AVENUE

Autonomous Vehicles to Evolve to a New Urban Experience

D2.16 A report on use case definition per Demonstrator city

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Index

1 Executive Summary

Deliverable D2.16, A report on use case definition per Demonstrator city, consists of two main parts: the demonstrator roadmaps that details the action plan and roadmap for each of the four demonstration sites of the AVENUE project (Copenhagen, Geneva, Luxembourg, and Lyon) and the evaluation plan of the overall AVENUE services, technologies, and functionalities.

The **demonstrator roadmaps** contain a baseline description of autonomous shuttles running under the supervision of the transport operators and compares 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 and 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 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 autonomous 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 will take place during Phase four (M12-M48) and WP8. The economic analysis of the used autonomous 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.

2 Introduction

The target of the AVENUE project is to demonstrate and pilot the adaptability and efficiency of the deployment of small and medium autonomous vehicles (AV's) in Lyon, Luxembourg, Geneva, Copenhagen and 2-3 replicator cities as of the 3d year of the project. The AVENUE vision for future public transport in urban and suburban areas, is that autonomous vehicles will ensure safe, rapid, economic, sustainable[1] and personalized transport of passengers, while minimizing vehicle changes. The goal is to provide door to door autonomous transport allowing commuters to benefit from autonomous vehicles.

At the end of the AVENUE project - 4-year period - the mission is to have demonstrated that autonomous vehicles will become the future solution for public transport. The AVENUE project will demonstrate the economic, environmental and social potential of autonomous vehicles - for both companies and public commuters - while assessing the vehicle road behavior safety.

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 contacted.

Task 2.5 "Demonstrator use case definition" target is to, on the one hand, develop the use case scenarios and, on the other hand, to enrich the provisional list of AVENUE services, selecting at least 10 services for demonstration. Part of the work in task feeds into deliverables 2.13-2.15, while the work of T2.5 that feeds into this deliverable focuses on the demonstrator roadmaps.

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 autonomous 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) 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 success level of the respective action plan for large scale demonstration. 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 business development needs. All technical functionalities (hardware and

[1] Within urban transportation sustainable most often refers to electric vehicles.

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. This task contributes to deliverable of D2.5 and D2.6.

3 Demonstrator roadmaps

3.1 Action plan and roadmap Copenhagen

3.1.1 Baseline description

Autonomous Mobility has currently two autonomous shuttle pilot projects running, one in Gothenburg, Sweden, and one in the Køge Hospital in Denmark.

Gothenburg (Sweden) 2018-2019

The pilot project in Gothenburg 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
- Passengers: students, university employees and local commuters. Total passengers: app. 1100.
- Operating hours: Monday-Friday 8-16
- With an operator on board (required by Swedish law)

The second phase of the pilot project starts in October 2018 and takes place in Lindholmen, a harbor area for the duration of 6 months. It will be a fixed route with fixed stops at first - later in the second phase AM is considering trying on-demand stops options on the fixed route.[2]

Learnings: Driving in mixed traffic provides many learnings regarding how the other road users act, and what obstacles and challenges that occur due to this. How much interference with the service arises when a cyclist or a car overtake the shuttle. 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 operator's functions were obtained.

Køge Hospital (Denmark) 2018-2019

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. The next two phases will take place in 2019. Details:

- Vehicle: 1 Navya Autonom Shuttle
- Route: Fixed route and fixed stops
- Passengers: patients, relatives and hospital staff. Total passengers: > 6500.

[2] Please note that changes can occur to the project.

- Operating hours: Monday-Friday 7:30-15:30
- With an operator on board
- Services: In the non-peak hours on-demand stops on the fixed route was tested, based on the fixed bus stops. The visitor could order the bus through the screen at the bus stop sign post, and then the bus would come to pick them up without stopping at the other stops unless others had made a demand.

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 type of users is able to interact with the service. Furthermore, many technical details regarding operation and the operator's functions were obtained.

3.1.2 Vision, needs, and goals

Vision

The city of Copenhagen has an overall goal to become the World's first CO2-neural capital by 2025. Autonomous Mobility (AM) and the AVENUE project will support this goal by implementing and operating autonomous electric shuttles in Copenhagen as a green initiative to last mile public transport.

The overall goal for AM is to implement and test services under the Autonomous Mobility Cloud on the Copenhagen site. In order to do so, AM aims at deploying at least four vehicles over a period of four years, while working towards expanding the route to multiple routes in the Nordhavn area. These routes will create a better connection between selected areas of Copenhagen and existing public transport solutions.

During the AVENUE project, AM 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 existing PTO solutions in the Copenhagen area.

Our services should be experienced as “Helpful, Simple & Seamless”: When autonomous vehicles become an integrated part of the cityscape, the user will be able to define your transport needs - and order your solution via AM’s Autonomous Mobility 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, parcels, shops - all in various shapes and sizes - around when needed.

At the end of this project, AM aims to have:

- Developed and implemented autonomous mobility cloud in Nordhavn,
- In an on-demand (door2door) autonomous transport system without fixed routes, and
- With the whole zone mapped & geo-fenced.

Needs

By deploying autonomous shuttles in Nordhavn we address the following needs:

- Transport solution for the Nordhavn area: in the area and connecting to existing public transport hubs.
- Lowering the CO2 emissions for the Nordhavn area
- Lowering the number of vehicles used in the Nordhavn area

Corresponding goals

- Provide AV services that was actually needed.
- Demonstrate that AVs are safe, sustainable, economic and can provide personalized transport.
- Test a fleet operation with multiple AVs, on-demand in mapped area, off route, with a speed up to 50km/h, in mixed traffic, without safety drivers on board.
- 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 autonomous shared transport in Nordhavn and lower the number of vehicles.

3.1.3 The pilot site: Nordhavn (2019-2022)

The Copenhagen test site will be 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 needs 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 autonomous vehicles to function as a new public transport solution, connecting the area much better than it is today. In 2020 two new metro stations will have been built – opening in the middle of the neighborhood.

The main expected users of the shuttle 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.

3.1.4 Use cases and roadmap

Autonomous Mobility will set up its AVENUE pilot project in the Nordhavn area of Copenhagen. Initially, the project will consist of one route, with other potential routes and route options being added throughout the project (if approved by the authorities). A plan of the first route can be found in annex 5.1[3]. The operation of the first route will start in the beginning of 2019, once it has been approved by authorities. The pilot route is going to be in mixed traffic with cars, pedestrians, bicycles etc. The area is in general a low speed area. Since the route is under approval the map of the route and stops is confidential and subject to change.

Planned services provided for the end users:

- The shuttles 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, but no real-time position in minutes available yet.
- Besides the bus stop sign, users can find information about the pilot project at AM website.
- 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 (at the moment it is unclear whether or not we will be allowed to accommodate wheelchairs).

	Use case 1	Use case 2	Use case 3	Use case 4	Use case 5
Time	Q1-Q3 2019	Q4 2019	Q1-Q3 2020	Q4 2020 – Q2 2021	As of Q3 2021
Approved?	Ongoing	Not yet	Not yet	Not yet	Not yet
Safety driver?	Yes	Yes	Yes	No[4]	No
Route	Fixed-route, timetable or	Fixed route, on call stops, on-	Fixed route service, on-	Geo-fenced area with	Multiple types of shuttles,

[3] This information is confidential and can therefore be found in the annex only (annex is confidential).

[4] Safety drivers will be slowly removed from the shuttle. They will stay present on-site in an on-site office, always in max. 5 min reach from the shuttle.

	headway based, metro mode, loop line with multiple fixed stops, mixed traffic	demand trials, loop with multiple fixed stops	demand, introduction of new routes and dynamic routing on these routes,	multiple mapped routes, dynamic routing, coordinate-based, testing of mobility cloud service D2D	dynamic routing, coordinate-based, further testing of mobility cloud (D2D) service, live mapping process[5]
Booking	None	Instant booking	Instant booking and pre-booking		
Vehicles[6]	2-4 shuttles adjusting to demand			Introduction of new types of AVs[7]	
Vehicle speed	20-50 km/h speed limit in the area. AV will drive at max. 23 km/h (expected 10-15 km/h)		20-50 km/h speed limit routes; AV at max. 23/30 km/h; expected 10-30 km/h	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 shuttles will run Mon-Fri. Exact timetable TBA.				

