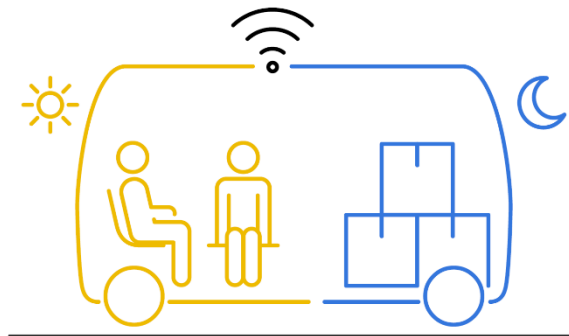




ULTIMO

Advancing Sustainable User-centric
Mobility with Automated Vehicles

DELIVERABLE

D5.1 Large Scale Demonstration Report



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Acronyms

AADT	Annual Average Daily Traffic
ADS	Automated Driving Systems
AFGBV	Autonomous Vehicle Approval and Operation Regulation
API	Application Protocol Interface
AV	Automated Vehicle
CICERO	Center for International Climate Research
DB	Deutsche Bahn
DRT	Demand-Responsive Transport
HD map	High Definition map
LaaS	Logistics as a Service
LOI	Letter of Intent
NVDB	Nasjonal Veidatabase / National Road Database (Norway)
MaaS	Mobility as a Service
OBU	On-Board Unit
ODD	Operational Domain Design
PRM	People with Reduced Mobility
PSA	Group PSA (PSA Peugeot Citroën)
PT	Public Transportation
PTA	Public Transportation Authority
PTO	Public Transportation Operator
PTS	Public Transportation Services
PUDO	Pick-Up and Drop-Off point
REM	Road Experience Management
R&D	Research & Development
RP	Road Profile
RUT	Ruter As
SAE Level	Society of Automotive Engineers Level (Vehicle Autonomy Level)
SMO	Shuttle-Modellregion-Oberfranken
SUV	Sport Utility Vehicle
TBD	To Be Decided
TPG	Transport Publics Genevois
TØI	Transportøkonomisk Institutt / Institute of Transport Economics
V2X	Vehicle to X (infrastructure (V2I)/pedestrians (V2P)/vehicles (V2V) etc.)
WP	Work Package
ZOB	Zentraler Omnibus Bahnhof – Central Bus Station

Executive Summary

This report is based on work done in many of the other ULTIMO work packages. The pilot sites will also be the basis for operationalization, learning, and data collection, as a continuous feedback-loop between all work packages.

The report provides a detailed description of the status of the rollout at the different pilot sites. The descriptions include challenges, problems, and obstacles, as well as proposed and implemented solutions.

Plans for the upcoming project period are also described.

The different pilot sites are at different stages of the rollout, but we have a common reporting structure to make it easier for the reader to see what is common and what is different between the sites. The pilot sites are described in detail, with Operational Design Domains (ODD), Road profiles, and socio-demographic factors that influence the design of the service.

1 Introduction

In recent years, various projects explored AVs in public transport and logistics, but they stayed in experimental stages due to economic and operational challenges. The ULTIMO project aims to change this by integrating AVs into MaaS and LaaS, deploying 15+ multi-vendor SAE L4 AVs at three European sites. They prioritize user-centric, seamless, and economically viable CCAM services, targeting fully automated AV operation without safety drivers. ULTIMO's innovative models aim for long-term global impact, ensuring stakeholder interoperability and maximizing safety through previous AV demonstrator project integration.

1.1 On-demand Mobility

Public transportation is a key element of a region's economic development and the quality of life of its citizens. Governments around the world are defining strategies for the development of efficient public transport based on different criteria of importance to their regions, such as topography, citizens' needs, social and economic barriers, environmental concerns, and historical development. However, new technologies, modes of transport and services are appearing, which seem very promising to the support of regional strategies for the development of public transport.

On-demand transport is a public transport service that only works when a reservation has been recorded and will be a relevant solution where the demand for transport is diffuse and regular transport is inefficient.

On-demand transport differs from other public transport services in that vehicles do not follow a fixed route and do not use a predefined timetable. Unlike taxis, on-demand public transport is usually also not individual. An operator or an automated system takes care of the booking, planning and organization.

It is recognized that the use and integration of on-demand Automated vehicles has the potential to significantly improve services and provide solutions to many of the problems encountered today in the development of sustainable and efficient public transport.

1.1.1 Fully Automated Vehicles

A self-driving car, referred in the ULTIMO project as a **Fully Automated Vehicle (AV)**, is a vehicle that can sense its environment and moving safely with no human input.

The terms *automated vehicles* and *autonomous vehicles* are often used together. The Regulation 2019/2144 of the European Parliament and of the Council of 27 November 2019 on type-approval requirements for motor vehicles defines "automated vehicle" and "fully automated vehicle" based on their autonomous capacity:

An "automated vehicle" means a motor vehicle designed and constructed to move autonomously for certain periods of time without continuous driver supervision but in respect of which driver intervention is still expected or required

"Fully automated vehicle" means a motor vehicle that has been designed and constructed to move autonomously without any driver supervision

In ULTIMO we operate **Fully Automated mini and micro shuttles for shared public transportation**. In relation to the SAE levels, the ULTIMO project will operate SAE Level 4 vehicles.



SAE J3016™ LEVELS OF DRIVING AUTOMATION

	SAE LEVEL 0	SAE LEVEL 1	SAE LEVEL 2	SAE LEVEL 3	SAE LEVEL 4	SAE LEVEL 5
What does the human in the driver's seat have to do?	You <u>are</u> driving whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			You are <u>not</u> driving when these automated driving features are engaged – even if you are seated in "the driver's seat" When the feature requests, you must drive		
What do these features do?	These are driver support features These features are limited to providing warnings and momentary assistance These features provide steering OR brake/acceleration support to the driver These features provide steering AND brake/acceleration support to the driver			These are automated driving features These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met This feature can drive the vehicle under all conditions		
Example Features	• automatic emergency braking • blind spot warning • lane departure warning			• traffic jam chauffeur • local driverless taxi • pedals/steering wheel may or may not be installed		

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

1.2 The ULTIMO dream for public transportation

Our city has a population of 700.000, and the local PTO (Public Transport Operator) deploys 3.000 Km of public transportation services' routes, with 4 backbone tram lines, 8 backbone large bus/trolley lines, and 340 fully automated multi-manufacturer mini and micro-shuttles in an on-demand, door-to-door shared public transport service. The fleet of the 340 automated mini-busses is composed of different vehicle generations and models from different manufacturers, as it was purchased in different batches during the last 12 years (it all started with the first 15 bought by a European project in 2023/24). It is today composed of the first 15 twelve-years old vehicles from manufacturer A, 160 eight-years old vehicles from manufacturer B and 160 two-years old vehicles from manufacturer A, which are the new generation of manufacturer's A vehicles. These last 160 vehicles re-placed the last 70 old, driver based, thermic busses that reached the end of their life after 18 years in operation. The change from driver large busses to automated mini-buses and from fixed line service to on-demand, door-to-door, for the last area of the city, was decid-ed 6 years ago, and was based to the great success of the already deployed AV-based ser-vices in the other parts of the city.

The integration of new vehicles in the PTO fleet was done within just a few days, thanks to the now standardised APIs of the automate vehicles' connection with the AV fleet management and orchestration service, that allows a plug-and-operate functionality, but also enables the

combination of AVs with all other means of transport, offering a seamless citizen centric journey to the users. Similarly, the now standardized High Definition (HD) maps between the vehicle manufacturers, allowed us to reuse the maps created in the past for the 3.000 Kms of routes of the city, with small adaptations for the new vehicle capabilities. At the same time of the purchase of the last 160 AVs, we also switched to a new AV fleet management and orchestration service, from another provider, which offers more precise trip time estimations, considering also traffic jams in the city and weather conditions (that affect traffic in the city). The replacement was made within just two weeks, thanks to the new standardised interfaces between AV fleet management and PTO MaaS services.

Passengers are now able to reserve, via their mobile phone app, on the fly or with pre-reservation trips from one side of the city to another, using the optimal transport mode available for them, with a combination of different transport modes, and having the automated vehicle arriving next (or almost) to their door entrance and bringing them to their final destination or to a backbone transport connection. All trips are offered with highly reliable and accurate transport and arrival times, based on real time, dynamic route changes of the vehicles, responding to the passenger needs. Many passenger services are available in the AVs via a mobile phone app, adapted to all passengers' needs, from special needs passengers (visually impaired, wheel-chair users, pregnant women, elderly, children), to persons transporting suitcases or a baby-stroller, providing adapted information of their trip (where to get-off, PTO general information, and even infotainment, like city related information and historical facts and anecdotes, related to their current position).

With the full suppression of on-board operators, automated in-vehicle monitoring provides a multitude of passenger services, which were, and are developed with a continuous collaboration and innovation between users and the PTO. An on-board unit identifies locally (that is, in the bus) incidents and events, like aggressions, vandalism, forgot-ten objects, littering, accidents, etc., and raises incident alarms to the PTO back-office. The PTO officer at the back-office evaluates the incident and decides, based on the operator policies, what action to take: dismiss the incident, or stop the vehicle and call one of the intervention teams to go to the vehicle and take the required action. The back-office operator, based on the number of incidents and intervention time legal obligations, can deploy any of the 15 intervention teams available in the city, ready to reach within a few minutes any AV. At the back-office, service operators are able, with one set of screens linked to the fleet management, to follow the vehicle status, trip reservations, routes chosen, open and closed road segments (due to works, accidents, etc. thus adapting dynamically the trip routings), while in a second set of screens, the back-office operators can follow the passenger services' incidents and the status and location of the intervention teams. The two systems, although independent, are linked so that the back-office operator can transfer incidents to intervention teams and turn-on, when possible and under the local legal re-strictions, video connection to inspect the incident.

The public transport services are operating 24/7 with different active vehicles, depending on passenger transport demands. The PTO, being eco-sensible, has defined that the vehicle must have an average occupancy of at least 3 passengers. This of course has implications, especially in off-peak hours, in the transport delays, but it is fully justified for an optimal and eco-responsible operation. Exceptions are made for people with special needs or when the passenger is ready to pay an additional price.

While at peak-hours the full 340 strong fleet of AVs is in service for public transportation, in the off-peak and night hours, due to the reduced transportation needs, part of the fleet is not serving passenger transportation. However, because having a vehicle waiting idly is a waste of resources, the PTO has signed an agreement with Logistics as a Service (LaaS) Service providers. During the off-peak hours the unused vehicles are dynamically chartered by the different LaaS providers to be used for other types of incidental transport of goods or even non-public transportation of passengers. Local shops and enterprises use the service, on demand with dynamic reservation, to offer home delivery of on-line purchases, or B2B delivery of goods from an urban consolidation center to the distribution center (hub, many to one or one to many [7], or even transport their VIP customers directly to their offices or exposition centers. This way they can deliver the goods to their customers in the city, with a delay of just 60 minutes with affordable prices, as the last mile is the most inefficient part of the goods delivery chain. The goods send can include books from local bookshops or libraries, supermarket bags or even documents exchanged between companies or waste. The local shops are even using the service in the early hours (5 o'clock in the morning) for re-provisioning their shops for the day. The so chartered AVs are "returned" to the PTO for public transport at the peak-hours automatically, at the end of the chartered time period..

1.3 Preamble – Large Scale Demonstration

In ULTIMO we aim to deploy a high number of vehicles in a small number of sites. Three sites, and at least 15 vehicles per site, in high passenger frequency areas. The purpose is to be able to provide and prove commercially viable CCAM services in real, daily operation, with all the service qualities of a public transportation service.

The objectives of Work Package 5 is to deploy this type of service in Herford (Germany) – T5.1, Oslo (Norway) – T5.2, and Belle-Idée/Champagne (Switzerland) – T5.3. We will start operating from day one at all sites and add incrementally more vehicles, expand the site and extend the services. During this period we will also collect all data that will be used for evaluation and business development – T5.4.

2 Project Site: Herford

The initial project area, as described in the Grant Agreement, was Rottal-Inn. However, it was determined that this area was too small for 15 vehicles. Additionally, the surrounding area was too sparsely populated to achieve an economically viable utilization of at least 15 automated vehicles. As a result, the project area was changed before the official start of the project to better accommodate the needs of the project and ensure its success.

Even the alternative solution of Kronach proved to be unsuitable in the first few months, as a clear distinction with the ongoing Shuttle-Modellregion-Oberfranken (SMO) project, funded by German grants, was not possible there. Additionally, there was not always the necessary local support to implement the project.

Therefore, in the first few months, a new project area was agreed upon, which was found with the district and the city of Herford. The service area is perfectly suited for advancing the

ULTIMO project due to its size and the possible use cases available there. It also provides a good contrast to the other two areas in Oslo and Geneva. The official start was marked by the signing of the LOI with the city and district in June 2023.

The hanseatic city of Herford is part of the district of Herford and belongs to the governate



Figure 1: City crest of Herford

Detmold. Herford is located in the federal state of North-Rhine Westphalia. The descriptive name "hanseatic" is an expression for the relevance of trade in the so named city. The so called "Hanse" is a trade organisation which dates back to the middle ages. Herford is one of the most densely populated districts of Germany and offers the main international traffic routes from Berlin and Hannover to the Rhine Region and the Netherlands. A broad field of industries is located in in the district of Herford, however the main industries are within furniture and textile. The district of Herford has 253.551 residents and a population density of 563 residents per square kilometer. The hanseatic city of Herford has 67.459 residents and a population density of 852 residents per square kilometer.



Figure 2: Geographic position of Herford in Germany

Local public transport in Herford is mainly defined by the municipal bus network with two central nodes: One is located at the Herford railway station, where the central bus station (ZOB) is, and the second transfer point at the Alter Markt. Herford's municipal bus network comprises a total of six lines (S1 to S6) and various regional buses offering connections to the surrounding towns.

The current variety of lines and timetable structure only allow for a limited development scenario, in which it is difficult to introduce new connections or a more flexible adaptation of local public transport. In addition, the road network in Herford limits the number of possible public transport axes that can be used for bus services. Currently there are two main axes, "Herford East" and "Herford West", both starting from the railway station. All of Herford's public transport axes offer

connections to both the ZOB and the railway station.

