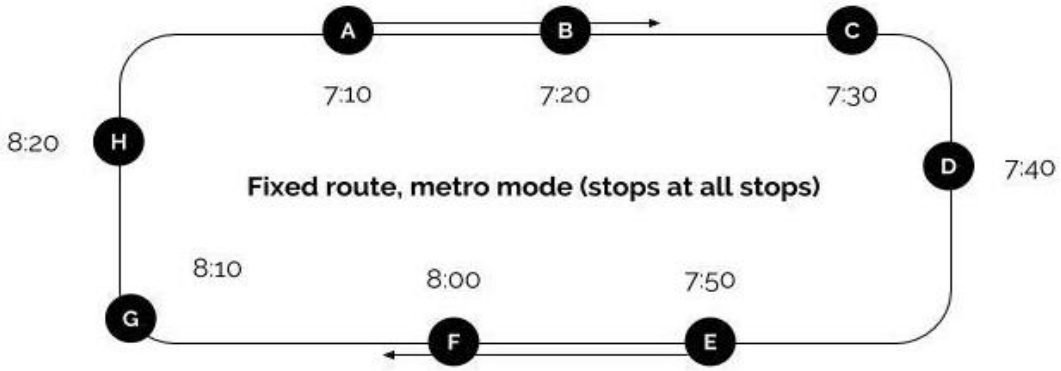


Figure 19: Routing use case 1 Nordhavn / Slagelse sites

5.1.1.2 Use case 2

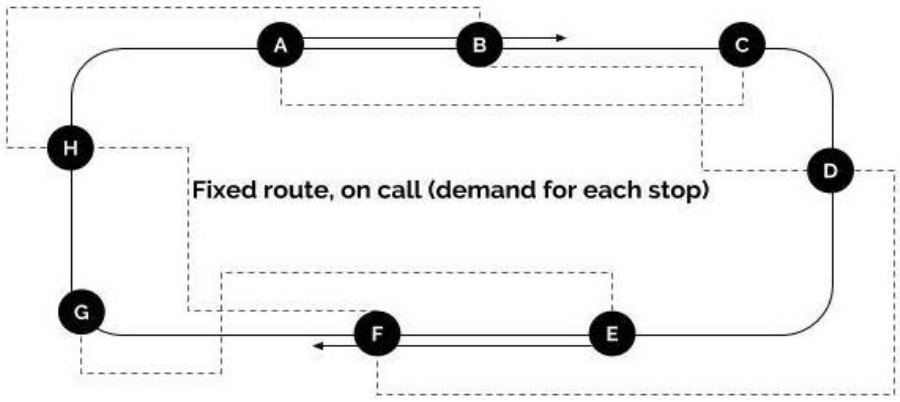


Figure 20: Routing use case 2 Nordhavn / Slagelse sites

[12] These annexes will be submitted to the European Commission but have to be removed from any public version of the deliverable.