For all use cases:

The focus throughout the whole project lies for AM 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 and second use case.[8] No SWOT analysis can be prepared yet for the use cases 3-5 since many things might change until those use cases are started.

3.1.4.1 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 sign posts • AM webpage	An app or another solution to make the on-demand requests	Fleet management system	AM's Mobility Cloud

Table 1: Use cases and their specifications

[5] If technology and regulations allow for that
[6] Until use case 4 (incl.) only Navya Autonom Shuttles
[7] Allowing the vehicle to drive into new streets. If technology and regulations allow for that.
[8] This information is confidential and can therefore be found in the annex only (annex is confidential).

3.1.4.2 Objectives and milestones per use case

	Objectives	Milestones
Use case 0 (05/18 - 02/19)	• 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	Fixed route, loop line, fixed stops, in mixed traffic.	<u>For use cases 1-5:</u> • Input from user surveys to be analyzed and implemented. • Input from safety driver to be analyzed and implemented.
Use case 2	The shuttles are expected to run on demand trials - on fixed route.	• On-demand on fixed route in non-peak hours.
Use case 3	more AV's are introduced (up to 4 shuttles) will be operational on demand - off routes, with safety driver on board, and increased speed. The plan is to get approval to introduce new routes.	• More AVs are introduced. • Increase in speed. • Mapping of streets that shorten the route, to allow for shortcuts/ a network. • 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 drivers on board. Plan to have a geo-fenced area mapped - and have permission to drive here.	• On-demand on mapped routes will be tested. • Slowly removing safety drivers on board towards safety drivers being present in an on-site office, 5 min from shuttle.
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 allows 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	• Operation in geo-fenced area, on-demand within mapped area, increased speed. • More types of AVs will be introduced if approvals and legislation allows to.

	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.

3.1.5 Evaluation plans for the use cases

Autonomous Mobility does not yet work with a local company on evaluating the AV shuttles. 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 to the evaluation).

Key Performance Indicators for AM to determine the success of the pilot are the following (non-exhaustive list):

- Passenger satisfaction (use cases 1-5)
- Number of passengers (use cases 1-5)
- Number of trips/km done by the shuttle (use cases 1-5)
- Punctuality of the shuttle (use cases 1-5)
- Uptime of the shuttle (use cases 2-5)
- App downloads/ on-demand system usage (use cases 2-3)
- Uptime of the fleet management system (use cases 4-5)
- Uptime mobility cloud (use case 5)

In order to evaluate the demonstration of the different use cases, AM 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 sub categories e.g. hard resets, times manual overtake, time in autonomous 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 driver 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)
- User experience and acceptance of the Mobility Cloud (use case 5)

3.1.6 Integrations and special needs

Integrations needed

Autonomous Mobility is already evaluating an integration with existing PTOs in Denmark, particularly a traveler application called Rejseplanen that allows to look for connections throughout different PTOs. Additionally, a new metro station is currently being built in the area, which is connected with a pedestrian underground tunnel to the nearby train station, scheduled to open in early 2020. This could be an interesting integration use case.

Special needs

Autonomous Mobility is interested to test all services that are being discussed in the framework of WP2 and developed in WP4 (see in particular D.2.13 First Definition of AVENUE services). In particular, they would like to ensure to provide a possibility to accommodate all types of passengers, including for example passengers with reduced mobility. Furthermore, they are interested to test on-demand if technically possible and approved by the authorities.

3.2 Action plan and roadmap Geneva

3.2.1 Baseline description

TPG has currently already one autonomous project set up in the canton of Geneva. Since 02 July 2018, one Navya Autonom Shuttle is running on an urban route in the neighborhood of Meyrin. The "Line XA" connects Meyrin train station with Meyrin village, and provides a transport solution for residents in a zone that is not served today by standard bus lines. The shuttle runs 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 have been predefined for the shuttle and many obstacles increase the complexity of the use case. The track is therefore very difficult and represents a real world urban driving test. The shuttle runs from Monday until Saturday during 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 are transported with the shuttle each day. A pool of 12 operators (safety drivers) takes turns in the shuttle, under supervision of two "super operators".

More information (in French): http://www.tpg.ch/vehicule-autonome-aux-tpg

3.2.2 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 busses, 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 busses with a driver isn't cost effective.

In fact, it would be good to replace one large bus with four autonomous shuttles and to have the former bus driver oversee all four shuttles 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 shuttle.

Another important argument to move towards autonomous, electric shuttles are the objectives of 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 autonomous robotized small-scale transport network

3.2.3 The pilot site

In order to deploy a fleet of autonomous Shuttles as part of the Avenue project, an agreement has been reached with the Belle-Idée site in Thonex, 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, between 2 and 4 vehicles will be running on the site, on a network of routes with around 10-35 stops. The picture below provides a first idea of possible routes.

Figure 1: Network of possible routes at the Belle-Idée site in Geneva

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
- Building to building

3.2.4 Use cases and roadmap

TPG will set up its AVENUE pilot project in the zone of the Belle-Idée hospital in Thonex. Currently, TPG is submitting the project with an ambitious use case foreseen for the end of the project for confirmation to the authorities with the intention, to already have the authorization for the most complicated use case from the start, allowing to move forward towards that use case as soon as feasible by the project partners.

Throughout 2018 and 2019, TPG is focusing its efforts on homologating the area of Belle-Idéé. Thereby the intention is to homologate a zone instead of a line, as well as three shuttles. The authorization process will take several months so that no service on the site will be possible before Q3 2019.

	Use case 1	Use case 2	Use case 3
Time	Q3 2019-2021	2019-2022	2022
Objective	Offer an “on demand” service with an operator inside every vehicle	Gradually introduce process automation to control, measure and manage	Deploy three/four fully autonomous driverless Shuttles, with an operator nearby
Safety driver?	Yes	Yes/No	No
Route	*Tbd: move as quickly as possible to full on-demand on the site.*	Dynamic route, predefined Shuttle stop based	

[9] Lists inconclusive

Booking	*Instant booking and pre-booking asap.*	Instant booking and pre-booking
Individual rides?	For specific patients, a “VIP reservation” would be interesting to have.	
Operation times	06:00 – 22:00 (tbc) with expected peak hours at 12:00-13:00 and 18:00 – 20:00	08:00-20:00 on-demand
Technical requirements	- Platform for disabled people - Possibility to order a Shuttle via a device/pole/button/screen at stop	

Increasing the speed of the AV is of less importance for TPG on this site. Safety is of utmost importance and development of object identification needs to be 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 autonomous vehicles completely depends on the user experience. Business development needs are of less importance than the former too.

3.2.4.1 SWOT analysis for this use case

Strengths	Weaknesses
• Real life use case. When successful definitely to be copied.	• No choice of Shuttle 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 shuttle in specific areas. • Safety-related: challenge for the shuttle provider to ensure safe behavior without predefined lanes. • Safety related: development of road behavior Shuttle: positioning, braking, acceleration/deceleration etc. • Safety related: stationary and moving object identification (not detection)

3.2.5 Evaluation plans for the use cases

TPG does not yet work with a local company on evaluating the AV shuttles. 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 to the evaluation).

Key Performance Indicators for TPG to determine the success of the pilot are the following (non-exhaustive list):

- Do the results match the objectives defined?
- Is TPG able to deliver the kind of services they had in mind?
- User experience

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
- Number of emergency stops/decelerations per 1000 km
- Minimum accepted gap at intersections or in lane changes
- Mean and maximum longitudinal acceleration and deceleration
- 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 autonomous to manual driving at the vehicles' request per 1000km
- Number of Incidents where the car must operate in safe mode
- Number of mechanical/sensor failures per 1000 km
- Down time frequency for mechanical servicing/cleaning
- Cost-per-vehicle-kilometer
- Operating efficiency
- Rider comfort
- Reliability
- Affordability
- Integration
- Satisfaction

3.2.6 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 a hospital, passengers with special needs will certainly be included in the use case definitions, such as passengers with reduced mobility.