There are currently bus connections, especially at the Alter Markt, which are served at certain minute times (15- and 30-minute intervals), to whom feeder and drop-off buses from the station to the rail connections at 30-minute intervals are dedicated.

With the idea of a new central bus station (ZOB), the focus on connections or the staggering of the regular-interval services is currently being discussed. One possibility is to stagger the

frequency of services along the "Herford East" axis with a 5 or 10-minute offset. This would have several effects:

- **Effect 1:** There would never be more than 2 buses travelling towards the station at the same time, which would prevent queue journeys.
- **Effect 2:** The staggering would lead to a higher frequency between the station and the city centre.
- **Effect 3:** The longer transition times to the train could be a result of this staggering.

Consideration is given to linking urban and/or regional services through to optimise the system. In one proposal, at least 6 axes "Herford East" are linked through with 6 axes "Herford West", resulting in 6 diameter lines. However, with a 5-minute staggering and the goal of a 15-minute frequency, only 4 buses would arrive at the ZOB at the same time.

The through-connection of long regional lines involves high risks due to possible consequential delays. Currently, through connections only work because of standstill times at the Alter Markt.

In addition, the city bus lines lack "real" final stops, which is why most of them are looped instead. It should be emphasised that safe operational connections, preferably between city buses, with clear line ends are needed to cope with buffer times.

With regard to the school booster journeys, it should be noted that the western schools in Herford have comparatively low pupil numbers, which is why no additional booster journeys are required here. The schools in Sz. Aawiesen act as feeders both as a "lead-in" and as a "distributor" for the regular trips in both directions. In contrast, the eastern schools in Herford Ost are served directly, which has no direct relevance for the Central Bus Station (ZOB). On the other hand, the schools in the eastern part of Herford West serve as a "lead-in" and "distributor" for the regular bus trips.

A small residual size of 1-2 COMs (buses) remains in the 1 p.m. time slot. In summary, the staggering of school times already results in a good distribution of pupils and the required amplification journeys are mostly carried out as direct buses. This has only a limited impact on the dimensioning of the ZOB.

The volume of pupils requires the use of articulated buses on most bus routes. This not only allows for more efficient transport of pupils, but also shorter bus platform lengths, as usually only one articulated bus is used per line.

The introduction of autonomous shuttles in on-demand operation in Herford holds a wide range of optimisation potential for urban mobility in the city. These innovative shuttles offer the opportunity to increase the flexibility and individualisation of public transport. Passengers can plan and book their journeys according to their needs, which can significantly increase customer satisfaction.

Route planning for these autonomous shuttles is, for example, extremely efficient. By using intelligent algorithms, the optimal routes to passengers' destinations are determined, which not only minimises travel time but also reduces energy consumption.

Also, a significant benefit is the reduction of car related traffic in the city. The shuttles allow several passengers to travel together instead of using separate cars. This not only relieves road congestion, but also minimises parking problems. The fleet size of the autonomous shuttles can be adjusted according to demand. This means that resources are used optimally and passenger-empty runs are avoided, which further increases the efficiency of the system.

Environmental impact is minimized by the electric operation of the shuttles, which is particularly important in urban areas to improve air quality and reduce CO2 emissions. Accessibility is also taken into account to provide barrier-free access to public transport for people with mobility impairments, especially senior citizens.

The collection of comprehensive mobility data enables continuous optimisation of the transport system and planning of future developments. On-demand operation enables precise cost control, as resources are targeted to meet actual demand. These autonomous shuttles can also be extremely attractive to commuters as they offer convenient and reliable transport options.

Furthermore, the introduction of autonomous shuttles positions Herford as an innovative city and can encourage investment as well as technological developments in the region. Overall, on-demand autonomous shuttles in Herford offer the opportunity to significantly improve urban mobility, optimise traffic, reduce pollution and increase the quality of life for residents.

Rural regions, like the district of Herford, frequently struggle with subpar public transportation networks, which can result in limited mobility options for residents. Autonomous on-demand vehicles can provide an innovative and flexible solution, ensuring that even remote areas within Herford have access to reliable transportation services. This is particularly beneficial for individuals who may not own private vehicles or face difficulties in accessing conventional public transportation.

2.1 Roadmap Until 2026

In the coming weeks, the focus will be on selecting the first routes. To this end, various workshops and appointments are planned, both internally and with representatives from the city and district of Herford. The goal is to have at least two vehicles in operation by mid-2024. Current plans indicate that these vehicles will be 2-3 Navya vehicles from previous projects, as a newer version of the vehicles is not yet available. The initial operation is intended to demonstrate and familiarize citizens with autonomous driving, as this region has not yet had any exposure to autonomous projects. The vehicles deployed will therefore operate at level 3 of autonomy.

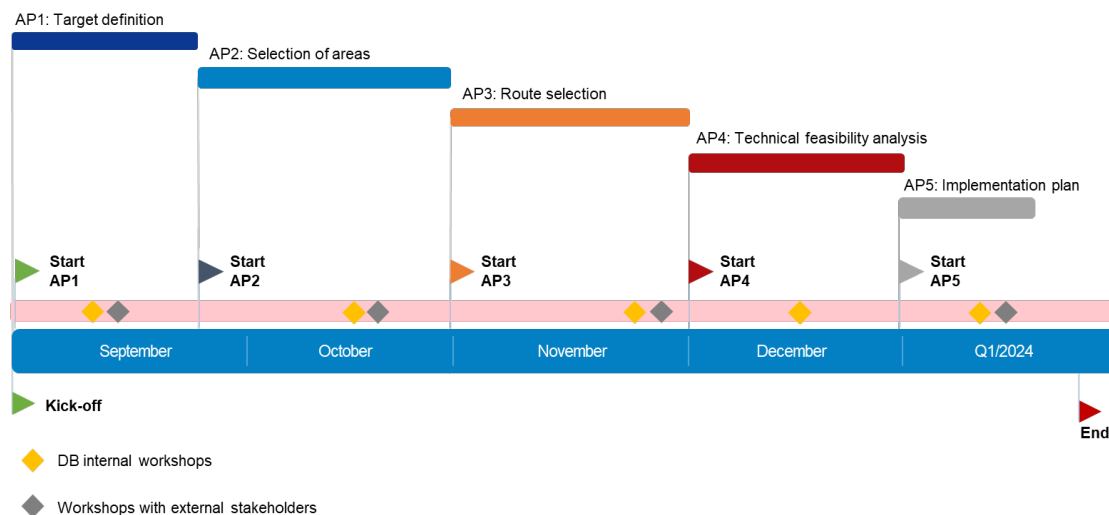


Table 2: Roadmap Herford

- **September 2023:**
 - Define the goals and objectives of the project
 - Identify potential areas for implementation
 - Conduct workshops with district/city/interest representatives to develop potential spaces
 - Engage relevant stakeholders, including government authorities, transit agencies, local residents, technology providers, and advocacy groups, to gain support and gather input.
- **October 2023:**
 - Select the first routes for implementation
 - Plan and schedule internal and external workshops and appointments with representatives from the city and district of Herford
- **November 2023:**
 - Finalize route selection
 - Select suitable autonomous vehicle technology that meets the requirements of planned routes.
 - Analyze legal, technical, and financial considerations.
- **December 2023:**
 - Initiate a procurement process to acquire autonomous vehicles.
 - Begin preparations for vehicle deployment, including charging infrastructure
 - Conduct a comprehensive feasibility study to assess the suitability and potential benefits of autonomous public transportation.
- **January 2024:**
 - Finalize procurement process
 - Start contacting the regulatory authorities

- Continue preparations for vehicle deployment, including charging infrastructure
- **February 2024**
 - Obtain all necessary permits and licenses from regulatory authorities.
 - Ensure compliance with all applicable regulations and standards for autonomous driving.
- **March 2024**
 - Vehicle delivery
 - Begin preparations for HD map
- **April 2024**
 - Continue mapping
 - Engage in extensive communication with the public to explain the introduction of autonomous transportation and address any concerns.
 - Provide information about the new services and vehicles.
- **May 2024**
 - Monitor and evaluate charging infrastructure
 - Obtain all necessary permits and licenses from regulatory authorities.
 - Receipt of all regulatory and approval documents
- **June 2024:**
 - Deploy first autonomous vehicles
 - Begin testing and evaluation phase
- **July 2024:**
 - Continue testing and evaluation phase
 - Make necessary adjustments based on feedback and data collected, including any changes to charging infrastructure
- **August 2024:**
 - Launch public operation of autonomous shuttles
 - Begin public education and outreach campaign to familiarize citizens with autonomous driving
- **September - December 2024:**
 - Conduct extensive testing and pilot projects on selected routes.
 - Monitor autonomous vehicles and collect data on performance and safety.
 - Monitor and evaluate the operation of autonomous shuttles, including charging infrastructure
 - Make necessary adjustments based on feedback and data collected

- Plan for future expansion of the project, including any necessary upgrades to charging infrastructure
 - Gradually introduce autonomous public transportation on selected routes.
 - Continuously monitor and evaluate the rollout, making adjustments as needed, and prepare for scaling to additional routes.
- **January 2025 onwards:**
- Introduce higher-speed vehicles on selected routes after the successful implementation of autonomous transportation.
 - Adapt infrastructure and technology to support higher speeds if needed for the vehicles.
 - Continuously monitor the performance, safety, and efficiency of autonomous transportation and higher-speed vehicles.
 - Regularly adjust schedules and routes based on data analysis and customer feedback.

Stakeholder Workshops

At the German project location, we divide the stakeholders into three different groups in order to involve them in the project accordingly. These groups are divided into:

1. **Key players:** These are representatives of the public authority, operator and offices of the city and district who are necessary for the planning and implementation of the project. These are always involved.
2. **Extended group of actors:** Are political representatives of committees and offices, as well as city management, mobility managers, municipal cycling officer, senior citizens' advisory board, advisory board for disabled people and local business development who have a special interest in the project or are very important multipliers for certain user groups. These are continuously informed and involved if their expertise or feedback is needed. They will also be invited to the co-creation workshop series with Open Geneva.
3. **Civil society:** residents of all age groups, social institutions, interest groups such as ADFC (Allgemeiner Deutscher Fahrrad-Club), kindergartens and educational institutions as well as clubs and organizations from all walks of life. These are involved in the stakeholder co-creation workshops ("hackathon" format by Open Geneva) and informed about the local media and our social media presence.

Since the local partners of the city, district, authorities and operators already have very good contacts with all stakeholders, they are also involved in activating, addressing and planning all activities. After each activity with a stakeholder group that produces a reportable result, a press release is published, which is then also prepared for social media channels and the other stakeholders are informed by email about it. The communication will be coordinated by us and the pr department of city and district of Herford.

The invitation to the official kick-off with the key players on September 20th was sent out by the transport authority. In addition to the project presentation, the added value for the city

and district was made clear. The roadmap to 2026 was then presented and the detailed focus was placed on the period up to the end of 2024. Previous mobility concepts and measures for the further development of local and public mobility for the next 10 years are superimposed and evaluated with the project in Ultimo. It became clear that the envisaged forms of transport and offers from Ultimo can close existing gaps and bring public transport in the region to a new level. For this purpose, the first ideas for common goals of the actors were presented with Ultimo. The session ended with a question-and-answer session.

At the end of August, the appointment for two more workshops in the 4th quarter of 2023 was started together with the authorities and key players. In the first workshop, a vision and goals (e.g., better connections between communities, operation of certain hotspots, tourist destinations, reinforcement of main axes) should be worked out and coordinated for the city and district of Herford. Finally, measurement criteria are also determined so that all project participants can orientate themselves on them in their project participation, but also a continuous target control can take place. This is the only way we can recognize a deviation from the target in good time and take countermeasures. Planned course of the workshop "Vision and Goals":

- i. Welcome, introduction round and agenda
- ii. Impulse lecture: "What can AF do in public transport in the future?"
- iii. Status quo mobility project district of Herford?
- iv. Relevant aspects from the mobility concept of the city of Herford and previous workshops results regarding classical bus services (supplements and classification of the DB analysts and local colleagues from BVO - Busverkehr Ostwestfalen GmbH).
- v. Interactive development of goals, based on the input provided and known customer needs.
- vi. Selection and description of measurement criteria for target achievement.
- vii. Summary, outlook and farewell

To prepare the route finding for the start of operations in 2024 and fleet operation in 2025, another workshop will be held this year with the key actors and the extended group of actors. Here, too, appointments are being made with the relevant stakeholders. Potential areas are to be defined here. The basis is formed by analysis from the mobility concept that was presented in 2022 and contains a large amount of relevant information for the projects in Ultimo. Planned workshop schedule:

- i. Welcome, introduction round and agenda
- ii. Explanation of terms and methodical procedure (theoretical basis by our experts from team mobility concepts - Colleagues from the same department as the autonomous driving team)
- iii. Presentation of areas by city and district (important POIs, special places, etc.)

- iv. Assessment by DB colleagues on site / autonomous team and team mobility concepts
- v. Interactive development of areas with a high potential for autonomous vehicle operations.
- vi. Summary, outlook and farewell

To finalize the route selection, there will be an internal project appointment with the PTA and the various teams from the DB departments involved. The aim of the meeting is to define routes for the exploration phase (level 3) from 2024 to Q2/2025 and for fleet operations from Q3/2025 to the end of Q3/2026.

Appointment agenda:

- i. Presentation of the suggested routes and evaluation of the technical feasibility by our experts.
- ii. discourse, fine tuning
- iii. prioritization and decision
- iv. The defined routes will be published for all stakeholders

Since the annual financial statements and annual planning for most of the key players prevent another workshop from being scheduled in December 2023 and January 2024, we will not hold the use case workshop planned for the end of the year with this stakeholder group until February 2024 and start planning it with the core project team on site in November this year. In this workshop we want to present the use cases developed with the partners in T 2.1, adapt them to local peculiarities and, if necessary, also include other use cases that our local project partners suggest.