5.1.1.3 Use case 3 (dynamic routing on-demand between all stoops given need from passenger. One or two routes.)

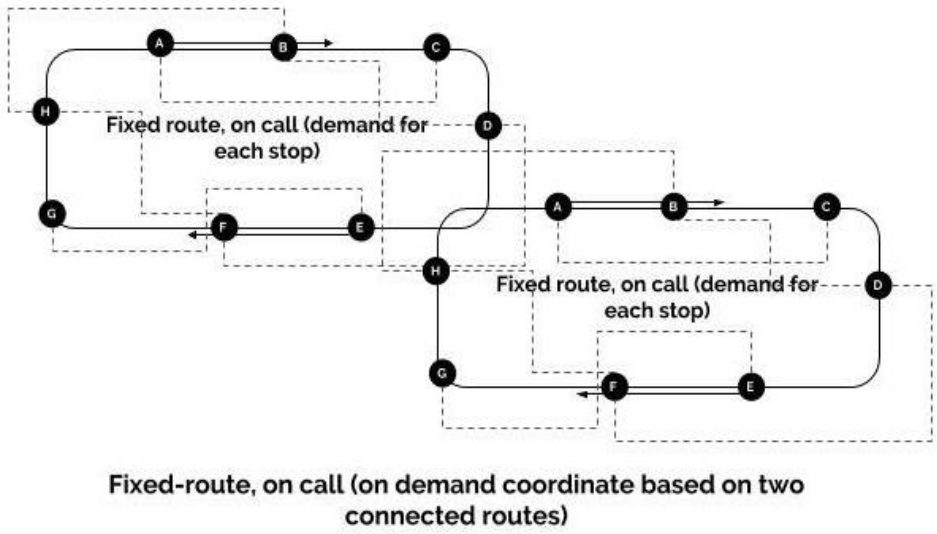


Figure 21: Routing use case 3 Nordhavn / Slagelse sites

5.1.1.4 Use case 4 (not possible)

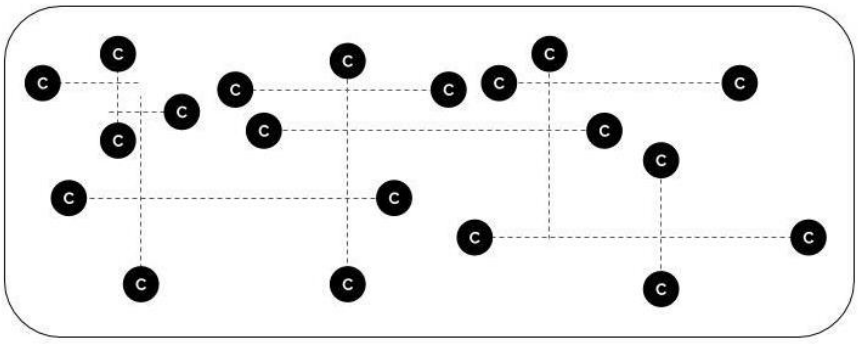


Figure 22: Routing use case 4 Nordhavn / Slagelse sites

5.1.1.5 Use case 5 (not possible)

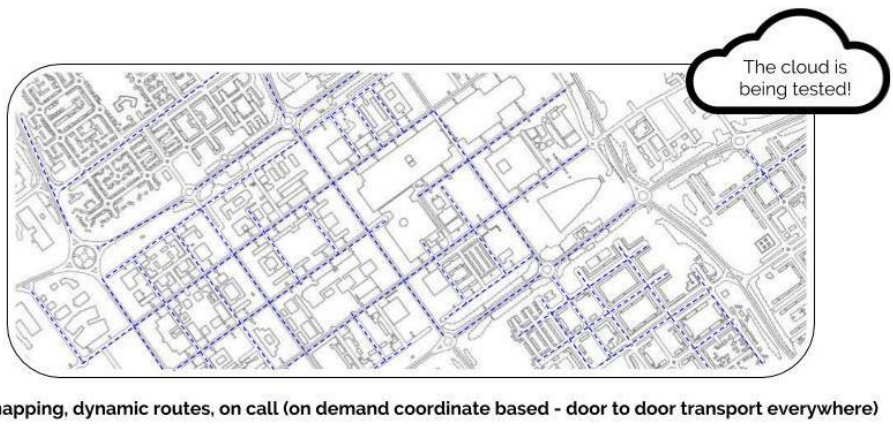


Figure 23: Routing use case 5 Nordhavn / Slagelse sites

5.1.2 SWOT analysis (for use case 1-3)(4-5 not possible)

5.1.2.1 Use case 1 (Nordhavn)

Strengths	Weaknesses
● Amobility is currently the only company operating autonomous vehicle in Nordhavn ● Amobility has tested autonomous vehicles in Denmark, Norway and Sweden for almost 4 years. ● Amobility has established a technical team competent to monitor and operate vehicles on site. ● Amobility has prior experience from other pilot projects – hence experience in terms of registration and regulations of autonomous vehicles and approvals of AVs and specific routes in real traffic. ● Amobility is perceived as first movers in terms of operation of autonomous vehicles and has a strong political network. ● Proactive, nimble, change ready spirit. ● Problem solving and focus on solutions. ● Good relations to partners and stakeholders. ● Due to proper organization, this first use case is the simplest possible scenario of operations and therefore a very good starting point to tune-in details for the following use cases. ● Fixed timetables can allow users to organize themselves in order to try the service in the first stage.	● Amobility is the first to go through the legal framework in Denmark – requires time and resources – three years of approval. ● People are not necessarily aware of the service at the beginning. ● Travelling time is penalized since the automated minibus will stop in every stop even if it's not required.
Opportunities	**Threats**
● Unique position as operator of autonomous solutions in the Nordics and the Baltic countries. ● In position to own agendas and frame the debate. ● Authority from pilot experience in real traffic with real passengers. ● The Mobility Cloud can change the perception of public transport, positively. ● Deploy multiple types of vehicles to fit a broad range of customer needs.	● Competitors winning end users' loyalty. ● Critical incidents in pilots could damage trustworthiness of the brand Amobility. ● Slowly developed laws and regulations could limit our operations, hence the development of Amobility. ● The technology is not matured enough. ● The technology is not robust enough. ● The temporary AV legal framework is generated as a test framework – which will be revised in 5 years and shut down – this can potentially become a threat for the deployment of AV's in Denmark.

Table 36: SWOT analysis use case 1 Nordhavn

5.1.2.2 Use case 2&3 (Slagelse Hospital)

Strengths	Weaknesses