3.3 Action plan and roadmap Luxembourg

3.3.1 Baseline description

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

3.3.2 Vision, needs, and goals

Vision

The vision for Sales-Lentz in the framework of the AVENUE project is to have set up an on-demand service with autonomous vehicles running in level 5 and with a speed of around 45 km/h by the end of the project.

With regards to the transport network, the objective is to fill the gap by providing a public transport service in areas where there is currently a lack of public transport, such as in the city center, connecting the valleys of Luxembourg city, and connecting different transport hubs.

Needs

- First & last mile transportation
- Providing local mobility solutions for low passenger volumes
- Offering public transportation in areas where no public transport is available at the moment

Corresponding goals

- Operating the autonomous shuttle with a safety operator between two points on an open road without passengers on a trial basis
- Operating the autonomous shuttle with a safety operator between two points on an open road with passengers
- Operating the autonomous shuttle fully autonomous without a safety operator
- Fully autonomous on-demand service

3.3.3 The pilot site

Since September 2018, Sales-Lentz is running 3 autonomous shuttles on two sites:

- Pfaffenthal, a valley in the city of Luxembourg, where two shuttles run on a short track connecting the train and funicular station of Pfaffenthal with the panoramic lift in Pfaffenthal that goes up to the city of Luxembourg. Services on this line started on 20.09.2018.
- Contern, an industrial area located around 10km east of Luxembourg city, where one shuttle connects the train station of Contern-Sandweiler with “Campus Contern”, a real estate development company. Services on this line started on 19.09.2018.

Both pilot sites will be described in more detail here below. Please note that the services as described apply to the beginning of the project, but can change throughout the project. It is also possible that the services will not be maintained on both sites throughout the whole project duration, and efforts might rather focus on one site.

Contern

One NAVYA Autonom Shuttle is running on the site of Contern between two stations: the new train station, and the Campus Contern. First, passengers will have to walk 300m from the train station to the shuttle stop. An extension of the route to the train station is planned for 11/2018. The depot and charging station for the shuttle will be close to the Campus Contern, see map below.

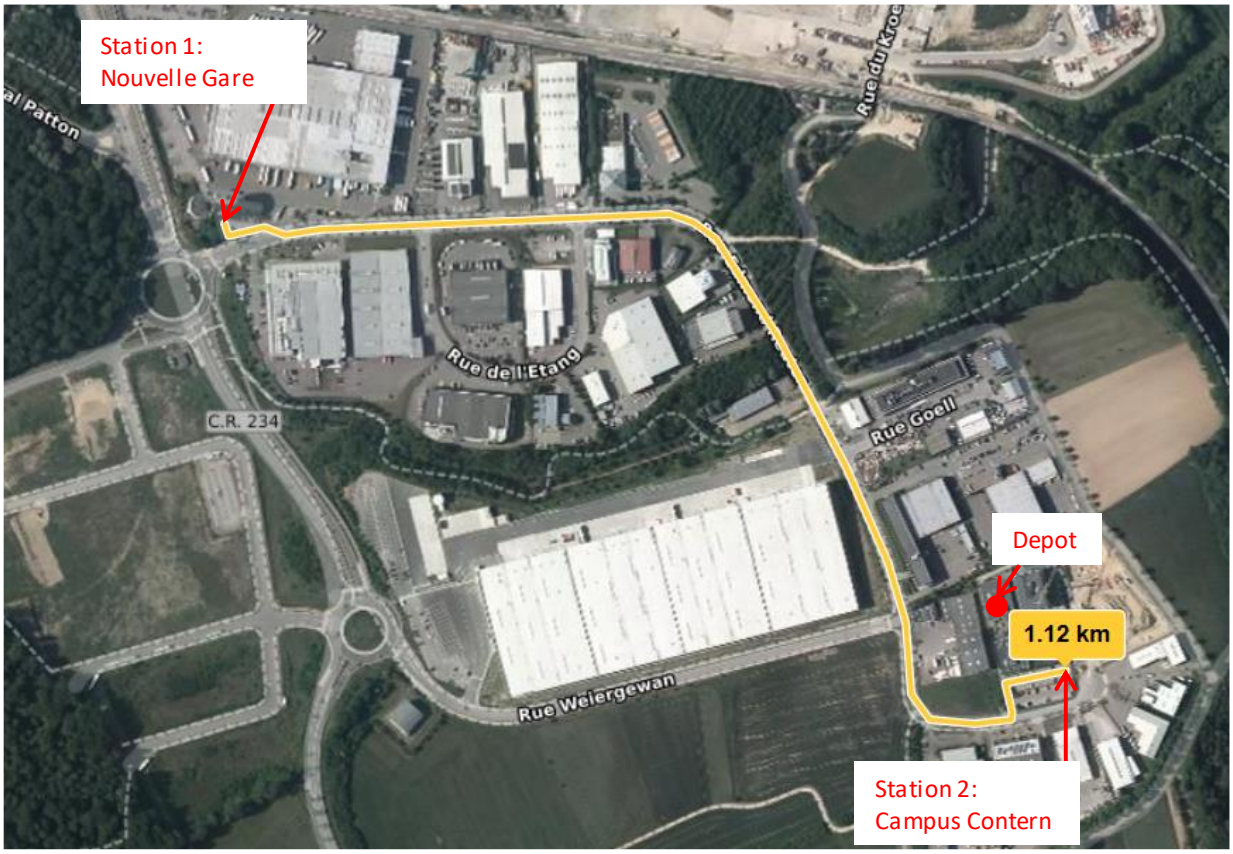


Figure 2: Map of the pilot site in Contern

The expected main users are employees working at Campus Contern and the companies nearby commuting by public transport. Consequently, the main expected usage scenarios are commuters arriving to Contern in the morning or leaving the area in the evening via the train station to get to and from work.

Pfaffenthal

Two NAVYA Autonom Shuttles 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 two stops and three stations and the depot and charging station for the shuttles are close to the station at the Pfaffenthal lift, see map below.

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 shuttle manufacturer to increase the maximum shuttle 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 we could park the shuttle during the night. The depot is especially important during winter conditions.

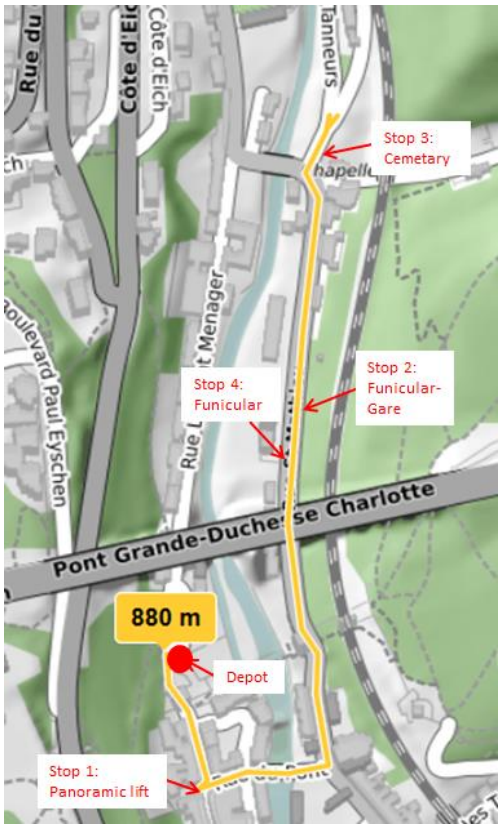


Figure 3: Map of the pilot site in Pfaffenthal

Different kind of user groups are expected for this pilot site: Commuters going to and coming from work, tourists, local residents, passers-by, etc. The main usage scenarios envisaged are:

Commuters:	1) Commuters arrive at the train station and take then the shuttle to get to the lift to reach the city center, where bus connections are available. 2) Commuters take the shuttle to get to the funicular station to get to Kirchberg, where bus and tram connections are available.
Tourists:	Going from the old town to Kirchberg or other way round
Local residents:	Taking the shuttle to get to the lift to reach the city center or reaching the funicular station to get to Kirchberg