This means that the preparations for starting operations in 2024 are well on track and form an excellent basis for the co-creation workshops with our partner Open Geneva, the extended circle of stakeholders and local civil society. Since Open Geneva started the workshop series with TPG in Geneva in 2023 and is busy with the implementation in Oslo until the end of Q1/2024, we can only start our co-creation workshops at the end of March or beginning of April. We want to use the time to make the project so well known in the city and district of Herford that we can register numerous registrations for the workshop series in spring 2024. The description of the co-creation workshop is part of another document. We therefore refrain from repeating the content here and prefer to report on it in the next version of this deliverable.

2.2 Use-Cases

The use of driverless shuttles in local public transport is linked to the hope of supplementing the existing offer and being able to provide services even when the demand is low. Technology, planning, and operation continue to pose challenges.

The overall goal is to test the operation of driverless vehicles as an additional and complementary component on public roads and to further develop the technical capabilities.

The defined use cases deal with the effects on the traffic system and the implications for municipal traffic planning, human machine interaction, functional safety, and the monitoring of ongoing operations, especially for the management of incidents. To guarantee economically viable concepts, it is necessary to automate processes and procedures to make the shuttles accessible to everyone. The use cases are written descriptions of how users will perform in special tasks. It outlines, from a user's point of view, all important steps of a system. The use cases support the definition and implementation of user requirements for autonomous shuttle systems. Since these are innovations that haven't been tested yet in public transport, acceptance by the passengers is the top priority. The implementation of the use cases follows the approach of automating the entire shuttle system and driving forward the optimal operational process.

The focus of the use case finding, use case definition and implementation is based on an integrated mobility concept. The term of integrated mobility stands for sensible planning and linking of different means of transport with the aim of providing customers with an attractive range of transport options tailored to their needs. The offer goes well beyond the legally regulated public services and offers customers the right mobility solution at any time of the day and for any destination. The offer of integrated mobility takes traffic, vehicle-related and user-oriented components into account and thus creates the best possible route chain. This includes any form of transportation – car or bike sharing, public transport, ride pooling, autonomous shuttles, first and last mile offers, etc. Decisive for an integrated mobility offer is the sustainability of its individual components regarding a long-term attractive offer for customers and passengers.

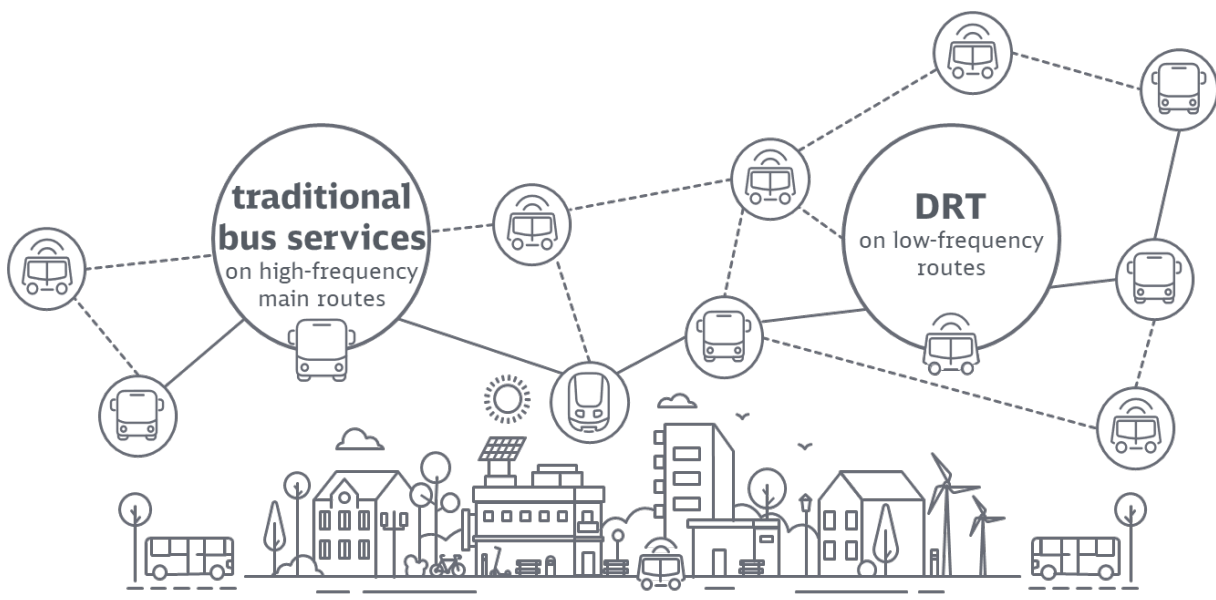


Figure 3: Integrated Mobility - A smart combination of traditional bus and DRT services in planning and/or operations

A use case refers to a specific situation which addresses specific needs or requirements to achieve a desired outcome. It describes the interactions between users (individuals or entities) and the system or product to accomplish an especial goal or task. They provide a detailed depiction of how users will engage with the system, outlining the steps involved and the expected results. These use cases will be formulated in the work package D2.1

2.3 Problem Descriptions

2.3.1 Vehicle availability

The current situation for European manufacturers of automated vehicles is difficult to assess. It is unclear when Level 4 capable vehicles for public transportation will be available on the market. The bankruptcies of Sensible 4 and Navya were symptomatic signs of the challenges facing the industry. Despite these setbacks, many companies are continuing to invest in the development of autonomous technology, and it is hoped that progress will be made in the coming years. In the race to develop autonomous vehicles, Europe is currently lagging behind both the United States and Asia, particularly China. These regions have made significant investments in the development of autonomous technology, and they are leading the way in terms of innovation and progress. While European manufacturers are also working hard to develop Level 4 capable vehicles, they face stiff competition from their counterparts in other parts of the world. It will be important for Europe to continue investing in this technology in order to remain competitive in the global market.

Some European manufacturers have announced plans to release Level 4 capable vehicles by 2025. Prototypes may even be available by mid to late 2024. At present, there are only mockups or designs in PowerPoint slides available for these Level 4 capable vehicles. While these designs provide a glimpse into the future of autonomous transportation, it is important to remember that there is still much work to be done before these vehicles can become a reality. The development of autonomous technology is a complex and challenging process, and it will take time for manufacturers to overcome the many technical and regulatory hurdles that stand in their way. It needs continued investment to ensure that these vehicles are safe, reliable, and efficient. The lack of availability of autonomous Level 4 vehicles can become a major risk for the deployment of driverless vehicles in the final year of the project.

2.3.2 Approval process

In Germany, we are fortunate to have a legal framework in place that allows operators to deploy vehicles without drivers. This framework is known as the Autonomous Vehicle Approval and Operation Regulation (AFGBV). The AFGBV regulates the approval of autonomous driving functions, the operation of autonomous vehicles in designated operating areas, and the market surveillance of autonomous vehicles. This regulation provides a solid foundation for the safe and responsible deployment of autonomous vehicles on German roads.

In addition to regulating the operation of autonomous vehicles, the AFGBV also allows for the type approval of autonomous vehicles. This means that the previously cumbersome process of obtaining individual approvals for each vehicle is no longer necessary. Instead, entire fleets of vehicles can be approved at once, making it much easier to deploy large numbers of autonomous vehicles. This is particularly beneficial for projects like ULTIMO, which aim to operate large fleets of autonomous vehicles.

It is worth mentioning that, to date, no manufacturer or operator has attempted to obtain such approval under the AFGBV. This is likely due to the current state of technology. As a result, there is no experience on how long the approval process might take, and the effort

required for operators like us can only be roughly estimated. This could have an impact on the deployment of Level 4 vehicles in Herford if the approval process takes longer than expected. However, it is important to note that this is a new and rapidly evolving field, and it is likely that the approval process will become more streamlined and efficient over time.

The potential challenges described in the approval process for vehicles can also be applied to the control center. There is currently no approved control center for Level 4 capable vehicles, so there is no experience to build upon. This means that the process of obtaining approval for a control center is also uncertain, and it is difficult to estimate how long it might take or what the requirements might be. However, as with the approval process for vehicles, it is likely that this process will become more streamlined and efficient over time as more experience is gained and best practices are established.

2.4 ODD in Herford

As the exact routes will only be defined in the joint workshops with the various representatives of the city and the district. Only general information on the ODDs can be given here.

2.4.1 Road Profile 1

The ODD encompasses streets in Herford, where the first autonomous vehicles in the project will be operating. These streets have a maximum speed limit of 30 km/h. They may include various types of streets, such as residential roads, main streets, and downtown areas. The surface is classic road asphalt or cobblestone in a few places. Typically, these streets are wide enough to accommodate the passage of two vehicles simultaneously, allowing for safe overtaking and maneuvering. The lane width is designed to ensure sufficient space for autonomous shuttles to operate comfortably within the lane. On some streets, permanent parking on both sides is possible. Along both sides of the street, there are designated pavements for pedestrians, separated from the road by a sidewalk or curb. These pavements ensure safe walking and provide space for waiting at bus stops or pedestrian crossings. Pedestrian crosswalks are clearly marked at intersections and designated points along the street. At major intersections, there may be traffic signals to regulate the flow of traffic. The streets may include roundabouts. Due to the geographic location of Herford, the ODD covers various road conditions, including dry, wet, or slightly icy surfaces. The slope of the streets is very low and can be neglected.

2.4.2 Road Profile 2

The second road profile closely resembles the characteristics of the first road profile, with the exception that the speed limit here extends up to 50 km/h. Additionally, in some sections of this road profile, there will be multi-lane roads with clearly discernible lane markings. In these areas, you might find a more urban or semi-urban setting, such as residential neighborhoods or suburban streets, where lower speed limits are typically enforced for safety reasons. This could entail a greater presence of pedestrian zones, crosswalks, and pedestrian traffic control measures to ensure the safety of those on foot. At intersections, traffic signals may regulate vehicle movement to maintain safety and coordination among different road users. On-street parking, whether parallel or diagonal, may be present on certain sections of the road, necessitating adherence to parking rules and regulations. Given the potential for a higher number of intersections and junctions, careful navigation and adherence to traffic rules

become crucial. The road's width may vary, with sections designed to accommodate multiple lanes, bicycle lanes, or parking areas. Enhanced pedestrian infrastructure such as sidewalks, crosswalks, and pedestrian islands may be present to facilitate safe walking and crossing.

2.4.3 Road Profile 3

In this Operational Design Domain (ODD), outlines the conditions and requirements for autonomous vehicles operating on a typical German rural road with speed limits ranging from 70 to 100 km/h. The road type characterized by varying terrain, curves, and straight sections. These roads are designed to accommodate speeds ranging from 70 to 100 km/h, reflecting the variability of speed limits encountered on such roads. The road surface on these rural roads is typically paved with asphalt, providing consistent and reliable traction. Road conditions may vary, including dry, wet, and occasional snowy or icy surfaces, particularly during the winter months. Lane configurations on these roads consist of two or more lanes, allowing for overtaking and safe maneuvering. Lane markings are well-maintained and clearly visible to assist autonomous vehicles in navigation. Lane width complies with German road standards, providing sufficient space for autonomous vehicles to operate comfortably within the lane. This ensures safe operation even when encountering oncoming traffic or vehicles traveling at varying speeds. Traffic control and signs are in place to indicate speed limits, warn of curves. Speed limits on this road may vary between 70 to 100 km/h, depending on specific segments and conditions. Intersections, T-junctions, and roundabouts may be encountered along the route. Clear road signage, road markings, and potential traffic signals regulate traffic at these points to facilitate safe and efficient navigation. The roadside environment may include trees, hedges, or other natural features typical of rural areas. Autonomous vehicles should be prepared to encounter potential obstacles such as wildlife or agricultural vehicles. This ODD covers a range of weather conditions, including sunny, rainy, foggy, and snowy conditions. Autonomous vehicles must adapt to changing weather conditions and maintain safe operation throughout. The road may have varying slopes, both uphill and downhill, which autonomous vehicles should be able to navigate comfortably.

3 Project Sites: Switzerland

Switzerland boasts two distinct testing locations for the evaluation of innovative technologies. The Belle-idée site, known for hosting the AVENUE project, stands as one of these sites, while the Champagne area currently serves as the backdrop for the On-demand service. Furthermore, the expansion of the On-demand service will see the emergence of additional testing sites in the coming years.

At present, the Belle-idée site is outfitted with autonomous vehicles, allowing us to explore cutting-edge features associated with full automation—eliminating the need for onboard operators. Additionally, we are actively examining other advanced capabilities like V2X communication.

On the other hand, the Champagne area is exclusively dedicated to On-demand transport and serves as the perfect arena for assessing various enhancements to the service. This encompasses testing the On-demand service's improvements, implementing passenger monitoring systems, and evaluating other novel functionalities within this specific setting.

In anticipation of automated vehicles becoming market-ready for rural areas, we are fully prepared to replace the current On-demand services with automated transportation solutions. Our sites possess the flexibility to seamlessly transfer features and insights between them, showcasing the invaluable adaptability of the Geneva Pilot sites.

3.1 Project Site: Belle-Idée



Figure 4: Overview of Belle-Idée site

The Belle-Idée site stands as a testament to innovation and patient-centric design within the realm of healthcare and clam. Tucked away within the sprawling hospital complex, this serene haven is enveloped in greenery and pleasing landscapes. The thoughtfully curated surroundings not only provide a visually pleasant

experience but also contribute to the holistic healing experience by creating an environment of calm and tranquillity. Patients and their families find solace in the therapeutic benefits of this green oasis, as it allows them to momentarily escape the clinical setting and connect with nature.

At the heart of the Belle-Idée site's appeal lies its groundbreaking integration of autonomous vehicles. These cutting-edge self-driving vehicles, seamlessly coursing through the well-mapped routes of the site, serve as a symbol of technological advancement in healthcare. They offer an unmatched level of accessibility and convenience for patients, visitors, and staff members alike. Whether you are arriving for a scheduled medical appointment, moving between different sections of the facility, or departing after treatment, these autonomous vehicles ensure a journey characterized by efficiency and comfort. This forward-thinking

approach not only streamlines transportation logistics but also elevates the overall patient experience, setting a new standard for healthcare facilities worldwide.