● Amobility is the only Danish company operating autonomous vehicles at the moment in public transport – fully approved for all traffic situations. ● Amobility has tested autonomous vehicles in Denmark, Norway and Sweden for almost 4 years. ● Amobility has established a technical team competent to monitor and operate vehicles on site. With both a trained maintenance team and a supervision team, the operations are constantly monitored and troubleshooted. ● Amobility has the most experience in the Nordics in terms of registration and regulations of autonomous vehicles, as well as approval of vehicles and routes. ● Amobility is perceived as first movers in terms of operation of autonomous vehicles and has a strong political network. ● On-demand testing on test track. ● In vehicle services with camera and sensor technologies. ● Proactive, nimble, change ready spirit. ● Problem solving and focus on solutions. ● Good relations to partners and stakeholders.	● Immature technology and expectations. ● Slow development pace, given regulations and laws. ● Low speeds challenge the business case.
Opportunities	**Threats**
● Unique global position as operator of autonomous solutions in the Nordics and the Baltic countries. ● In position to own agendas and frame the debate. ● Authority from pilot experience in real traffic with real passengers. ● The Mobility Cloud can change the perception of public transport, positively - in the future when all the components are fully developed. ● An increase in number of users. ● First movers in on-demand testing and dynamic routing within the Nordic countries.	● Competitors winning end users' loyalty. ● Critical incidents in pilots could damage trustworthiness of the brand Amobility. ● Slowly developed laws and regulations could limit our operations, hence the development of Amobility. ● Immature legal framework develops slowly and does not match the speed of technological development. ● The technology is not matured enough. ● The technology is not robust enough. ● The temporary law is alternated in such a way that it obstructs the possibility to operate or it is drawn back. The law is being revised this year.

Table 37: SWOT analysis use cases 2&3 Slagelse

5.2 Annexes Sales-Lentz Autocars

5.2.1 Use cases and roadmap

5.2.1.1 Pfaffenthal

	Use case 1	Use case 2	Use case 3
Time	Q4 2018 – Q2 2019	Q2 2019 – Q4 2021	Q2 2019 – Q4 2021
Description/ Objective	Implementing an autonomous shuttle system on a fixed route with pre-established schedules and fixed stops	Providing a service during weekends	Implementing a new stop and a new optimized route
Approved?	Yes	Yes	Ongoing
Safety operator?	Yes	Yes	TBD
Route	Fixed route, station-based	Fixed route, station-based	Fixed route, station-based
Vehicles	2 Navya Autonom minibuses	2 Navya Autonom minibuses	2 Navya Autonom minibuses
Booking	None	None	None
Vehicle speed	20 km/h	20 km/h	> 25 km/h*
Operation times	Mo-Fr 07:00 – 21:00	Tu,Th: 12:00 – 16:00 &16:45 – 20:00 Sa,Su, bank holidays: 10:00 – 21:00	TBD
Shared rides / Individual rides	Shared	Shared	Shared