3.3.4 Use cases and roadmap

	Contern: Use case 1	Contern: Use case X	Pfaffenthal: Use case 1	Pfaffenthal: Use case X
Time	19/09/2018 – 31/12/2018	TBD	20/09/2018 – 31/03/2019 (possibly extended for 6m)	TBD
Safety driver?	Yes	Yes/No: to be removed slowly	Yes	Yes/No: to be removed slowly
Route	Fixed route,	1st extension of	Fixed route, fixed	Several

	fixed stations: first & last mile between Contern industrial zone to railway station, 1,12 km.	the route to the train station (early 11/2018), 2nd extension planned for summer 2019	stations	extensions possible, see 2.3.4.1.
Stops	Two stops, one at the start and one at the end of the route	Additional 3 or more stops are possible if the concerned companies contribute to costs of the line, and additional on extension.	Four stops	Depending on extensions
Vehicles	1 Navya Autonom Shuttle	TBD	2 Navya Autonom Shuttle	TBD
Booking	None	Instant and pre-booking	None	Instant and pre-booking
Vehicle speed	Public road with speed limit of 50 km/h, planned vehicle speed: 30 km/h. Currently the max. speed of the shuttle is 18 km/h.	Increase vehicle speed to 45 km/h on straight road	Public road with speed limit of 30 km/h, planned vehicle speed: 30 km/h. Currently the max. speed of the shuttle is 18 km/h.	Increase vehicle speed to 45 km/h on straight road
Operation times	07:00 - 09:00, 16:00 - 19:00		• Service hours: 07:00 - 21:00 • 1 vehicle on route and 1 charging • Connection to the trains that arrive every 10-15min	

As a public transport provider, Sales-Lentz 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 both sites:

- Training and technical equipment for the mechanics
- Access to a simulator software would be very helpful for the training of the operators

3.3.4.1 Pfaffenthal / Luxembourg-City: Possible line extensions

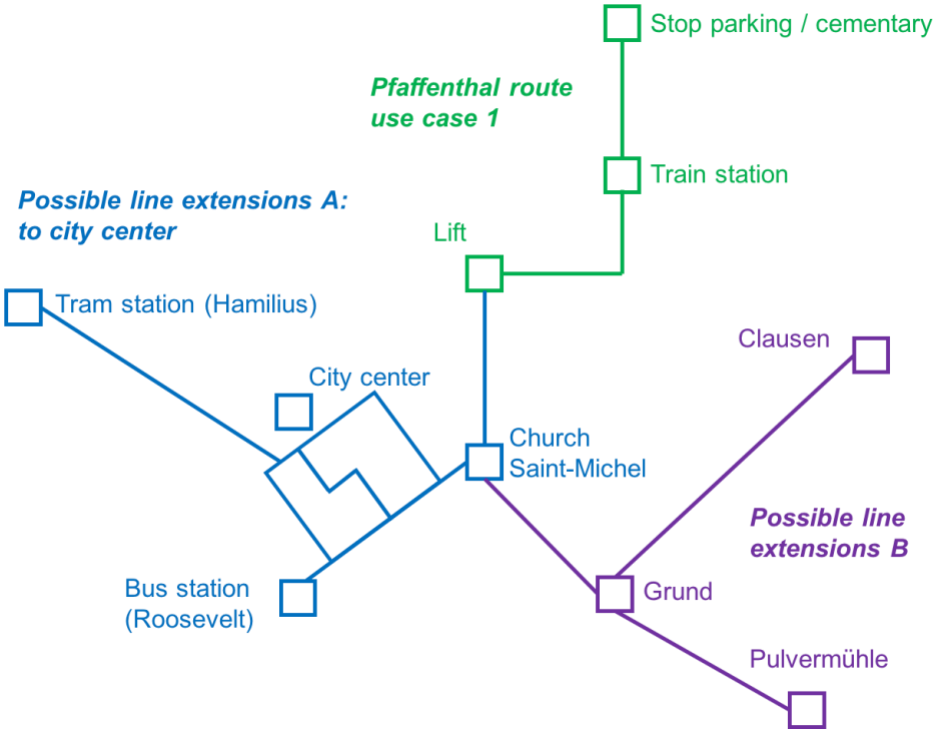


Figure 4: Possible line extensions of the shuttle service in Pfaffenthal city

Possible line extensions A:

- Extension until upper town & thus providing connection to the old town, until March 2019
- Extending to bus line 50
- Network with several route options through old town + connection to several transport hubs / mass transport

Possible line extensions B:

- Valley Grund
- Extension to other neighborhoods?

3.3.4.2 SWOT analysis for the use case in Contern

Strengths	Weaknesses
• Little traffic (except construction work 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 shuttle service, the shuttle 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 autonomous shuttle service.	• Construction works on the road, construction work traffic

3.3.4.3 SWOT analysis for the use case in Pfaffenthal

Strengths	**Weaknesses**
• A lot of pedestrian traffic between the planned stations, so there is a high chance that pedestrians will switch to the shuttle, Especially during winter because of bad weather.	• Difficult to find a garage to store and charge the shuttle during the night • The great amount of pedestrian traffic could easily block operations of the shuttle if the infrastructure is not properly designed to control this flow.
Opportunities	**Threats**
• Collecting data from implementing an AV into real traffic	• Safety of pedestrians since there is a lot of pedestrian traffic. • Reaction from road traffic • There is a lot of bike traffic in the morning and evening. Bikes are overtaking the shuttle that is operating at a speed of 18 km/h which can potentially lead to dangerous situations.

3.3.5 Evaluation plans for the use cases

Sales-Lentz does not yet work with a local company on evaluating the AV shuttles. 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. For the evaluation method, SLA would like to focus on user studies, with an expected participation of 100 (Contern) – 250 (Pfaffenthal) passengers per day. A user study (qualitative survey with in depth interviews)) 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.

Key Performance Indicators for Sales-Lentz to determine the success of the pilots are the following (non-exhaustive list):

- Passenger satisfaction
- Number of posts in social media

- Total number of passengers transported
- Total number of trips/km per day done by the shuttle
- Punctuality of the shuttle
- No breakdowns of the shuttle

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

- Incident reports from NAVYA regarding Safety Relevant Events and Safety Critical Events
- Acceptance and reactions from passengers, local residents and shuttle operators
- Feasibility of the integration of the autonomous shuttle into real traffic and how are the reactions from other traffic participants
- Reliability of the autonomous software (% of time in autonomous / manual mode)
- Reliability of the NAVYA Shuttle (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) broken down, etc.
- Impact of weather conditions on the autonomous shuttle software and hardware
- Counting total number of passengers in the shuttle per day

3.3.6 Integrations and special needs

Integration needs for both sites

- Integration with the train timetable: ensure that the AV waits for the connection with the train – this is currently done manually by the safety driver
- Integration with the traveler information system mobilité.lu to plan a trip, get suggestions and receive information about interruptions
- Integrate with Luxembourgish Public Transport System INIT, which integrates different transport means and is already set up in all busses that are operating RGTR and AVL public transport in Luxembourg (not just SLA busses). Services, that this integration should provide/automate, are for example
    - Telling the driver to wait for a traveler at night (currently done manually)
    - Alerting the shuttle of delay of train when it is at the train station, so that shuttle waits for the arrival of the train and doesn't leave before.
- Integration with RGTR: regional transport (INIT system)
- Integration with AVL: Luxembourg city public transport (ITCS)

Special needs

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

3.4 Action plan and roadmap Lyon

3.4.1 Baseline description

The Keolis Group runs various autonomous shuttle projects worldwide. Keolis is currently running one autonomous shuttle project in Lyon, called “NAVLY”. Navly consists of two Navya Autonom Shuttles that run on a fixed-route with fixed stations in the area of Confluence in Lyon, an old harbor area that has been revitalized 15 years ago and nowadays combines businesses, services, restaurants, event venues with a residential neighborhood.