In addition to its remarkable embrace of autonomous technology, the Belle-Idée site goes the extra mile to foster inclusivity and daily interaction with its shuttle services. Purpose-built pathways for pedestrians and cyclists not only encourage several encounters with the automated shuttle. These interactions are a crucial part for these autonomous vehicles.

Furthermore, the site's unwavering commitment to public transportation connectivity ensures that it remains accessible to all, regardless of their mode of transit. Buses seamlessly navigate through the premises, providing a dependable and eco-friendly means of access for those who rely on public transport. This commitment not only aligns with the hospital's ethos of sustainability but also minimizes the environmental impact of commuting, making it an exemplar of responsible healthcare infrastructure.



Figure 5: Centre of Belle-Idée

The Belle-Idée site stands out as a beacon of innovation and convenience with its cutting-edge covered depot dedicated to automated vehicles. Nestled within the hospital complex, this covered depot is a secure haven for automated vehicles, safeguarding them from the elements and always ensuring their operational readiness. Regardless of weather conditions, these vehicles remain sheltered and protected, guaranteeing their reliability and availability whenever required. Equipped with adjustable charging stations, and soon to be equipped with advanced diagnostic and monitoring equipment, the depot can be tailored to meet specific AV requirements. The depot supports the development of a

comprehensive fleet management system and monitoring for passengers. Advanced tracking and monitoring technologies enable the fleet operator comprehensive state of any situation related to the vehicle interior and its passengers, ensuring prompt responses to requests and optimizing the use of these cutting-edge resources.

In summary, the Belle-Idée site's fusion of tranquillity, cutting-edge autonomous vehicle technology, accommodation for diverse road users, and seamless integration with public transportation creates a paradigm shift in healthcare design.

3.2 Project Site: Champagne

The Champagne area, nestled in the tranquil Swiss countryside near Geneva, is a place where the beauty of nature meets the necessity of connectivity. While it boasts the charm of small villages and vineyards, it also recognizes the importance of efficient transportation links to Geneva or transportation hubs. This is where OnDemand services step in to bridge the gap and make the region more accessible and vibrant.



Figure 6: Champagne PUDO example

In a landscape where sprawling vineyards and idyllic hamlets define the scenery, establishing a fixed-line public transport system presents challenges. The low frequency of commuters and the relatively modest number of passengers traveling between these smaller villages and the bustling city center make traditional public transportation less viable. However, the emergence of automated vehicles designed for public transport heralds an exciting future for the Champagne area.

The introduction of automated, on-demand public transportation services is set to revolutionize travel in the Champagne region. As these advanced vehicles become available for countryside conditions, public transport authorities are poised to expand their services significantly, ensuring that even the most remote villages are seamlessly connected to the heart of Geneva.

With on-demand services, the Champagne area can offer flexibility that suits the unique needs of its residents and visitors. Passengers can request transportation when and where they need it, eliminating the wait times associated with traditional fixed-line schedules. This not only enhances convenience but also encourages greater usage of public transport, further reducing individual car dependence and mitigating traffic congestion.



Figure 7: The Champagne site

Moreover, the potential for automated vehicles to be equipped to navigate rural roads and challenging terrain in the Geneva surroundings holds great promise. With such capabilities, they could ensure safe and reliable transport, even in inclement weather conditions, ultimately enabling year-round accessibility to the region's natural and cultural treasures. However, it's important to note that these advancements have not yet been fully implemented in the area, but they represent a promising future possibility for enhanced transportation in the Champagne region.

As these technological advancements continue to evolve, the Champagne area anticipates a transportation renaissance. The landscape will be dotted with autonomous shuttles and buses, seamlessly connecting the charming villages, vineyards, and scenic vistas with the vibrant urban hub of Geneva. This transformation will not only enhance the accessibility of the region but also contribute to its sustainable development and preservation of its rural charm.

In summary, the Champagne area, with its stunning countryside and quaint villages, recognizes the need for efficient connectivity to larger cities. On-demand automated public transportation services are poised to revolutionize travel in the region, offering flexibility,

reliability, and expanded access to the Geneva surroundings. As technology advances, this transformation promises to make the Champagne area an even more enticing destination, seamlessly blending rural tranquillity with urban convenience.

3.3 Operational Design Domain (ODD) in Champagne

The Operational Design Domain (ODD) of the pilot will be explained in connection with the five distinct Road Profiles (RPs). The subsequent sections will provide more insight into the characteristics of the roads within each RP. A comprehensive depiction of each RP will be provided, accompanied by an illustrative example of a road within that RP.

3.3.1 Road Profile 1



Figure 8: Simple road summer Belle-Idée



RP1, representing the nadir of risk levels within the ODD (Operational Design Domain) assessment, is emblematic of the utmost safety and tranquility. Roads allocated to this category adhere to a stringent speed limit, capped at a sedate 30 km/h, and boast an exceptionally meager Average Annual Daily Traffic (AADT).

In the enchanting confines of the Belle-Idée site, the prevailing ethos is that of "slow roads," where verdant vistas merge harmoniously with an atmosphere of profound serenity. These thoroughfares, bearing the RP1 designation, encapsulate a leisurely pace that seamlessly integrates with the surrounding natural beauty, fostering an environment where potential risks are profoundly mitigated.

Within this idyllic landscape, these RP1 roads assume dual roles of paramount importance:

They serve as the lifelines for healthcare professionals, ensuring their untroubled ingress and egress to and from healthcare facilities nestled within Belle-Idée. This languorous pace guarantees a secure passage for medical personnel - doctors, nurses, and caregivers - as they embark on their noble mission of providing essential care to patients.

Moreover, these roads facilitate the efficient and safe transportation of indispensable medical supplies. Whether it be the swift conveyance of pristine linens or the secure transit of vital medical materials, vehicles ply these RP1 roads with unwavering ease, ensuring the seamless flow of critical resources.



Figure 9: Road profile 1 - Belle-Idée simple roads overview

3.3.2 Road Profile 2



Figure 10: Belle-Idée main road



RP2, the second-tier road risk profile in the assessment, represents a moderately higher risk level compared to RP1 but still emphasizes safety. These roads enforce a maximum speed limit of 30 km/h and maintain a moderately low Average Annual Daily Traffic (AADT) to ensure controlled traffic flow. Within the Belle-Idée site, RP2 roads contribute to the varied road environment, retaining the essence of "slow roads" while allowing for a slightly more active road atmosphere. They accommodate everyday vehicles, provide secure passage for residents and visitors, and support public transportation routes.

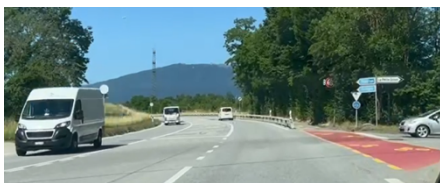


Figure 11: Road profile 2 - Belle-Idée main road

3.3.3 Road Profile 3



Figure 12: Champagne main road



RP3, positioned above RPs in terms of speed, introduces a somewhat middle risk profile. These roads feature a maximum speed limit of 90 km/h to 80km/h and exhibit a high Average Annual Daily Traffic (AADT). In comparison to the serene RP1 and the moderately active RP2, RP5 roads occupy a distinctive niche within the Champagne area.

What sets RP3 roads apart is their capacity to accommodate slightly higher speeds and traffic volumes, while still maintaining safety measures. They cater to specific transportation needs, particularly:

- **High Speed:** RP3 roads, with a 90 km/h speed limit, allow for a brisker pace compared to RP1, RP2 and RP4. This is balanced with the safety protocols and traffic management strategies to ensure secure travel.

- **High AADT:** While traffic on RP3 roads is more noticeable than RP5 it still maintains a high level of Average Annual Daily Traffic. This ensures smoother traffic flow without excessive congestion.
- **Road Characteristics:** RP3 roads encompass broader, well-maintained lanes with ample double lanes, bike and pedestrian separation, making overtaking other vehicles more accessible. This feature enhances traffic efficiency and safety for drivers.

In summary, RP3 roads strike a balance between speed and safety within the Champagne area. They accommodate high traffic volumes at peak hours while providing the necessary infrastructure for overtaking and efficient travel, making them a vital component of the transportation network.

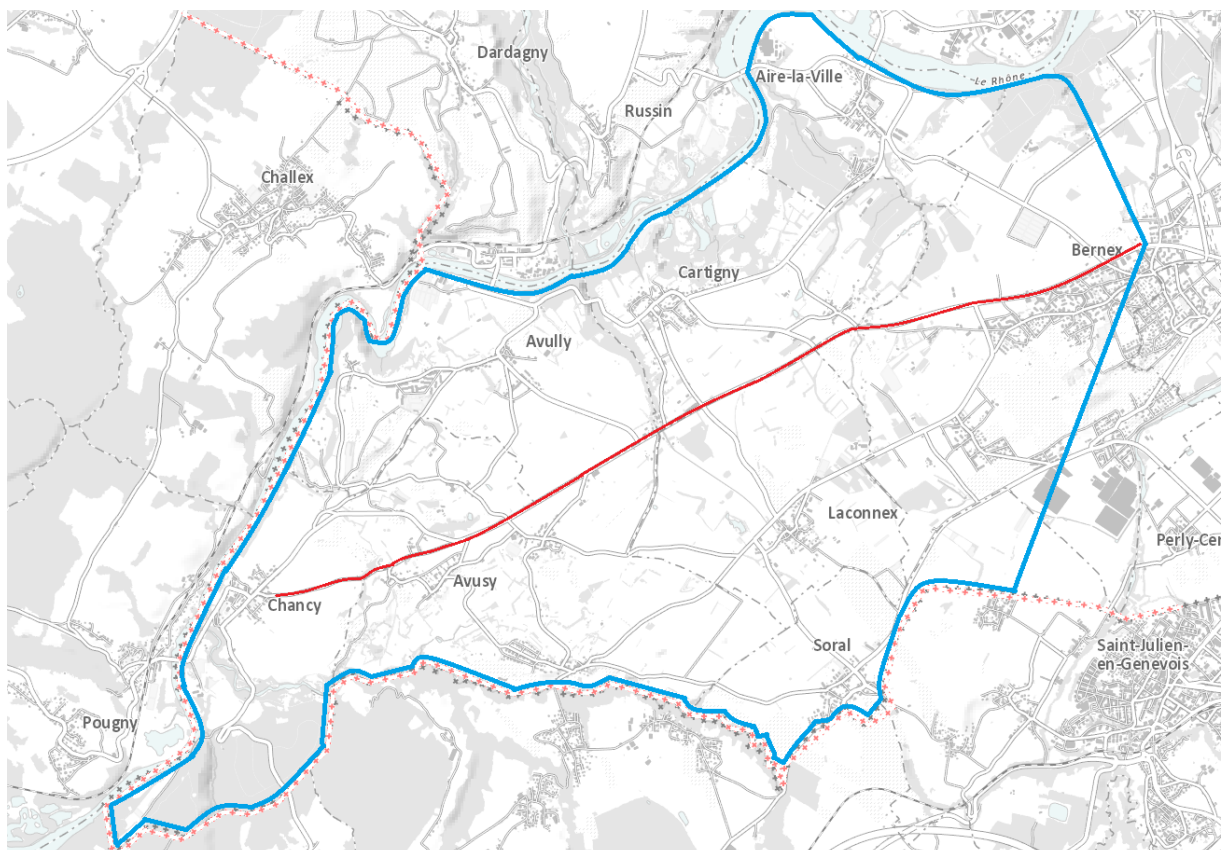


Figure 13: Road profile 3 – Champagne main clear road

3.3.4 Road Profile 4



Figure 14: Champagne villages



RP4, has a special place in the hierarchy of risk levels, characterizes a distinct mid to high-range risk profile. These roads feature a maximum speed limit ranging from 30 km/h to 50 km/h and exhibit a moderate to high Average Annual Daily Traffic (AADT). In contrast to the serene

RP1, the moderately other road profiles RP4 has a huge range of different situations due to the village configuration and sometimes tight area packed with pedestrians, sharp road angles... This is a common situation in the Champagne area since city centers are key drop-off points for the on-demand services, connecting diverse communities and catering to multifaceted transportation needs.

RP4 roads, with their specific attributes, cater to a wide range of transportation dynamics:

- **Moderate Speed Limits:** With speed limits ranging from 30 km/h to 50 km/h, RP3 roads balance the need for efficient urban travel with a focus on safety.
- **Diverse Vehicle Traffic:** These roads traverse through villages and urban areas, accommodating a myriad of vehicles, including cars, trucks, and bicycles, alongside the presence of pedestrians. The dynamic mix of traffic adds complexity and necessitates vigilance.
- **Challenging Narrow Sections:** Certain segments of RP4 roads may be narrow, requiring vehicles to slow down, come to a full stop, or even execute reverse maneuvers to navigate safely. These areas demand heightened attention and cautious driving.

In essence, RP4 roads serve as lifelines connecting communities and enabling daily life within the Champagne area. Their dynamic nature, featuring moderate speed limits and accommodating diverse traffic, underscores their significance in maintaining connectivity while ensuring safety within urban and village environments.