Table 38: Use cases and roadmap Pfaffenthal

5.2.1.2 Contern

	Use case 1	Use case 2	Use case 3	Use case 4
Time	Q4 2018	Q4 2019	Q4 2021	Q1 2022
Description/ Objective	Implementing an autonomous shuttle system on a fixed route	Implementing a new and far longer route	Implementing an on-call system during the whole day, and adding	Implementing a dynamic route system and remove the

	with pre-established schedules and fixed stops		more shuttles to the fleet	operator if possible
Safety operator?	Yes	Yes	Yes	TBD
Route	Fixed route, station-based	Fixed route, station-based	Fixed route, on call	Dynamic or fixed route on call
Vehicles	1 Navya Autonom Minibus	1 Navya Autonom Minibus	1 Navya Autonom Minibus	TBD
Booking	None	None	TBD	TBD
Vehicle speed	20 km/h	20 km/h	20 km/h	> 20 km/h*
Operation times	Mo-Fr: 07:00 – 09:00, 16:00 – 19:00	Mo-Fr: 07:00 – 09:00, 16:00 – 19:00	TBD	TBD
Shared rides / Individual rides	Shared	Shared	Shared	Shared

Table 39: Use cases and roadmap Contern

5.2.1.3 Esch-sur-Alzette

	Use case 1	Use case 2	Use case 3
Time	Q2/Q3 2021	Q4 2021	Q1 2022
Description/ Objective	Implementing an autonomous shuttle system on a fixed route with pre-established schedules and fixed stops for the whole day	Testing without Safety driver and 5G support but also launching a night service	Deploying more automated minibuses from various manufacturers
Safety operator?	Yes	TBD	TBD
Route	Fixed route, station-based	On-demand, dynamic routing, station-based	Launch an door-to-door service (TBD).

Vehicles	1 Navya Autonom Minibus	1 Navya Autonom Minibus	TBD
Booking	None	Yes	Yes
Vehicle speed	20 km/h	20 km/h	> 20 km/h*
Operation times	Mo-Fr: 07:00 – 09:00, 16:00 – 19:00	TBD	TBD
Shared rides / Individual rides	Shared	Shared	Shared

Table 40: Use cases and roadmap Esch-sur-Alzette

* Speeds higher than 20km/h are there considered realistic by the AVENUE team. This type of speeds has indeed already been achieved within the project (peaks at 23km/h). This represents less and less danger as the balance between a too powerful braking that expose the vehicle occupants but allows high speeds without endangering pedestrians and longer braking distances that reduce the maximum possible speed without putting pedestrians at risk is becoming more and more refined (AVENUE teams are actively working to support this effort). This combined with technological advances such as the improvement of recognition capabilities and the range of LIDARs will soon allow considering even higher speeds (see chapter 1.2.2 for more details).

As a public transport provider, Sales-Lentz Autocars does not want to offer the possibility of booking private rides on any of the sites; booking shall always be for pooled rides.
The focus throughout the whole project lies for SLA in passenger and operation safety. Next comes the service quality provided, followed by business development needs.

Technical requirements for all sites:

- Garage for parking the automated minibuses outside of the operational hours
- Mobile application for passenger information system
- Mobile application with the possibility to book the minibus (use cases 3&4 Contern)
- TRAPEZE Connection (Pfaffenthal)
- INIT Connection (Contern)