The AVs are running from Monday to Friday, between 07’30 and 19’00. The service hours can be readapted during specific events: during the modern art biennial festival, the service took place from Monday to Saturday.

The Confluence/Navly pilot project started in September 2016. Since then, the two AVs ran around 26.000 km and were used by more than 35 000 passengers.

3.4.2 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 inhabitants and tourists.

Needs

We need to increase the mastery of AVs to offer regularity services. To be useful, AVs have to be at Décines Grand large station every 15 minutes during peak hours, and every 30 minutes during off-peak hours.

Corresponding goals

- Offer a regular service
- Fluid interaction between AVs and urban traffic
- Social acceptance of AVs
- Improve passenger information

3.4.3 The pilot site

The area around the Groupama Stadium is currently being intensely developed. In the next months and years, several professional buildings, restaurants, a hotel, a recreation center, and a medical center will be built. These different kind of activities are expected to cause small flow passengers all along the day, and AVs would help speed up traveler flows and prevent congestion at the bus station Décines Grand Large.

The new AV service in the area would transport people between the tram station Décines Grand Large and the Groupama Stadium, being complimentary to another bus line. At the beginning of the pilot project, two shuttles will run between two stops, one at the tram station and one at the stadium. In a later use case, a third stop could be added. The map below shows the route as foreseen and as submitted to the PTA. Please note that this maps shows just an indication of the expected track. The PTA (SYTRAL) is still working on the final decision.

Figure 5: Route in Lyon, connecting the tram with the Groupama Stadium

Usage of service

- Students, tourists, employees of the stadium and the area
- First and last mile solution between the mass transit system (T3 tram) and the stadium area

3.4.4 Use cases and roadmap

	Use case 1	Use case X
Time	Spring 2019 – TBD	TBD
Safety driver?	Yes	Slowly removing the operator from the shuttle[10]
Route	Fixed route, 2 fixed stops, metro mode. First and last mile solution between the	• Extension of route to OL training center, OL museum, hotels • Vehicles pass each other

[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.

	tram station Décines Grand Large (tram 3 & 5 buses) to the Olympique Lyonnais football stadium (Groupama Stadium); 2,5 km round trip	autonomously (without interference of the operator)
Objective	Avoid crossroads difficulties	• Increase the part on open road, with automatic inclusion on roundabout • Sensitize local community about AVs
Stops	2	3 (additional on-demand stop) or more
Booking	None	Booking foreseen via mobile app, form tbd by PTA
Vehicles	2 Navya Autonom Shuttles	2 or more
Vehicle speed	Increased AV speed to current speed	Increased AV speed
Operation times	• Monday to Saturday from 8:30 am to 8pm except during game day at the stadium. It might evolve regarding the evolutions of other modes of transport • Difference between peak and off-peak hours are still to be validated by the PTA	TBD
VIP service?	No	Yes
Technical requirements	• Increase commercial speed • Provide communication between AVs	TBD
Special services to passengers	No	Provide a dynamic and real-time information on connections

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

3.4.4.1 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	• The itinerary pass through a disadvantaged district, and we're waiting for incivility. We are already thinking about the organization of awareness event

Opportunities	Threats
• The itinerary can level up in keeping with the new area development	• The different pole of attraction of the new area are really different, and it's going to be hard to define rush hours and off-peak

3.4.5 Evaluation plans

Keolis does not yet work with a local company on evaluating the AV shuttles. 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.

Key Performance Indicators for Keolis to determine the success of the pilots are the following (non-exhaustive list):

- Be able to increase the part of itinerary run 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

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

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

3.4.6 Integrations and special needs

Integrations

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

Special needs

No special needs to be considered for this site.

4 Evaluation plan for services

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 with the task T2.2 Passenger needs (including 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 consistent with D2.5, i.e. following the human centered design process for interactive systems (ISO 9241-210) and ensures that all relevant stakeholders (including younger and older persons, their family and healthcare professionals) play an important role in the requirement and the evaluation phases and throughout the project. Emphasis must also be put on the cultural and organizational differences within the user group, 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.

4.1 Conceptual framework

Rather than focusing on absolute terms, the evaluation framework is built on a systematic comparison between two dimensions of a service - the user side and the service provider side – and aims at assessing each service in relative terms.

On the user side, we must understand that the objective experiment assessed by the user at one place and one moment (hic et nunc) is widely determined by representations of the situation which are largely influenced by previous experiments, individual mind set and values. Therefore, the evaluation has to integrate the users' expectations and perceptions in the process in order to measure the gap between the user's cognitive reception and tangible data.

On the provider side, service specifications aim at building a specific added value for users that 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 has to compare initial objectives given to a specific service and the actual performance, the effective performance as well as the perceived performance.

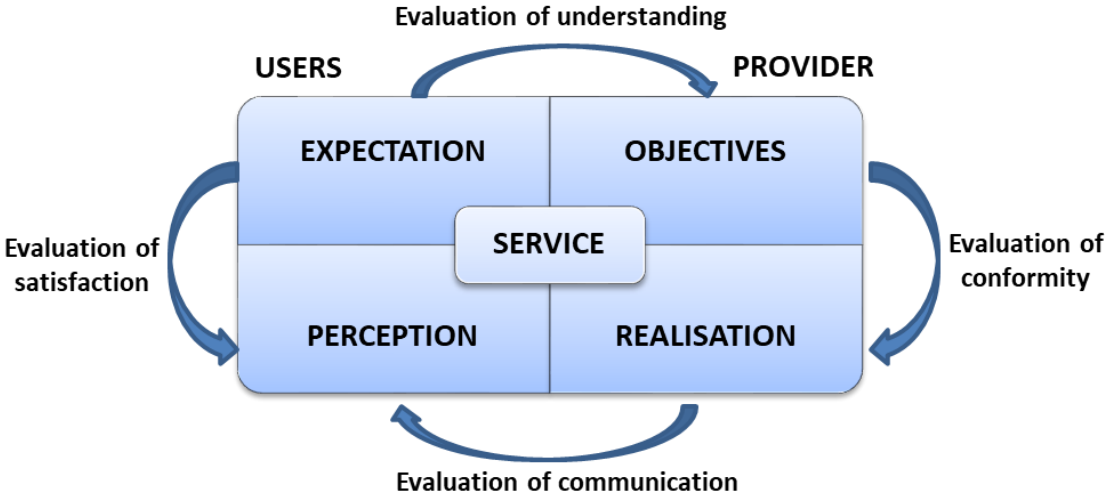


Figure 6: Aspects of evaluation

Evaluation has to measure:

- Understanding: to what extent did the provider understand users' expectations et succeed in specifying an adapted service
- Conformity: the difference between the objectives identified by the provider by KPIs and the realization either measured by sensors or appreciated by the users
- Satisfaction: to what extent do users estimate that the service is answering to their expectations
- Communication: to what extent do users perceive and understand the proposed service

4.1.1 Understanding assessment

The "users" is not just an abstract idea; they are living, breathing beings that move with all their "stuff". Understanding exactly who they are is imperative to propose relevant services.

To achieve this understanding, building detailed Personas and Journey Maps are the best way to identify exactly who the users are, what they need, and how they can engage with the autonomous shuttle.

Personas are fictionalized models the service provider create to represent users. They must be believable which means one must believe it, they must have names, personal backgrounds, and behavioral identifiers like motives, attitude, and negative trigger points.

Make personas pop with detailed characteristics:

- Demographics: age, location, education, income, household or family size
- Personal Histories: goals, needs, and interests when they interact with your company
- Expectations: How their needs differ from various avenues and touch points, and how those needs change over time

The understanding assessment is concretely linked with the Task T2.2 Passenger needs (including PRM) and requirements specification. In this task "emphasis must also be put on the cultural and organizational differences within the user group, 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.

The service provider will create its own personas and compare its characters with the personas proposed by Task 2.2. The gap's evaluation measures the level of understanding. If needed, discussion with T2.2 team will help reduce the gap.

4.1.2 Conformity assessment

The conformity assessment procedures must demonstrate that a service conforms to the essential requirements targeted by the specifications decided before it is placed into the market.