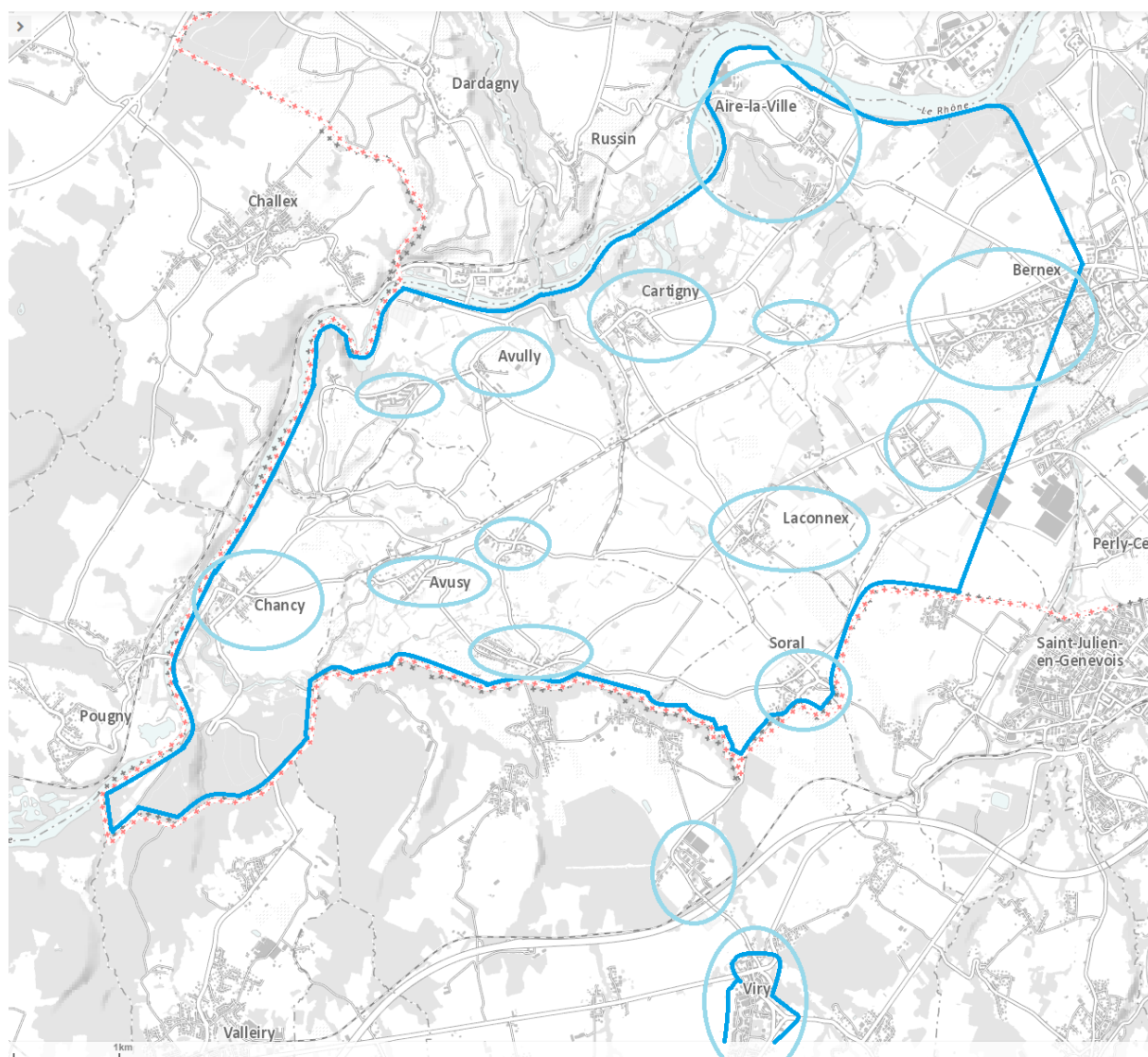


Figure 15: Road profile 4 – Champagne villages

3.3.5 Road Profile 5



Figure 16: Champagne secondary roads



Positioned close to RP3, RP5 roads encompass a unique character within the Champagne site's road network. RP5 roads are versatile and serve a multitude of transportation needs while been less accessible due to the narrower roads with less traffic but still less visibility but at a high speed mostly been 90km/h.

- **Mostly high-Speed Limits:** With speed limits spanning from 50 km/h where roads are too windy or dangerous to 90 km/h, RP5 roads allow for efficient travel while upholding safety standards, catering to both urban and interurban contexts.
- **Diverse Users:** These roads accommodate a wide range of road users, from pedestrians traversing on the side of the road to vehicles of various sizes, including trucks. The diverse mix of users necessitates careful navigation and mutual respect among all road participants.
- **Varied Road Conditions:** RP5 roads may exhibit varying road conditions, from stretches that are relatively wide and clear to sections that can be notably tight. The ability to adapt to changing road dynamics is crucial for both safety and efficiency.

RP5 roads serve as essential conduits connecting different parts of the Champagne area, facilitating the movement of people and goods. Their versatility, combined with the potential for diverse road conditions and users, underscores their pivotal role in maintaining the overall transportation network's functionality and safety.

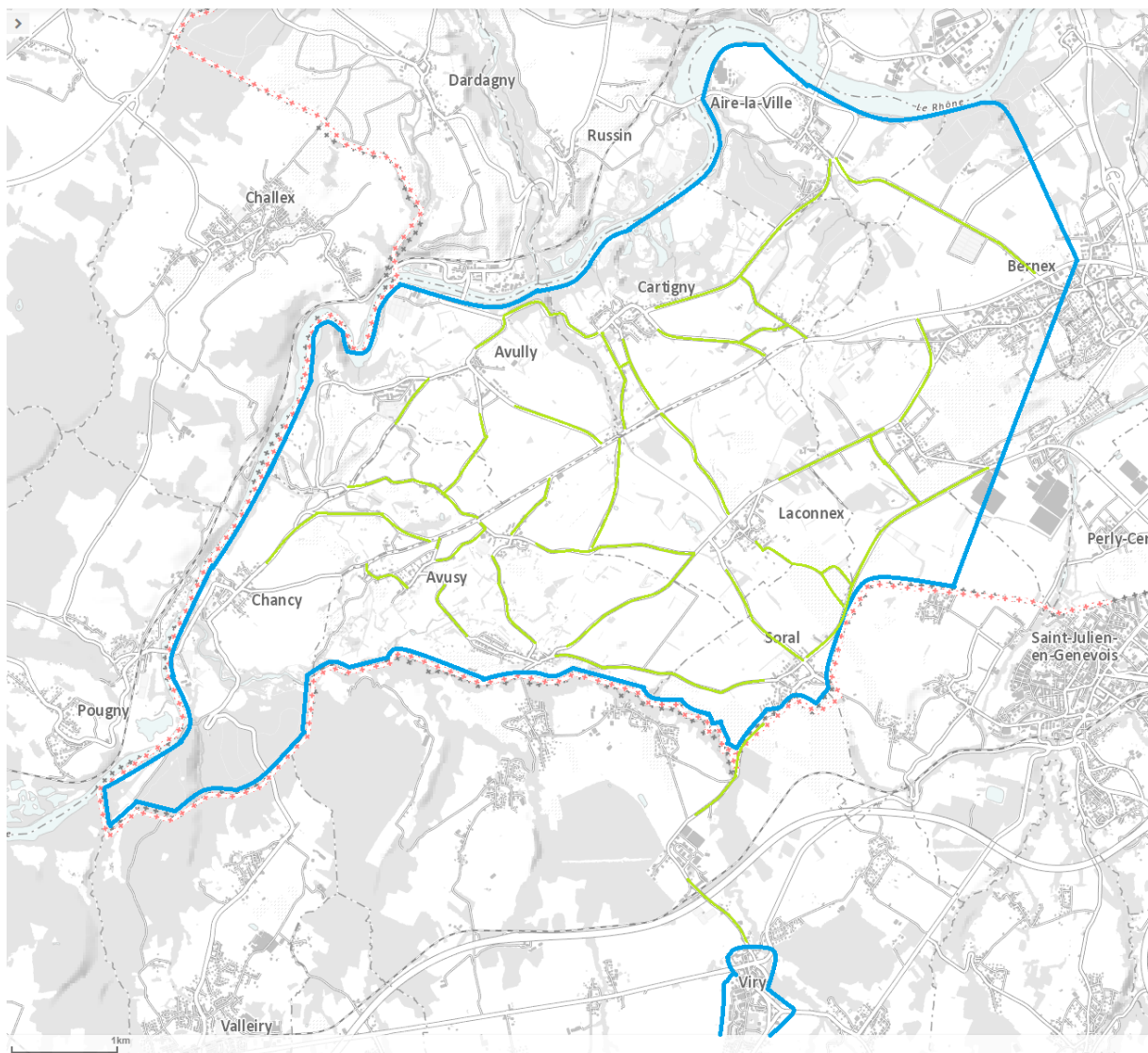


Figure 17: Road profile 5 – Champagne secondary roads

3.4 Roadmap Until 2026

In the coming years, TPG's strategic roadmap paves the way for the advancement of on-demand public transport and autonomous vehicles (AVs). This roadmap offers a detailed overview of our key initiatives and milestones, with a focus on significant events at the Geneva site and a rough estimated timeline.

1. Universal Accessibility (Target: Mid of 2024)

Our commitment to universal accessibility is at the forefront, with a particular emphasis on passengers with reduced mobility. Ensuring accessibility for all is a cornerstone of our mission as transporters. This accessibility will be enhanced and improved with a few iterations and testing done by different associations in the Geneva area.

2. V2X Implementation on Site (Target: End of 2024)

A top priority is the implementation of Vehicle-to-Everything (V2X) communication at the Belle-idée site. This represents a substantial leap forward in seamlessly integrating AVs into

our transportation network starting with autonomous vehicles that benefit the most from the V2X feature. By the close of 2024, we aim to establish V2X communication with infrastructure that facilitates real-time communication between vehicles and infrastructure, thereby enhancing safety and operational efficiency.

3. Depot Automation (Target: End of 2024)

Our commitment to automation extends beyond the vehicles themselves. By the end of 2024, we intend to achieve full automation of our depot on the Belle-Idée site. This strategic move optimizes vehicle maintenance, charging procedures, and overall operational processes. The outcome ensures that our AVs are always ready for service, minimizing downtime and maximizing operational efficiency. This process is a step closer to removing completely safty operators from AVs.

4. Testing Advanced and Robust OBUs for Onboard Passenger Monitoring (Target: End of 2024)

Safety and passenger experience take precedence. Ultimo is enhancing the advanced Onboard Units (OBUs) designed to monitor passengers within our AVs. By the close of 2024, we will commence testing the latest, more robust passenger monitoring OBUs, meticulously ensuring that they meet the highest safety and security standards while providing invaluable insights into passenger behavior.

5. Operational Testing of Passenger Monitoring Systems via OBUs (Expected in 2025)

In 2025, we will expand our testing to encompass passenger monitoring systems within an operational on-demand environment. This real-world testing will enable us to refine and fine-tune our passenger safety measures while gathering crucial data for continuous improvement relative to passenger feedback and surveys.

6. Introduction of advanced ADS technology vehicles (Target: End of 2025)

Our aspiration is to lead in autonomous mobility. By the end of 2025, we are determined to deploy a fleet autonomous shuttle for the Belle-idée site, entirely devoid of onboard drivers. This milestone represents a significant leap forward in our pursuit of safer, more efficient, and sustainable transportation solutions.

7. Deployment of a Second Fleet Orchestrator in Partnership with ZF for Logistics Enhancement

To bolster our logistics capabilities, we are forging a strategic partnership with ZF to deploy a second fleet orchestrator. This collaboration will ensure the efficient operation and management of our AV fleet, optimizing the supply chain of a logistics company and enhancing overall service delivery providing very useful insights into the future of logistics.

8. Implementation of Logistics as a Service (LaaS) (Scheduled for 2026)

Looking forward to 2026, we plan to introduce Logistics as a Service (LaaS), a revolutionary concept set to transform logistics operations for a company expert in logistics within the transportation industry. This initiative aims to provide logistics when passenger transportation is not needed, making them more efficient and adaptable to the ever-evolving demands of our customers.

Our strategic roadmap serves as a showing of our commitment to innovation, safety, and customer satisfaction. Together, with Ultimo partners we will continue to push the boundaries of on-demand public transport and autonomous vehicles, revolutionizing the way people and goods move within our possibilities.

3.4.1 Stakeholder Workshops with Open Geneva

Recently, OpenGeneva, in collaboration with TPG (Transports Publics Genevois), orchestrated a series of highly productive workshops right in the heart of Geneva. These workshops were a remarkable partnership initiative that brought together citizens hailing from an array of diverse fields of expertise. They served as invaluable platforms for fostering engaging discussions and knowledge sharing.

During these collaborative sessions, participants from various walks of life lent their voices to the dialogue, resulting in a wealth of constructive feedback and insightful perspectives. These interactions not only showcased the vibrant tapestry of ideas within the Geneva community but also highlighted the collective commitment to enhancing the quality of public transportation and urban life.

Building upon the resounding success of these workshops, TPG is firmly dedicated to continuing this collaborative effort and hosting future workshops. Our unwavering objective is to delve deeper into the perspectives of end users, embracing their invaluable insights and experiences. By doing so, we are poised to fortify our knowledge base and refine our services to align more closely with the evolving needs and expectations of the diverse communities we serve.

This ongoing commitment to engagement and co-creation underscores our vision of public transportation as a dynamic and evolving ecosystem. It underscores our determination to craft solutions that not only meet the immediate demands of our riders but also contribute to the long-term sustainability and vitality of Geneva's urban landscape.

As we look ahead, we envision a future where our public transportation services are not merely functional but also deeply enriching, enhancing the quality of life for all residents and visitors alike. The journey towards this vision is a collaborative one, and we eagerly anticipate the next chapter of engagement with our vibrant and diverse community. Together, we are steering the course towards a more accessible, sustainable, and inclusive Geneva.

3.5 Problem Descriptions

In the current project, we grapple with a significant and pressing issue: the scarcity of vehicles designed for public transportation to operate within autonomous systems at sufficiently high speeds on modern roadways. This predicament extends beyond our project and is a global concern, exacerbated by the absence of European manufacturers in this new market.

4 Project Site: The Groruddalen Valley in Oslo

The Groruddalen valley, situated northeast of Oslo's city center, encompasses the districts of Bjerke, Alna, Grorud, and Stovner. This area is home to approximately one in five of Oslo's 690,000 residents. The population here is projected to increase in the upcoming years. Notably, the districts in Groruddalen have a higher percentage of children and young people compared to the Oslo average. However, they have a lower proportion of young adults, while the share of older adults (40-66 years) and elderly individuals (67+) is higher.

The residential zones in this valley were planned as "satellite cities," featuring expansive apartment complexes separated by green spaces. These neighborhoods offer essential amenities like schools, kindergartens, shops, a shopping mall, and recreational opportunities. We find it interesting to explore how transport infrastructure development in the Groruddalen area could align with the changing demographics and urban layout. Additionally, investigating the potential implementation of autonomous vehicles within this context could bring about innovative solutions for enhancing mobility options in these satellite cities.