5.2.2 SWOT analysis Pfaffenthal

5.2.2.1 Use case 1 (Pfaffenthal)

Strengths	Weaknesses
• A lot of pedestrian traffic between the planned stations, so there is a high chance that pedestrians will switch to the automated minibus, especially during winter because of bad weather.	• Difficulties to find a garage to store and charge the minibus during the night. • The great amount of pedestrian traffic could easily block operations of the automated minibus if the infrastructure is not properly designed to control this flow. • Minibus speed is max. 15 km/h, speed limit on the

	road is 30 km/h, the minibus could slow down the traffic which can lead to traffic jams and create frustration and anger amongst other car drivers.
Opportunities	**Threats**
• Collecting important data from implementing an AV into real traffic with very different other road users (cars, cyclists, pedestrians, trucks, busses, etc.). • No other mobility solution available here. • Very dynamic environment for Pfaffenthal with very different and constantly changing user profiles. If the pilot is successful, it will give SLA an edge in the market and will also feed more simple contexts of operations for SLA and others. • The presence of a retirement home near the minibus route. The minibus could be a mobility solution for its inhabitants.	• Construction works on the road, construction work traffic signs, construction vehicles parking on the automated minibuses' road etc. which will be seen as obstacles for the minibuses and will cause them to brake or stop. • High traffic density in the morning and evening peak hours.

Table 41: SWOT analysis use case 1 Pfaffenthal

5.2.2.2 Use case 2 (Pfaffenthal)

Strengths	**Weaknesses**
• The minibus is not driving anymore in the morning peak hours when the traffic is very dense and hectic. This could lead to a smoother operation because the automated minibuses encounter fewer other vehicles on the road. Furthermore, the automated minibus will not slow down the traffic during the morning peak hours.	• No mobility solution available in the busy morning peak hours for people that are commuting to work.
Opportunities	**Threats**
• The automated minibus is now driving during the weekends and on all bank holidays when a lot of people are in Luxembourg City. Passenger volume will rise.	• Loss of passengers that used the automated minibus in the morning peak hours to commute to work.

Table 42: SWOT analysis use case 2 Pfaffenthal

5.2.2.3 Use case 3 (Pfaffenthal)

Strengths	**Weaknesses**
• Simplified route, no need of complex turning maneuvers.	• Automated minibus will have to cross a cycling path so it will encounter a lot of cyclists who will pass/overtake the minibus. This could have a negative impact on the operation of the

	minibuses.
Opportunities	**Threats**
• Adding another stop in a residential area and thus offering a mobility solution to more people.	• Safety operator will get bored driving in a loop all day long.

Table 43: SWOT analysis use case 3 Pfaffenthal

5.2.3 SWOT analysis Contern

5.2.3.1 Use case 1 (Contern)

Strengths	**Weaknesses**
• Little traffic.	• Currently few potential clients: few people are currently using the train to get to Contern because there is no connection between the train station and the work place. A weakness could be that it needs a few weeks/months until people get aware that there is now a connection from the train station to their work place. It could be that in the beginning of the automated minibus service, the minibus will not be much used.
Opportunities	**Threats**
• No public transport is available on the last mile to get from the train station to the working place, opportunity to fill this gap by the automated minibus service.	• Speed limit on the minibuses route is 50 km/h. The automated minibuses are driving max. 18 km/h. The high difference of speed between the automated minibus and the other traffic participants could be a safety issue and could lead to an aggressive behavior from other users.

Table 44: SWOT analysis use case 1 Contern

5.2.3.2 Use case 2 (Contern)

Strengths	**Weaknesses**
• People know the automated minibus already and acceptance is already there.	• The new route is far longer than in use case 1. Travel time will be much longer.
Opportunities	**Threats**
• Possibility to connect more companies to the train station because the new route is passing along more companies.	• If more stops are implemented the travel time will rise even more. User acceptance could drop because automated minibus takes too long to go from A to B.

Table 45: SWOT analysis use case 2 Contern

5.2.3.3 Use case 3 (Contern)

Strengths	Weaknesses
• Automated minibus will be used during the whole day and not only during the morning and afternoon peak hours.	• Maybe 1 automated minibus is not sufficient to answer the demand. An estimation on the demand is difficult to make at this moment.
Opportunities	**Threats**
• Possibility to deploy more automated minibuses if the demand is there.	• User acceptance not there because of the automated minibuses' low speed.