Conformity assessment must not be confused with market surveillance, which consists of controls after the product has been placed into the market.

Conformity assessment has to be performed by the service provider and registered for the whole duration of the AVENUE project.

The service provider ensures himself the conformity of the service to the project requirements (T2.2, D2.2) implementing following tasks for each service:

- Identification of the applicable requirements
- Translate the requirements in a set of KPIs adequate to the service
- Selection of all measures necessary so that the development process ensures compliance of the services with users' needs
- Implementation of detailed tests and controls consistent with the pre-identified KPIs
- Monitoring of the compliance of the service
- Reporting to the AVENUE WP2 team leader
- Decision on the go/no go to deliver the service to the users.

4.1.3 Satisfaction & communication assessment

The satisfaction assessment process is embedded in T8.3 Social impact evaluation (M6-M48). The aim of this subtask is to study the user experience, the user acceptance and the potential changes in mobility behavior in the use of public transport systems.

The services' benefits for all users will be examined within this task, mainly the quality of service regarding different aspects such as

- speed,
- coverage,

- time,
- reliability,
- convenience,
- seamless experience,
- security,
- safety,
- price.

The social impact evaluation estimates the potential shift from private cars or other means of transport to autonomous public transport or door-to-door service to quantify an urban impact (decongestion) and potential reduction of territorial and social inequalities.

Questions regarding the user experience connected to the overall autonomous public transport system will be answered via a combination of observation and interview techniques. These techniques will be adapted from classic methods used in user experience design and evaluation, such as usability testing or contextual enquiry.

Questions regarding the user experience connected to the overall autonomous public transport system will be answered via a combination of observation and interview techniques. These techniques will be adapted from classic methods used in user experience design and evaluation, such as usability testing or contextual enquiry.

To deduct the changes in mobility behavior and the adoption of urban and suburban autonomous mobility concepts a user-oriented survey (approximately 80 – 100 responses) among active and potential users per demonstrator will be conducted and flanked by follow-up semi-structured interviews with the stake-holders identified in task T2.3 “Stakeholders identification, expectations and barriers imposed”.

Questionnaires for users will be distributed in the autonomous project vehicles and published via official registers and websites of the participating cities. Other potential users like private car drivers will be integrated as well. Face to face interviews especially for PRM will be conducted for users with autonomous transport experience. The perception of the concept by potential users will be evaluated in larger numbers by using online panel interviewees.

4.2 Social impact KPIs

The results of the surveys are due to present a relevant picture of social impact and customer satisfaction. The 4 following indicators will outcome the surveys as synthetic picture: USAT, NPS, URR and Servqual.

4.2.1 User Satisfaction Score (USAT)

Users are asked to rate their satisfaction with the service. The score is the average of all users' responses. The score has to be analyzed per users' segment and at least twice during the key phases of service delivery. The USAT scale can consist of regular numbers, but it could also consist of stars, smiley faces, colors, etc.

4.2.2 Net Promoter Score (NPS)

The NPS measures how likely the users are to refer the service to someone else. Its advantage over the USAT is that it targets an intention and not an emotion. As a result, the reply is less influenced by the mood of the moment. Users are asked how likely they are to recommend the service on a scale from 1 to 10. Their replies put them into one of three categories: promoters (9-10), passives (7-8), or detractors (0-6). Take the percentage of respondents who fall under the 'promoter' category (10 - 9) and subtract it from the 'detractors' (0 - 6), there's the NPS.

NPS measures may not be compared between the four operations 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 appreciate its evolution.

4.2.3 User Retention Rate (URR)

User retention 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 routine 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.

User Retention Rate = ((E – N) / S)) x 100
E = Number of users at end of period
N = Number of users acquired during period
S = Number of users at start of period

For now, a driver is needed in the autonomous shuttle. The driver can follow the users' reuse of the shuttle service in the demonstrators and extract statistics.

4.2.4 SERVQUAL

The multi-dimensional KPI measures "service + quality" are considered as the most common method for measuring the subjective elements of service quality. Users are asked to rate the service and this rate 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 user to better understand and respond to abstract information (its satisfaction with a service).

The questions cover 5 elements of service quality: RATER.

- Reliability: the ability to deliver the promised service in a consistent and accurate manner.
- Assurance: the extent to which the service provider creates trust and confidence.
- Tangibles: the appearance of the service (e.g. the shuttle, website, equipment)
- Empathy: the extent to which the service provider cares and gives individual attention.
- Responsiveness: the delay needed by the service provider is to offer rapidly an adapted service.

4.3 How to gather users' feedback

4.3.1 Surveys

The most simple, direct, way to get feedback from the users is simply to ask for it with a survey — a list of questions about their experience. Surveys with multiple-choice questions can easily be quantified, which allows to draw conclusions from the data using graphs, scatter plots, etc.

Surveys are given at the end of the user's experience. For a specific service, the survey has to be conducted twice: at launching time to get spontaneous reaction and a few weeks later to see how the user get used to the service and appropriate it or rejected it. Surveys should be short and simple. The simpler and to-the-point the survey is, the more likely people are to fill it out.

Organizing a follow up survey is very important; it gives users some time to use the service before asking for their opinion. Feedback survey may be carried out by email, social media, or in-app and should be tailored to the user's segmentation (e.g. demographic groups, uses groups)

4.3.2 Usability tests

Usability tests offer the ability to obtain feedback from users during their use of the service, while observers watch and take notes. The participants may be asked to complete specific tasks with the service — if they can't complete them, this can be a sign that the service has design issues. Usability tests can give extremely valuable data about how to improve a service. The test will be organized by the operators in each city where the autonomous shuttle will be operated. An observation survey has to be planned during the AVENUE project coherently within the 4 operators in Geneva, Lyon, Luxembourg and Copenhagen.

4.3.3 Monitoring of social media discussions

Communication online about the AVENUE shuttles services is more likely to be honest, than it may be in person. Thus, evaluation will be supported by tools that should be implemented to analyze online conversations mentioning the shuttle and monitor social media "footprint".

4.3.4 Analytics data, online relations with users

Some users are probably going to visit the shuttle website; the provider may also encourage them to do so (with gaming for example). Evaluation process can use the power of web analytics to draw conclusions about the quality of service. By monitoring which pages users view, how long they stay

on each page, and other browsing habits, it will be possible to get valuable overview of the quality of online service (popular web analytics tools include: Google Analytics (free), Open Web Analytics (free), Clicky (requires registration), Mint (paid), and Click Tale (paid)).

4.3.5 Incentivize the feedback process

The evaluation process is more likely to get feedback from users if it makes it worth their while. It may be possible to incentivize users to give a good feedback by offering gift cards or store credit, free merchandise sponsored by surrounding businesses.

The evaluation team must also show users that their feedback matters. One easy way to do this is to respond to the users' comments and concerns on social media, where they will be most visible to all.

4.4 Economic evaluation

Economic evaluation is an output of the task T8.2 Economic impact evaluation. The economic analysis of the used autonomous electric vehicles will thus focus first on business viability. Therefore, a comparison of the demonstrators will be conducted via a Total-Cost-of-Ownership (TCO) calculation.

4.4.1 The Total Cost of Ownership method

The TCO takes a dynamic approach identifying savings and cost drivers, integrating investment costs as well as functional costs

- the development of electric energy costs,
- the energy costs due to shifts in battery
- the costs for the maintenance of charging station infrastructure for public transport
- hidden costs (e.g. cleaning costs or vandalism in vehicles without drivers)

The economic evaluation integrates savings through mobility on demand.

The task T8.2 will evaluate the economic viability of autonomous vehicles as a part of an integrated public transport system considering the global value chain.

Alternative business models will be analyzed and the economic benefits of the urban automated vehicle fleets for the user and the potential users will be evaluated.

The economic effects on cities will be assessed and compared with other cities in Europe and the rest of the world (e.g. C40 cities): possible adaptation and investments in infrastructure like charging stations, software and other costs; free up of parking space through substitution of private cars; possible need of special lines; extension of transport services to narrow roads or urban

areas with week infrastructure, possible growing attractiveness of suburban areas; possible job effects through evaluation of job cuts (e.g. drivers) and job creation (e.g. operator) etc.