4.1 Current Public Transport Situation

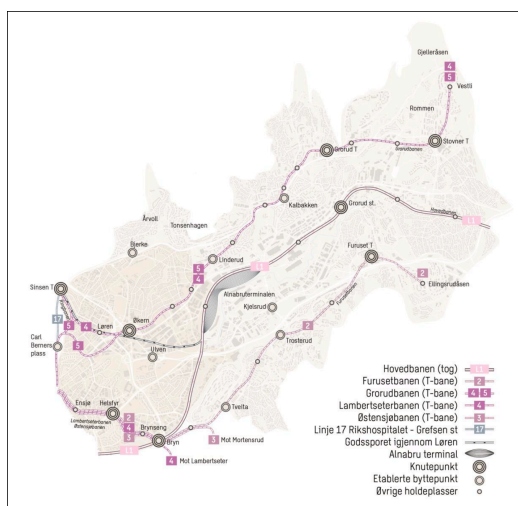


Figure 18: Metro and train in Groruddalen, Oslo

Two metro lines and two main highways run along the north-east/south-west axis of the valley, creating efficient transport towards the city centre and back. Local traffic within the valley, though, has several challenges:

- Internal travels amount to approx. 40% of all trips. The PT system has a poor competitive position compared to private cars, due to good access to parking lots and long transit time between transport modalities.

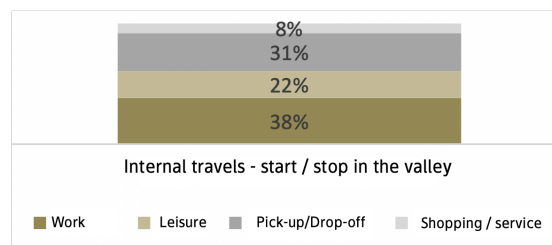


Table 3: Internal travels in Groruddalen, Oslo

- Private "pick-up and drop-off" journeys are lower than other areas in Oslo, indicating use of private car to a greater extent as a replacement for PT offering.

Road infrastructure

Three main highways run through the valley. These were designed to prioritize regional traffic. In addition, there are two highways running cross within the valley:

- Ring 3 – a ring road designed to relieve car traffic from the main highways, so it has a significant regional function.
- Rv 191 Nedre Kalbakkvei: important connection, especially for freight traffic to/from the Alnabru train terminal.

These highways are big barriers for pedestrians and other mobility modes like bikes and other micro-mobility options.

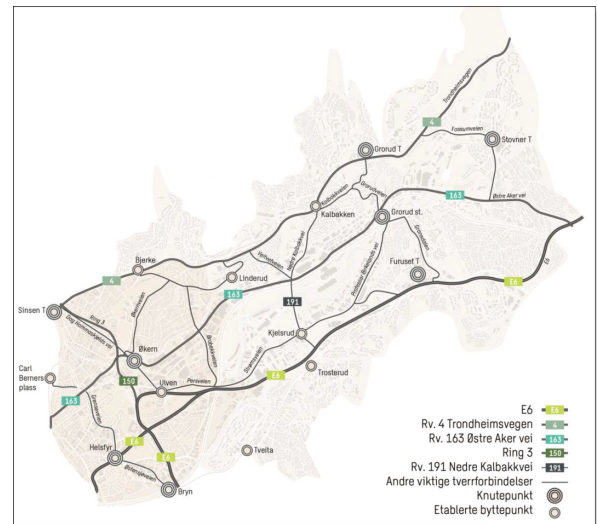


Figure 20: Highways and roads in Groruddalen, Oslo

Climate

Groruddalen offers an all-seasons ODD with high annual rain fall, proper winter with snow falls, icy roads and landscape covered by snow, and low-hanging sun during winter.

4.1.1 The Case for Running a Pilot

Improved mobility and a sustainable transport system for the population in our region.

Even though the public transportation system in the Oslo region is among the best in the world, the private car is still preferred for short trips in many cities and neighbourhoods. Private car ownership poses a considerable sustainability challenge to the Oslo metropolitan area – and it will continue to pose a challenge even if more and more of those cars become electric or even self-driving. If a growing population continues to rely on the private car and insists on driving one car each, the number of vehicles will eventually overload the road network. Furthermore, there is the issue of social sustainability: A transport system built around private car ownership places a significant disadvantage on those who cannot afford a car or are unable to drive, thereby increasing inequality rather than reducing it.

The introduction of shared self-driving vehicles into the public transportation system addresses several sustainability challenges: ride-sharing can reduce the number of vehicles on the roads, and we can reduce social inequality by providing a new form of flexible mobility to those who do not have access to their own car. Door-to-door mobility should not be limited to those who own a car; it should be available to everyone.

The transition to a sustainable society is urgent, and we in Norway and the Oslo region must do what we can to accelerate the adoption of new technology that addresses these challenges. We believe we are in a good position to contribute: We have a technologically competent population with high trust in public institutions and bipartisan agreement to invest in public transportation. While self-driving vehicle projects are being conducted in many countries, integrating them into public transport is not something that many have progressed far with, which makes the ULTIMO project pioneering work internationally.

Even in an automated future, public transportation will remain recognizable. Rail-based transport and high-capacity bus lines will continue to be the backbone of the system, efficiently transporting large numbers of passengers along the main routes. Vehicle staffing will also still be necessary in some cases; even though self-driving vehicles navigate the roads without a traditional driver, some customer groups (such as the elderly or people with disabilities) will still require human assistance on board. In the future, just like today, we will depend on skilled individuals who work in public transportation every day to enable the rest of us to move around where we want to.

As autonomous vehicle technology now is becoming increasingly mature, we must first and foremost put it to use where it can provide the greatest benefit for all residents of the region and for our planet—namely in the public transportation system.

4.1.2 Customer journey and key learning objectives

Ruter's AV initiative aims to make autonomous shared mobility the primary mode of transportation for most users, reducing the reliance on personal vehicles. The Groruddalen pilot is a crucial step in understanding the requirements to achieve this vision. It's important to note that this pilot, due to its limited scale, won't have a significant statistical impact on mobility in the area, nor can it immediately match the convenience of private vehicles.

Nonetheless, this pilot is a valuable learning experience. It follows a user-centric approach with a specific focus on several key aspects of the customer journey:

- **Technology Safety and Acceptance:** Ensuring that the technology is safe and gaining public acceptance is paramount.
- **Sharing Experience:** Understanding user needs, expectations, and pricing to create a comfortable and predictable shared mobility experience.
- **PUDOS (Pickup and Drop-Off Points):** Effectively communicating virtual pickup and drop-off locations to users.
- **Accessibility:** Identifying essential accessibility features for a shared AV service and developing solutions for users who may not benefit from the initial pilot.
- **Integration for Future Service:** Planning how an expanding fleet of AVs can seamlessly integrate with Ruter's existing services to provide a more convenient overall journey for passengers.

In summary, Ruter's AV initiative is about gradually transitioning towards a future where shared autonomous mobility becomes the norm, with the Groruddalen pilot serving as a valuable learning opportunity to pave the way for this transformation.

4.2 The Pilot Area

4.2.1 General Information About the Pilot Area

To document and evaluate the entire Groruddalen, a visual inspection of every single road would be an extremely time-consuming task. Also, with the large amount of data available from the Norwegian authorities, a data driven approach has been found to provide a more accurate assessment of the pilot area.

Data regarding one-way streets, speed limits, sidewalks, round-about etc. has been extracted from the Nasjonal Vegdatabank (NVDB) and visualised using the Geographic Information System QGIS. By using this data, it has been possible to assess all roads in the area based on the speed limit, annual average daily traffic (AADT) and other traffic data such as the presence of sidewalks.

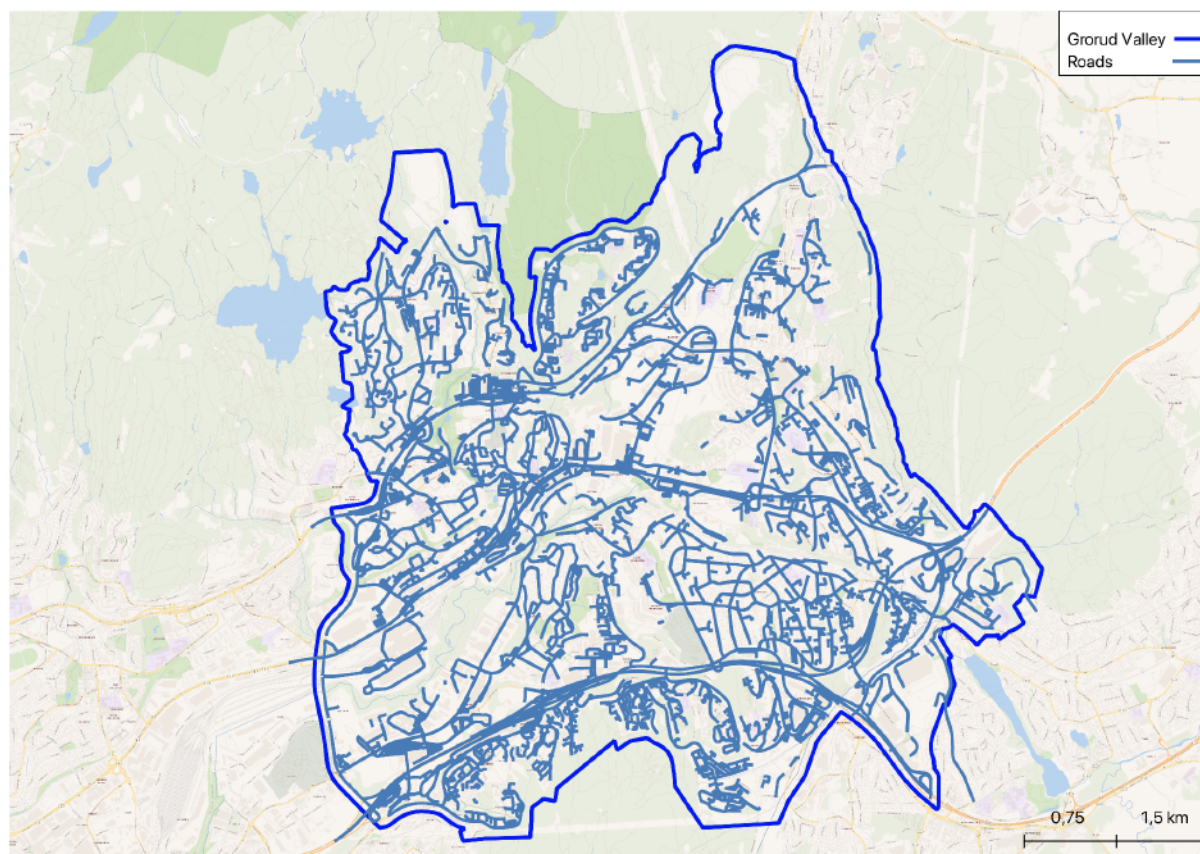


Figure 21: Roads in Groruddalen

By using the data available in NVDB, all the roads in Groruddalen have been categorised into one of the six road profiles presented in the table below:

Road profile	Total length of roads
1	33.5km
2	154.7km
3	11.4km
4	40.8km
5	26.9km
6	22.0km

Table 4: Road profile with total length

These Road profiles are derived from a combination of traffic density and speed limits. Traffic density is measured as Annual Average Daily Traffic (AADT), which describes average

daily traffic based on the total annual traffic. The table below gives a full overview of the pilot areas AADT in relation speed limits, resulting in the road profiles:

AADT	Speed					
	30 km/h		40 km/h	50-60 km/h	70-80 km/h	90 km/h
<800	1	2	3			
<3000	2		3	4	5	
≤9000	3		3	4	5	6
>9000			4	5	6	6

Table 5: Annual Average Daily Traffic (AADT)

For each road profile, the table below presents all types of roundabouts, intersections, traffic lights, pedestrian crossings found in the pilot area.

Road profile	Number of roundabouts	Number of 3 legged intersections	Number of 4 legged intersections	Number of traffic light regulated intersections	Number of mergings	Number of pedestrian crossings
1	1	25	6	0	0	68
2	1	97	10	0	0	38
3	0	46	10	2	0	76
4	3	59	3	0	0	52
5	7	23	3	8	0	37
6	7	0	0	0	1	1*

Table 6: Road elements present in each road profile

Additionally, the data regarding private or municipal roads is limited in the National Road Database (NVDB). This requires manual reclassification of roads, particularly smaller ones, that have been categorised without sidewalks. This manual process is crucial in creating an accurate representation of the area.

4.2.2 Operational Design Domain (ODD)

The Operational Design Domain (ODD) of the pilot will be explained in connection with the six distinct Road Profiles (RPs). The subsequent sections will provide more insight into the characteristics of the roads within each RP. A comprehensive depiction of each RP will be provided, accompanied by an illustrative example of a road within that particular RP.

4.2.2.1 Road Profile 1

RP1 is the lowest risk level considered in the ODD assessment. Roads that fall into this

classification have a maximum speed limit of 30 km/h and an AADT below 800. Additionally, they must have a regulated one-way system or include level-separated sidewalks.



Figure 22: Example of Road Profile 1

Displayed in figure above is the Groruddalen region with RP1 roads highlighted. These roads are predominantly situated in residential areas.