Table 46: SWOT analysis use case 3 Contern

5.2.3.4 Use case 4 (Contern)

Strengths	Weaknesses
• Automated minibus is accepted by the users who know the minibuses from the previous use cases where the minibus drove on a fixed schedule. Users are ready to test on-demand service without a fixed schedule.	• TBD.
Opportunities	**Threats**
• The automated minibuses are only driving when there is a real demand and aren't driving empty.	• Technology not ready for on-demand trials. Users need a possibility to call the automated minibus.

Table 47: SWOT analysis use case 4 Contern

5.2.4 SWOT analysis Esch-sur-Alzette

5.2.4.1 Use case 1 (Esch-sur-Alzette)

Strengths	Weaknesses
• Little traffic. • Increase safety. • Automated minibus will be used during the whole day and not only during the morning and afternoon peak hours.	• A lot of pedestrians will walk in front of the automated minibus. This could have a negative impact on the operation and the speed of the automated minibuses. • In the morning the delivery vehicles are accepted on the automated minibus route.
Opportunities	**Threats**
• Adding new stops and a new service in a pedestrian area.	• Acceptance of an automated minibuses in a pedestrian zone. • Safety operator will get bored driving this path all day long.

Table 48: SWOT analysis use case 1 Esch-sur-Alzette

5.2.4.2 Use case 2 (Esch-sur-Alzette)

Strengths	Weaknesses
• Increase safety.	• Maybe the number of automated minibuses is not sufficient to answer the demand. An estimation of the demand will have to be done.
Opportunities	**Threats**
• Possibility to deploy more automated minibuses if the demand is there. • Test without Safety operator. • Test 5G. • Launch a "Night Rider" service.	• User acceptance not there because of the automated minibuses' low speed. • If more stops are implemented the travel time will rise even more. User acceptance could drop because automated minibus takes too long to go from A to B. • Automated minibus speed is max. 15 km/h, speed limit on the road is 30 km/h, the automated minibus could slow down the other traffic and create frustration amongst other car drivers

Table 49: SWOT analysis use case 2 Esch-sur-Alzette

5.2.4.3 Use case 3 (Esch-sur-Alzette)

Strengths	Weaknesses
• Possibility to deploy more automated minibuses from various manufacturers.	• TBD.
Opportunities	**Threats**
• Launch a door-to-door service (TBD).	• User acceptance not there because of the automated minibuses' low speed

Table 50: SWOT analysis use case 3 Esch-sur-Alzette

5.2.5 Evaluation plans for the use cases

For the evaluation method, SLA would like to focus on user studies (qualitative survey with in-depth interviews). This is preferred over a focus group, because it is expected to be easier to execute and less time consuming than a focus group. In addition, more people can participate. Sales-Lentz Autocars expects around 500 participants in Pfaffenthal, and between 200 and 300 participants in Contern.

Key Performance Indicators for Sales-Lentz Autocars to determine the success of the pilots are the following (non-exhaustive list). These KPIs are inspired by the list of indicators described in chapter 3.2.1, but are more specifically established on the basis of SLA internal discussions and reflections, to meet the needs related to the context and the specificities of the project; this list is then specific to this context:

- Results of the user study
- Total number of passengers transported
- Feedback from Safety operators
- Feedback from other traffic participants

In order to evaluate the demonstration of the different use cases, SLA would like to collect the following data during use cases 1-4 in Pfaffenthal and Contern (exhaustive list):

- Acceptance and reactions from passengers, local residents and the Safety operator
- Integration of the automated minibus into real traffic, reactions from other traffic
- Reliability of the automated software (% of time in automated/ manual mode)
- Reliability of the NAVYA Minibus (hardware)
- Uptime/ downtime of service (if the vehicle is supposed to run 12 hours non-stop, how many minutes was the vehicle a) driving b) waiting c) stopped d) broke down, etc.
- Impact of weather conditions on the automated minibus software and hardware
- Minibus punctuality
- % of manual mode per distance and not per time
- Total number of passengers
- Safety operators' feedback on operation of the automated minibus

Esch-sur-Alzette: TBD