With the use of this methodology, direct and indirect costs and savings as well as cost drivers and hidden costs (e.g. cleaning costs or vandalism in vehicles without drivers) will be clearly identified and evaluated as a basis for the development of a business plan to evaluate the economic viability of autonomous vehicles as a part of an integrated public transport system. The possible improvements of journey time and the possible substitution of traditional individual transport modes like cars will be analyzed

Thus, business models and potentials will be evaluated regarding the balance between users demand and the economic benefits of the urban automated vehicle fleets for the city.

The economic effects on cities will be assessed and compared with other cities in Europe and the rest of the world, and the Task 8.3 will carry out a cost/benefit analysis regarding

- adaptation and investments in infrastructure like charging stations,
- software and platforms,
- free up of parking space through substitution of private cars,
- need of special lines,
- extension of transport services to narrow roads or urban areas with week infrastructure,
- growing attractiveness of suburban areas,
- job effects through evaluation of job cuts (e.g. drivers) and job creation (e.g. operator)

The TCO "Total cost of ownership" will be evaluated integrating different figures; the evaluation TCO takes into accounts the following concept that are to be estimated.

Investment	**Prospective**	**Operating costs**	**Business models**
Asset	Ownership Life	Obvious Cost	Resource Base Model
Asset Lifecycle	Depreciable Life	Hidden Cost	Activity Base Model
	Economic Life	Cost Savings	Cash Flow Estimates
	Service Life	Opportunity Cost	Incremental Cash Flow

The Task 8.2 will propose a TCO Calculator that will help to understand the total costs of the autonomous shuttle, over its whole life. The calculator will help to compare the TCO for several options and scenarios.

4.4.2 The hidden costs

The so-called "hidden" costs are the less apparent costs due to ownership that are easy to overlook or omit from acquisition decisions and planning. Hidden costs can be substantial and real. All hidden costs to consider in TCO analysis if both conditions apply:

1. the expenditures are indeed due to the decision to own the asset.
2. the costs are material i.e. Large enough to matter.

Hidden Costs May Include:

- Acquisition costs: These can include many kinds of spending due to identifying, selecting, ordering, receiving, inventorying, and purchasing. Any of these costs can signal the start of ownership life for the analysis.
- Upgrade, Enhancement, Refurbishing costs.
- Reconfiguration costs.
- Setup and Deployment costs: Costs due to configuring space, transporting, installing, setting up, integrating, and outside services.
- Operating costs: For example, expenses for human operator labor, or energy costs and fuel costs.
- Change management: costs: For example, expenses for user orientation, user training, and workflow or process change.
- Infrastructure support costs: For example, the costs of heating, lighting, cooling, or IT support costs due to asset acquisition.
- Environmental impact costs: For example, expenses for waste disposal, clean up, and pollution control. These may also include charges for "environmental compliance" reporting.
- Insurance costs.
- Security costs:
- Physical security: For example, expenses for building locks, secure entry doors, closed-circuit television, and security services.
- Electronic security: For example, the costs of security software, offsite data backup, and disaster recovery services.
- Financing costs: For example, fees for loan interest and loan origination.

The list of hidden cost categories above could, of course, extend further for the autonomous shuttle.

4.4.3 Economic KPIs

TCO analysis is relevant only if it includes cash flow statements. The task 8.2 will use several kinds of information to make these cash flow estimates mainly concerning revenue models, activity models and resource models that will allow the design of scenarios and cash flow statements for each scenario.

Finally, the TCO Analyst will use the "bottom lines" of the cash flow statements to compare scenarios using standard financial metrics. These metrics will be evaluated as economic KPIs.

These metrics are:

- Three-year Net cash flow.
- Year by year cumulative cash flow.
- Net present value NPV.
- Total capital costs CAPEX.
- Total operating expenses OPEX.
- 3-year Total cost of ownership TCO.
- Payback period.
- Return on investment ROI.
- Internal rate of return IRR.
- Break-even point.

4.5 Conclusions evaluation plan

Throughout the project a continuous evaluation process is established, which 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 autonomous 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 autonomous 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

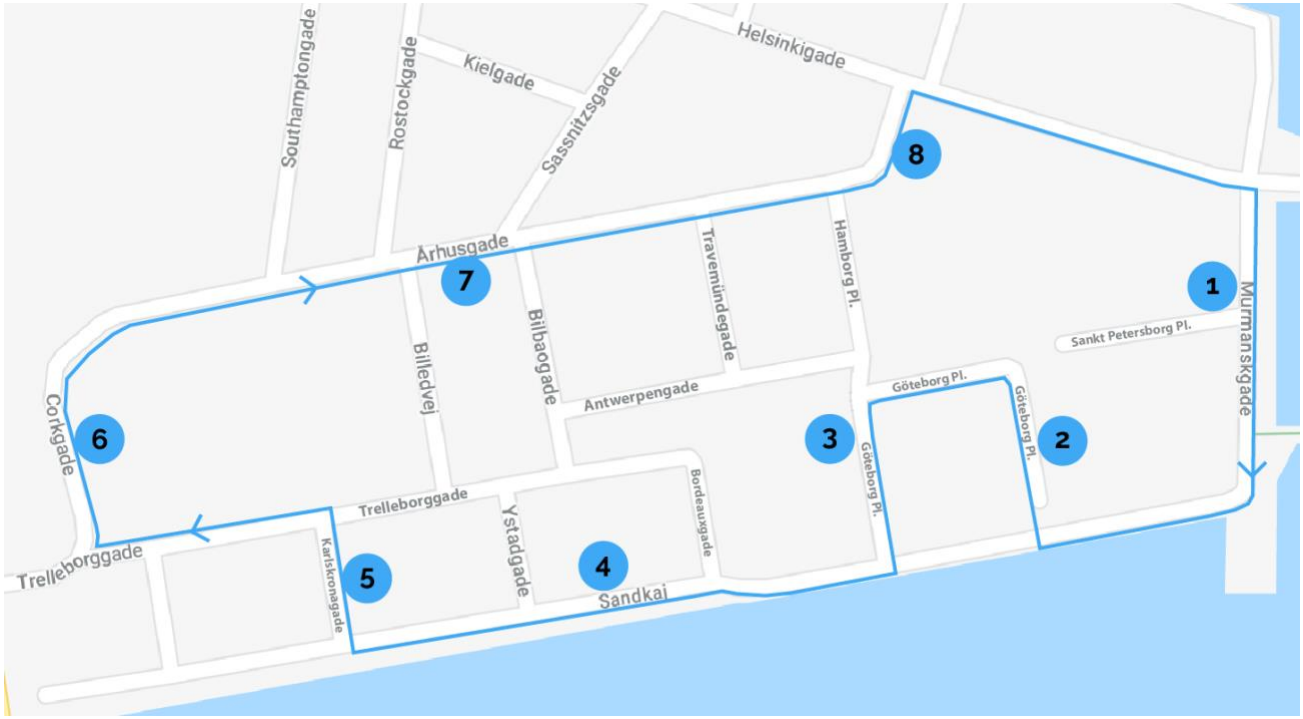
Step 3 – Data analysis

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

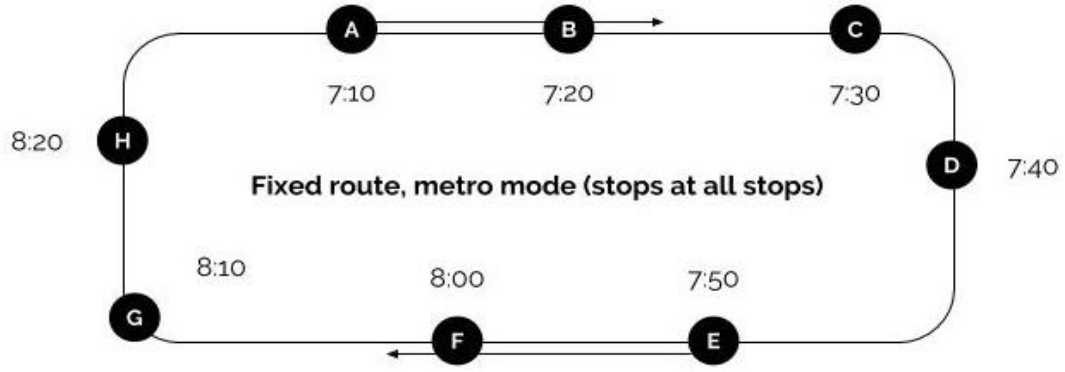
5 Annexes (confidential)[11]