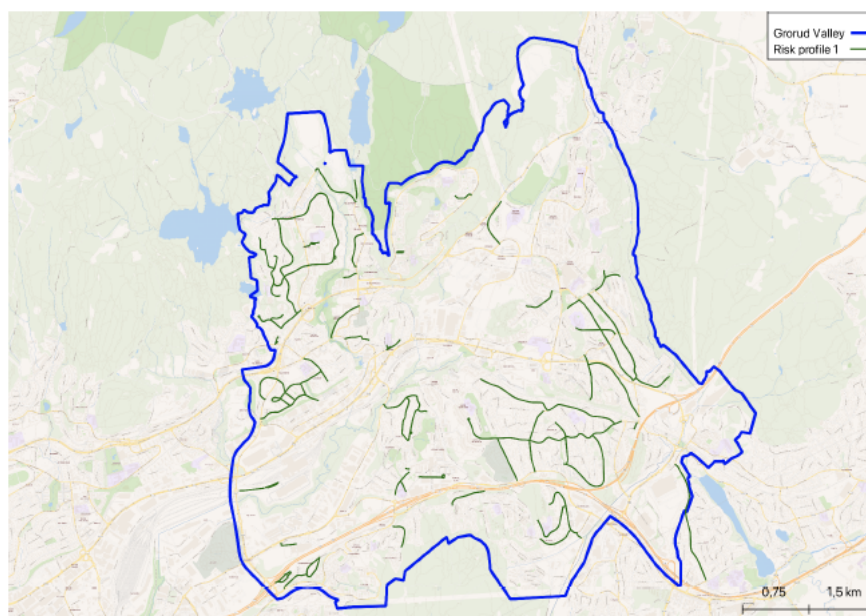


Figure 23: Groruddalen region roads with road profile 1

4.2.2.2 Road Profile 2

RP2 is the second lowest road profile considered in this assessment. According to the assessment criteria, roads classified as RP2 are subject to a maximum speed limit of 30km/h and an AADT range of 800 to 3000. Also, if a road lacks level separation between vulnerable road users and vehicles, even if it has a 30 km/h speed limit and an AADT below 800, it is classified as RP2. The majority of roads in the Groruddalen area fall into this category. Figure below shows an example of a RP2 road.



Figure 24: Example of Road Profile 2

In terms of road length, RP2 surpasses all other risk categories significantly. Similarly to RP1, a vast majority of RP2 roads are located within residential areas, but with a more dynamic environment between vulnerable and heavier road users compared to RP1. Figure below serves as a visualisation of the locations of RP2 roads within the Groruddalen area.

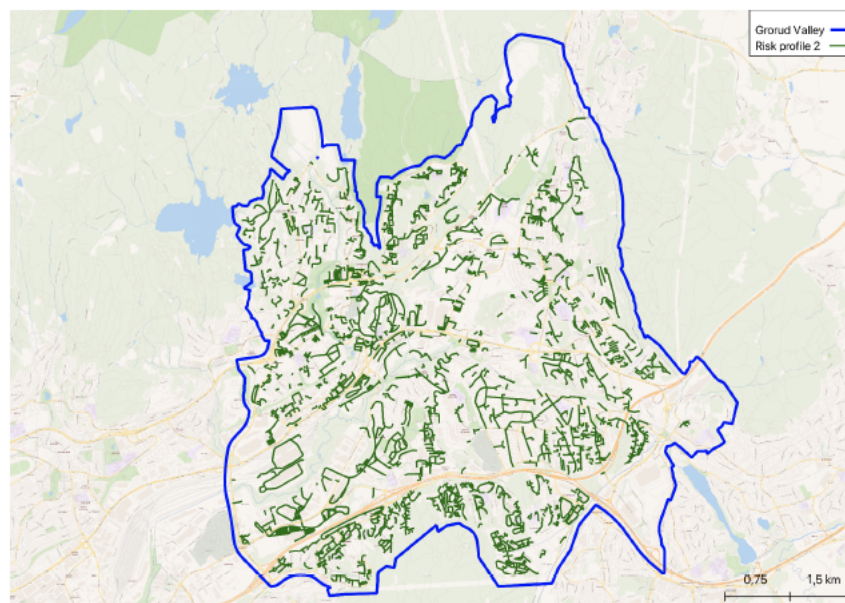


Figure 25: Groruddalen region roads with road profile 2

4.2.2.3 Road Profile 3

Roads falling within the range of 3000 to 9000 AADT with a maximum speed limit of 30km/h are categorised as RP3. Furthermore, all roads with a speed limit of 40km/h and an AADT below 9000 are also placed in this RP.



Figure 26: Example of Road Profile 3

RP3 encompasses the smallest road length, amounting to a mere 11.4km. Figure above illustrates that RP3 roads are broader, with a degree of separation between heavier and vulnerable road users, and therefore permitting a higher speed limit. However, even at the maximum allowable speed limit of 40km/h, the speed limit remains relatively low in relation to the size and capacity of these roads. Figure below presents the distribution of RP3 roads within the operational area.

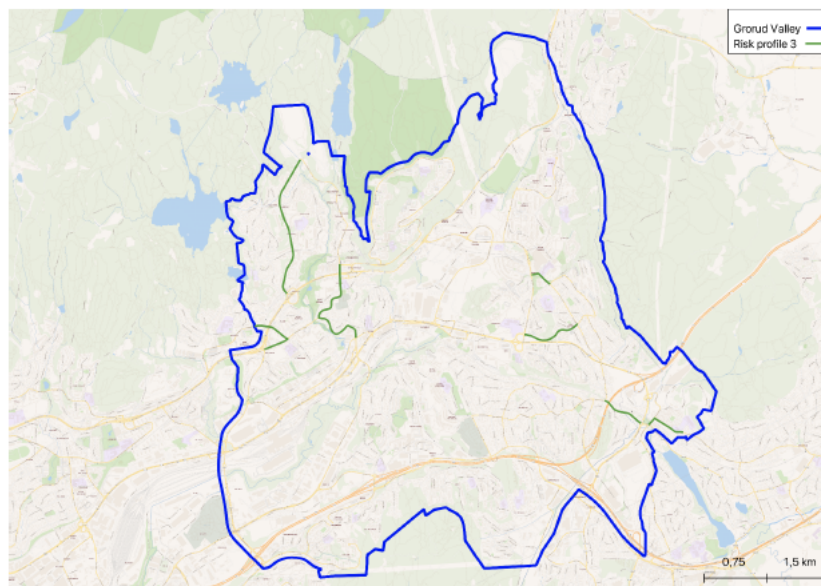


Figure 27: Groruddalen region roads with road profile 3

4.2.2.4 Road Profile 4

Roads that have a maximum speed limit of 40km/h but an AADT exceeding 9000 fall under RP4. Additionally, roads with a speed limit ranging from 50 km/h to 60 km/h and an AADT below 9000 are also categorised as RP4.



Figure 28: Example of Road Profile 4



Figure above portrays that RP4 roads are broader and permit a higher speed limit in comparison to those in RP3. These roads typically serve as intersection points for multiple RP2 roads. Figure below provides an overview of the locations and layout of RP4 roads.

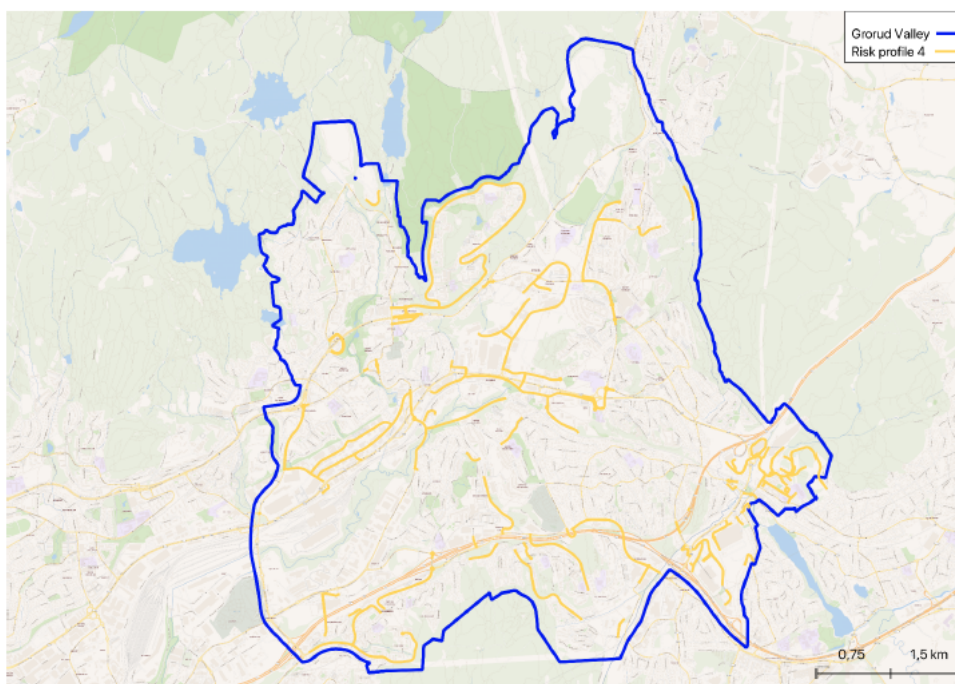


Figure 29: Groruddalen region roads with road profile 4

4.2.2.5 Road Profile 5

Roads with a speed limit of 50 km/h or 60 km/h and an AADT beyond 9000 are classified as RP5. Similarly, roads with a speed limit ranging from 70 km/h to 80 km/h and an AADT less than 9000 are also placed in this category.



Figure 30: Example of Road Profile 5



RP5 comprises exit roads or sections of highways leading to or from Oslo, including merging-points that connect with RP6 roads. From figure below it can be seen that the RP5 roads are concentrated around the largest traffic arteries in the area.

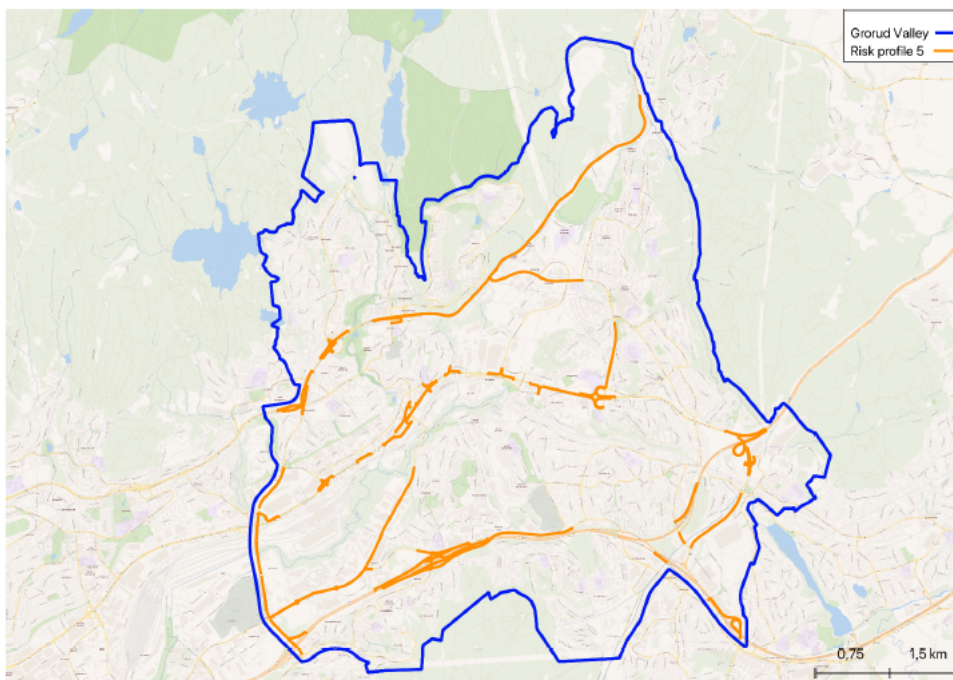


Figure 31: Groruddalen region roads with road profile 5

4.2.2.6 Road Profile 6

RP6 is the highest road profile considered in this ODD assessment. Roads with a maximum speed limit of 70 km/h to 80 km/h and an AADT exceeding 9000 are categorised as RP6. Furthermore, roads with a speed limit of 90 km/h, regardless of the AADT.



Figure 32: Example of Road Profile 6

Figure above highlights that road profile 6 roads are the most extensive transportation arteries within the Groruddalen region. These highways feature high traffic volumes and have the highest speed limits in the area, serving as crucial roads for regional transportation. Moreover, they are well-connected, allowing for seamless navigation and accessibility, and can be easily avoided if needed. The sort of highway that exists in RP6 has clear lane markings and two-way lanes.

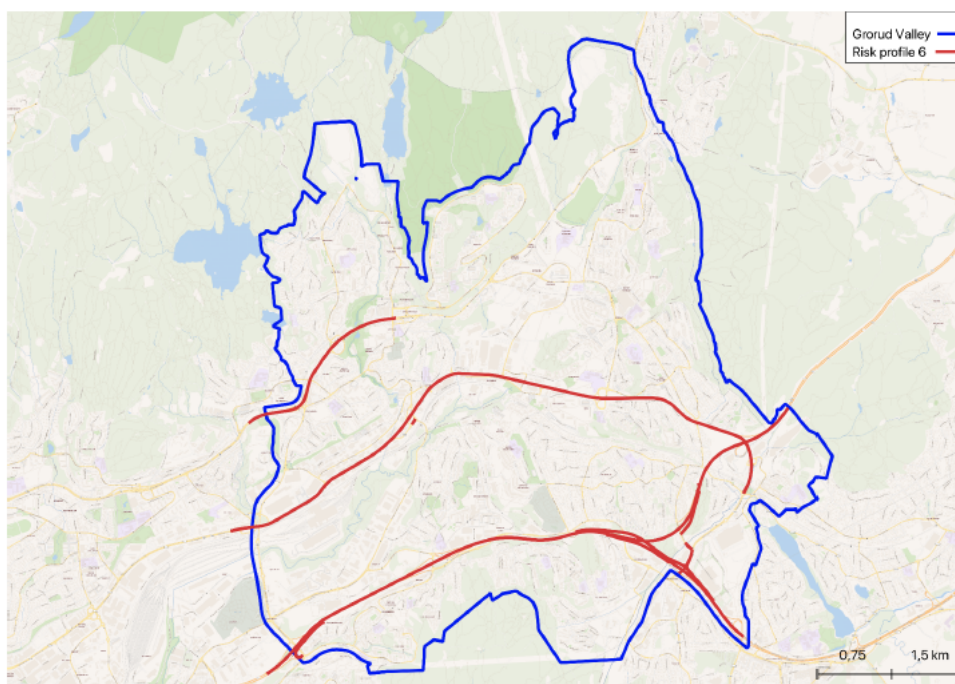


Figure 33: Groruddalen region roads with road profile 6

4.2.3 PickUp and DropOff – Points (PUDOs)

The end goal is for the AVs to be able to stop anywhere except areas where no stopping is allowed, due to road regulation or self-imposed restrictions. The figure below illustrates our hypothesis on how we are going to achieve that goal in a step by step approach.