5.1 Annexes Autonomous Mobility

5.1.1 Route at Nordhavn pilot site



5.1.2 Routing in the Nordhavn area for use case 1

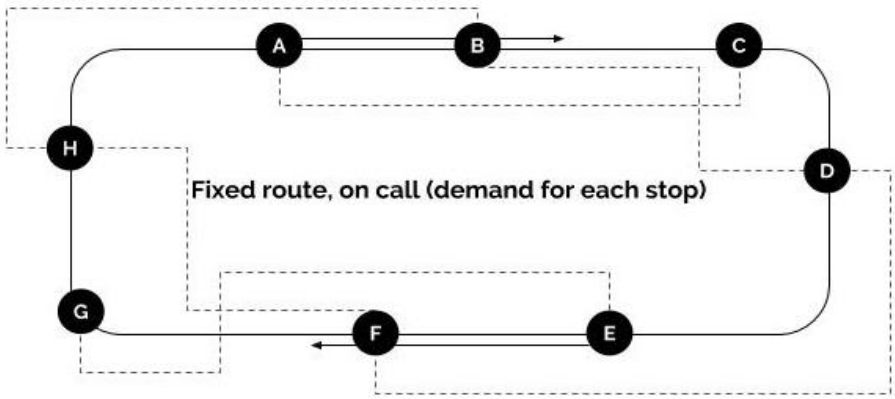


[11] These annexes will be submitted to the European Commission but have to be removed from any public version of the deliverable.

5.1.3 SWOT analysis use case 1

Strengths	Weaknesses
• AM is currently the only company operating autonomous vehicle in Nordhavn. • AM has testes autonomous vehicles in Denmark for almost 2 years. • AM has established a technical team competent to monitor and operate vehicles on site. • AM has prior experience from other pilot projects - hence experience in terms of registration and regulations of autonomous vehicles and approvals of AV's and specific routes in real traffic. • AM 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	• AM is the first to go through the legal framework in Denmark - requires time and resources. • People are not necessarily aware of the service at the beginning.
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 AM • Slowly developed laws and regulations could limit our operations, hence the development of AM • 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.

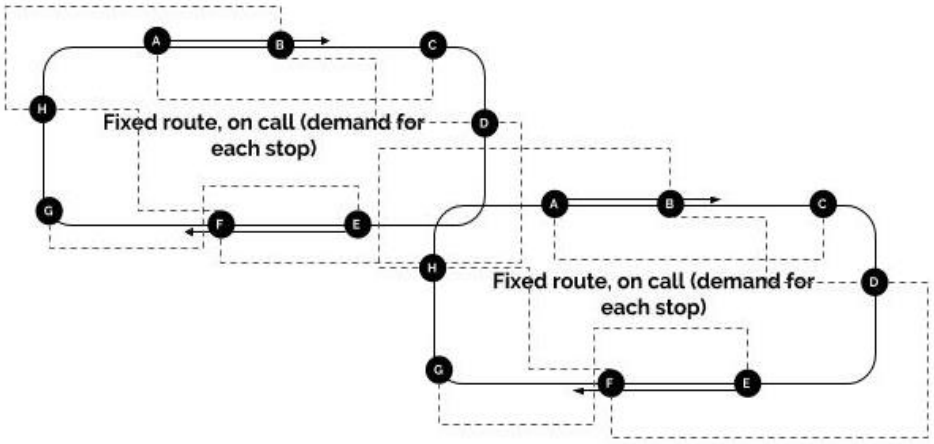
5.1.4 Routing in the Nordhavn area for use case 2



5.1.5 SWOT analysis use case 2

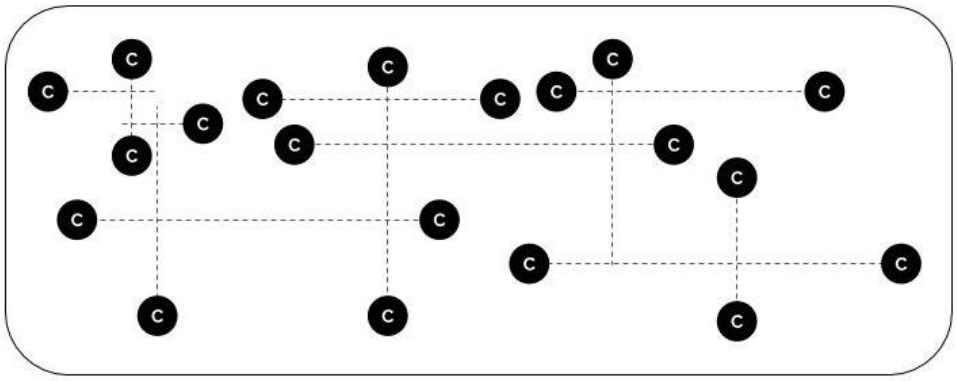
Strengths	Weaknesses
• AM is the only Danish company operating autonomous vehicles at the moment. • AM has testes autonomous vehicles in Denmark for almost 2 years. • AM has established a technical team competent to monitor and operate vehicles on site. • AM has the most experience in the Nordics in terms of registration and regulations of autonomous vehicles, as well as approval of vehicles and routes. • AM 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	• Lack of focus and reflection in communications • Target groups not considered sufficiently • Messages too diverse • Slow development pace, given regulations and laws
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 • Deploy multiple types of vehicles to fit a broad range of customer needs • An increase in number of users	• Competitors winning end users' loyalty • Critical incidents in pilots could damage trustworthiness of the brand AM • Slowly developed laws and regulations could limit our operations, hence the development of AM • 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.

5.1.6 Routing in the Nordhavn area for use case 3



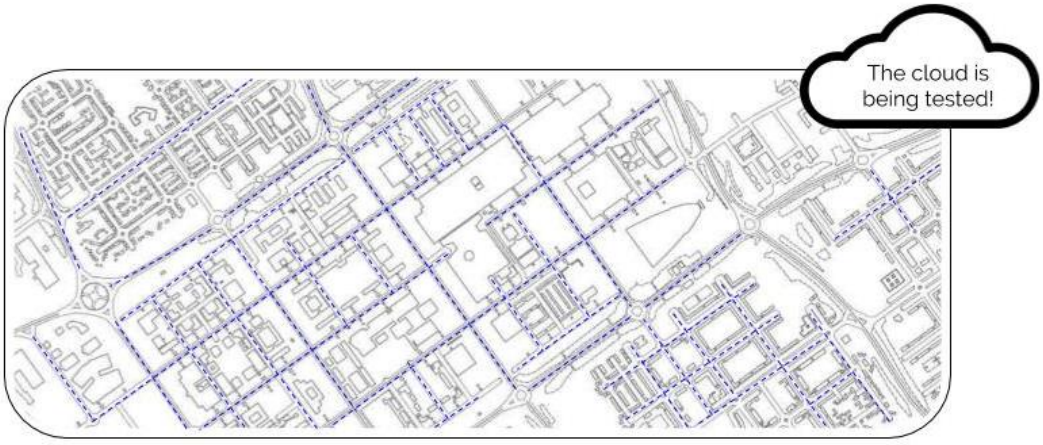
Fixed-route, on call (on demand coordinate based on two connected routes)

5.1.1 Routing in the Nordhavn area for use case 4



Dynamic routes, on call (on demand coordinate based)

5.1.1 Routing in the Nordhavn area for use case 5



Live mapping, dynamic routes, on call (on demand coordinate based - door to door transport everywhere)