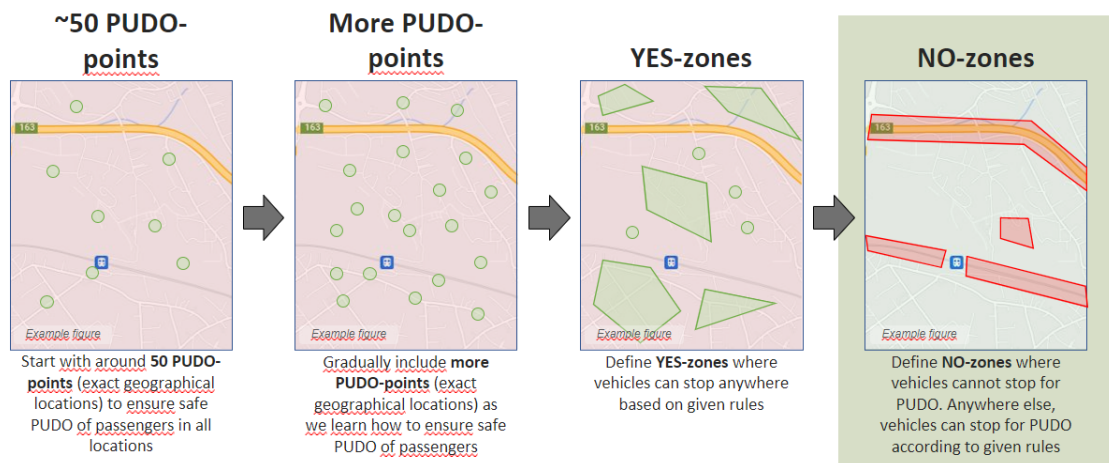


Figure 34: PUDO points evolution

Learning objectives

Throughout this process we wish to learn more about:

- Different types of PUDOs required and operational requirements
- Where is it not possible to stop and how can we digitalise that information?
- How to combine fixed and dynamic stops?
- What is required at PUDOs when moving from SAE level 2 to 4?
- Are there any special requirements for stops at schools and PT hubs?
- What is required at virtual stops?

The approach

We started identifying approximately 50 pick-up and drop-off points across the pilot area. PUDOs were chosen based on a mixture of;

- Proximity to customers
- Existing PT services and points of interests
- AV accessibility. Avoid reversing
- Traffic safety (lighting, feels safe, safe waiting area, visibility, speed limit, special considerations by schools)
- Traffic flow (area size, traffic volume, speed limit)
- Comfort level (low priority in the pilot)
- No-stopping areas (according to Norwegian traffic regulation)

Simulations using a total of 59 points indicated the need for a significant increase in number of stops in order to provide a service that was available to the majority of people living in the area. We therefor increased the number of PUDOs to 135. The second simulation indicated a coverage of 92% of all residents in the area and 71% of employees, given up to 400 meters walking distance. We believe that up to 135 PUDOs might suffice in the pilot, however when scaling up we would like to aim for a shorter walking distance closer to 200 m, and ultimately being able to stop “anywhere”.

Walking distance	Residents in the area	Employees in the area
200m	37 600 (46%)	24 500 (37%)
300m	63 900 (78%)	42 100 (63%)
400m	75 800 (92%)	47 100 (71%)

Table 7: Simulation of coverage with 135 Pick-up and Drop-off points. The coverage varies with the walking distance. august 2023

The first 59 points have been categorised by type of area, and type of stop (infrastructure). We have purposely chosed a variety of types in order to learn as much as possible. The majority of points are placed in residential areas. Typically, in turning areas or existing bus stops and parking lots (accessibility).

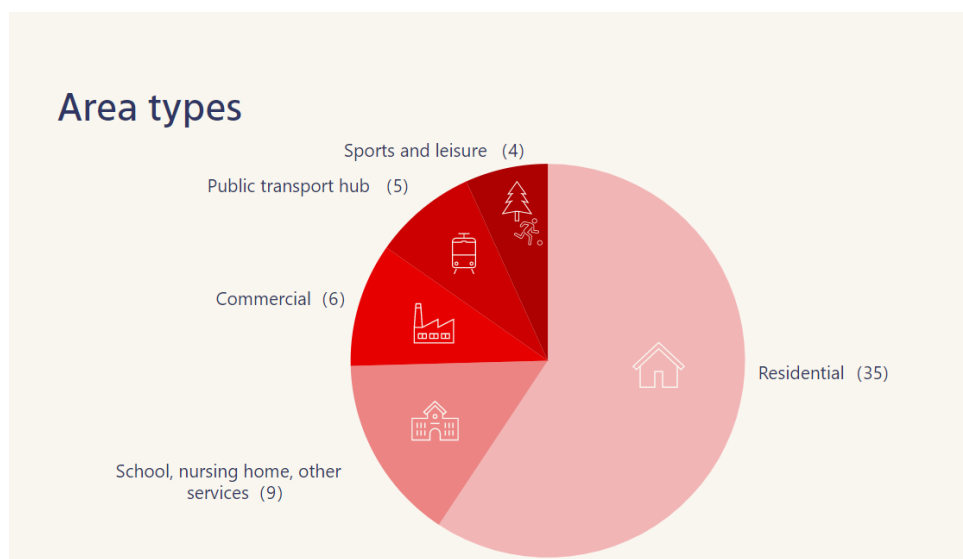


Table 8: The number of Pick-up and drop-off points grouped by area type.

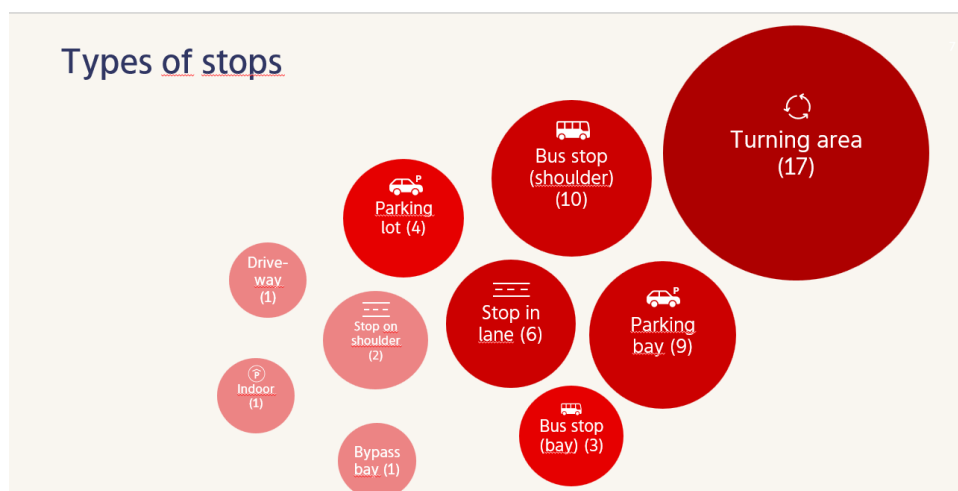


Table 9: The number of Pick-up and drop-off points grouped by stop type

In addition to pick-up and drop-off points there will be a smaller number of break stops (facilities for safety drivers) and wait stops (holding area in between tips, if needed). Taking into account the geographical size of the pilot area, we believe 1-2 centralised break stops will be sufficient. When choosing wait stops we have made the following considerations:

- Proximity to potential customers (i.e expected areas with high demand and other central locations across the pilot area).
- There must be enough space across all wait stops to support the total AV fleet. The capacity (no of vehicles) at each wait stop is registered.
- Parking must be allowed

4.3 Current Activity

4.3.1 Ruter's R&D Partners

Ruter is a Public Transport Authority (PTA) in Oslo and surrounding region. We administrate public transportation, using multiple operators through public tenders. Hence, we rely on having external R&D partners to provide additional financing and services to our initiatives.

4.3.1.1 Holo

Since 2019, Ruter has a contract with Holo as an R&D-partner. Together we have run the previous AV pilots. Holo will operate the services in our pilot based on Mobileye Technology on Nio SUVs. They will continue to be our partner /"operator" for the Groruddalen project, implementing and operating 15 MobileEye-vehicles.

Holo is the leading operator of autonomous vehicles in Europe with activities across the Nordic and Baltic region. Holo will be responsible for getting the vehicles safely on the roads of Groruddalen and leading the application and approval related work both related to SAE level 2 permit and later SAE level 4 permits. During operation, Holo's role is to staff the vehicles with trained safety drivers, ensuring safe and stable operations with AVs. Holo will also be responsible for supporting the operation with the first line of Supervision and expert support.

4.3.1.2 Mobileye

Mobileye's technology keeps passengers safer on the roads, reduces the risks of traffic accidents and has the potential to revolutionise the driving experience by enabling autonomous driving. ME proprietary software algorithms and EyeQ® systems on chip (SoC) perform detailed interpretations of the visual field in order to anticipate possible collisions with other vehicles, pedestrians, cyclists, animals, debris and other obstacles. Mobileye's products are also able to detect roadway markings such as lanes, road boundaries, barriers and similar items; identify and read traffic signs, directional signs and traffic lights; create a RoadBook™ of localised drivable paths and other landmarks using REM™ technology; and provide mapping for autonomous driving.

Mobileye's technology is deployed on over 50 million vehicles of more than 25 car manufacturers around the world. Currently the company numbers approximately 3,000 employees. Mobileye is testing its AV technology with AV Test Vehicles in Israel and continuously expands to other regions with the goal to develop and validate the AV technology for consumer vehicles as well as self-driving Mobility-as-a-Service (MaaS) vehicles.

4.3.1.3 Moovit

Moovit is an Israel-based Mobility-as-a-Service provider and journey planner app. Moovit is owned by Intel through the Mobileye subsidiary since 2020. For the Groruddalen pilot project Moovit will deliver their mobility as a service white-label app to Ruter, which allows travellers to book trips for the service, herunder enabling sustainable transportation solutions for ride-sharing.

4.3.2 MobilEye and NIO Vehicles

The vehicles that will be used for the Grorud Pilot Project will be of the type Nio ES8, retrofitted with Mobileye autonomous hardware and software. The Nio ES8 is a battery-powered, 6 or 7-seat full-size SUV, manufactured by Chinese electric car company; Nio.

Mobileye will retrofit the vehicles with hardware in order for the vehicles to drive autonomously. The Nio ES8 vehicles are today already deployed by Mobileye in autonomous operation in Israel and are at this point in time being deployed in München, Germany after approval has been granted by technical service and third party agency; TÜV Süd.

The vehicles are shown in the below photos.



Figure 35: NIOs ready for shipping to Oslo



Figure 36: - First draft of NIO branding

4.4 Plans Forward, Roadmap Next 12 Months

The Groruddalen site has recently started a more operational phase of the pilot project. Throughout July and August 2023 all roads within the pilot area have been digitally mapped, and the first AVs are expected to arrive in Oslo by the end of September. As all pilot projects in this domain, the timeline is subject to uncertainty and heavily depends on when the vehicles will be approved for operation on Norwegian roads. However, the expected timeline for the next 12 months is outlined below.

- **Preparation of operation:**
 - Finalize digital mapping of the pilot area (September 2023)
 - Vehicle shipment to Oslo (September 2023)
 - Registration, vehicle inspection and wrapping (September/October 2023)

- Permit for operation with safety drivers (fall 2023)
- Preparation of garage facilities (September/October 2023)
- Finalization of trainers training / safety driver education (October 2023)
- Hiring and training of safety drivers and supervisors (Q4 2023)
- Start validation driving in the pilot area (Q4 2023)
- Testing and validation of platform for fleet management (Q1 2024)
- Collaboration with emergency services (continuously throughout pilot)
- **Industrial research**
 - Video analysis of high-risk situations in parallel with adaption of the technology to Norwegian conditions (TØI - Institute of Transport Economics)
 - Verification of the technology's fit to the expectations and needs of central user groups, in parallel with tailoring service for public transportation (CICERO - Center for International Climate Research)
- **Customer journey and service definition:**
 - Continue definition of service parameters
 - Scenario testing and user interviews
 - Design and customization of customer app and in-vehicle screens
 - PUDO testing and validation (locations and physical/digital visibility)
 - Prioritization of use cases and adaptations for PRMs given pilot restrictions
 - Customization of physical vehicle interior
 - Testing and validation of customer app
 - Customer service setup
 - Definition and testing of different price models
 - First limited user tests (spring/summer 2024)
 - Public service (TBD)
- **Interoperability/standardization**
 - Conclusion of process for additional R&D partners
 - Planning and preparation of testing interoperability with multiple AVs and fleet management systems
- **Communication and involvement**
 - Communication activities, including showcasing vehicles/service for the public
 - Involvement of residents and stakeholders

5 Conclusion

The ULTIMO project is not merely focused on deploying "demonstrators"; its core objective is to establish commercially viable CCAM services in practical, day-to-day operation, mirroring the quality standards of traditional public transportation services.

Each project site presents unique starting conditions. Oslo is set to launch vehicles as early as this autumn. In Geneva, an existing service area will undergo expansion, while in Germany, considerable efforts have been invested in locating a new pilot area.

This variation aligns with our expectations. These sites are designed to contribute input to activities in other work packages, while conversely, other work packages will provide input for pilot confirmations. This dynamic fosters an iterative synergy, facilitating continuous learning shared among consortium participants.

The availability of vehicles is also a concern, given the current landscape for European manufacturers of automated vehicles. The timeline for Level 4-capable vehicles for public transportation remains uncertain. The recent bankruptcies of Sensible 4 and Navya exemplify the industry's challenges.

AVs are on the brink of commercialization, with several international companies achieving Level 4 autonomy in select areas. However, there is still much innovation to be done at the service level.

Nonetheless, the primary objective remains consistent across all ULTIMO sites: to establish a foundation for large-scale CCAM services in high passenger frequency areas, utilizing vehicles from diverse manufacturers with varying capabilities. These services will operate under an integrated, open, and interoperable fleet management system. Our ambition is for these services to persist beyond the project's conclusion and expand with the support of Public Transport Authorities/Operators (PTA/PTOs).