



Advancing Sustainable User-centric
Mobility with Automated Vehicles

DELIVERABLE

D5.2 Large Scale Demonstration Report – Second version



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Version Comparison Summary

Delivery D5.1 Large Scale Demonstration Report was submitted on September 30, 2023. This delivery – D5.2 – has the former report as basis, and updated with lessons learned and insights based on what has happened over the past year.

The main changes are summarized in the following table:

Topic	D5.1	New / added in D5.2
Herford, Germany		
Description of the pilot area	General description of area, current public transportation	Potential project site added
Roadmap 2026		Road map updated to current status
Stakeholder Workshops	Description of the planed work shops	First co-creation workshop in Herford took place (chapter 2.2.1.)
Vehicle availability		Updated to the current situation
Approval process	Description of the approval process in Germany	Updated and explained in more detail
ODD	General description of the road types	Detailed explanation of the ODD of the first route including weather conditions
Security operators		New chapter; Requirements for safety drivers
Infrastructure & V2X		New chapter; Explaining the planed infrastructure and depot automation
MaaS Integration		New chapter; Description of the current status of implementation and planned work on accessibility
PUDO		New chapter; Legal situation for PUDOs in Germany
Passenger monitoring		New chapter; Overview of the planned activities
Approach Level 4 Training		New chapter; Plans for Level 5 training in the future
Pricing strategy		New chapter; Current status of discussion regarding pricing strategy in Herford
Switzerland		
Extension of the pilot area	General description of area of Champagne only	General description of area ZIPLO area in Champagne and added new zone of Mandement.
Security operators		Added a complete section on the security operators and how we see things.
Infrastructure		Small sample of infrastructure wished for in Geneva.

Universal accessibility	This is a topic of high importance and a legal obligation to be compliant in Switzerland.	
App	Status of the apps for TPG clients for LaaS and On-demand transport and other apps destined to end users.	
Passenger monitoring	This is crucial for TPG to replace the driver and guarantee the best for passengers.	
Operations statistics	Statistics are the most important information gathered and will totally improve our services.	
Weather conditions	Weather conditions for the region of Geneva.	
Approach on L4 training	Our approach on L4 training and integration of possible students as operators.	
V2X	V2X covered for the depot as well as future possible use of V2X.	
PUDOs	Our take on PUDOs in the countryside area and experience with virtual PUDOs.	
Approval process	What is Geneva’s approach on approval process and the status.	
Pricing strategy	Pricing will not come soon but is of interest.	
Depot automation	The automation of the depot is of high importance for Geneva.	
Status on vehicles	The actual status on the vehicle.	
Market elaboration	Small description of our market elaboration done at TPG.	
Roadmap Until 2026	Did not need update for now.	
Oslo		
Description of the pilot area	General description of area, current public transportation	
	Scenario descriptions	
	Key learning objectives	
	General description of the operational area	Further description of the area, looking into a standardized description of ODD based on ISO 34503
PUDO, ODD	General plan on identifying and validating Pickup and DropOff points (PUDOs)	Further elaborations on PUDO, status of the work, elaborations on route selections and validations, comparison with parallel DRT project in Ruter on PUDO identification and validation. Lessons learned.
		ODD feature: weather conditions in the operational area

Winter conditions		Initial experience and lessons learned from first winter driving.
Vehicles	General about the first five vehicles from Mobileye/NIO	Branding strategies
	Primary R&D partners	Status on additional vehicles and technology providers
Operations		HD map coverage
		Operational data and analysis from first period of driving
		User testing, elaborations and strategies. Key insights from first use tests.
		Recruiting and training av safety operators
Approval		Elaboration on Norwegian legislative framework, approval process and status for the pilot.
Price strategies		Current elaborations on pricing of the service.
Industrial research		Overview of industrial research being done based on the pilot
Plans and KPIs	Plans for 2023/2024	Status of previous plans, and updated plans for the coming year 2024/2025
		Update on KPIs as stated in the Grant Agreement

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Acronyms

AADT	Annual Average Daily Traffic
ADS	Automated Driving Systems
AI	Artificial Intelligence
AFGBV	Autonomous Vehicle Approval and Operation Regulation (Germany)
ALARP	As Low As Reasonably Practicable
ALKS	Automated Lane Keeping Systems
API	Application Protocol Interface
AV	Automated Vehicle
B2B	Business-to-Business
CCAM	Cooperative, Connected, and Automated Mobility
CERTH	Centre for Research & Technology Greece
CICERO	Center for International Climate Research
DB	Deutsche Bahn
DRT	Demand-Responsive Transport
ETA	Estimated Time of Arrival
HD map	High Definition map
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
KBA	Kraftfahrt-Bundesamt – Federal Motor Transport Authority (Germany)
KPI	Key Performance Indicator
LaaS	Logistics as a Service
LiDAR	Light Detection and Ranging
LOI	Letter of Intent
NVDB	Nasjonal Veidatabase / National Road Database (Norway)
MaaS	Mobility as a Service
ME	Mobileye
NOK	Norwegian Krone
OBU	On-Board Unit
ODD	Operational Domain Design
PbefG	Personenbeförderungsgesetz – German Passenger Transport Act
PDCA	Plan Do Check Act/Adjust
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
RSD	Road Segment Data
RUT	Ruter As
RVU	National Travel Survey (Norway)
SAE Level	Society of Automotive Engineers Level (Vehicle Autonomy Level)
SMO	Shuttle-Modellregion-Oberfranken
StVZO	Straßenverkehrszulassungsordnung – German Highway Traffic Act
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.)
WCAG	Web Content Accessibility Guidelines
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 descriptions of the operational areas, road profiles, and socio-demographic factors that influence the design of the service.

It has been a year since the previous delivery, D5.1. A lot of work has been done in the project overall. As the project progresses, more and more work packages are being integrated with each other. This is reflected in the report, where parts are duplicated and/or discussed in a somewhat more general manner in relation to the work package(s) that cover specific topics.

Work packages 2 (Passenger use cases and vehicle ODDs), 3 (Vehicle and AV fleet management open APIs), and 4 (AI leveraged services for MaaS passengers, LaaS users, Vehicle and Infrastructure), in particular, set the stage for much of what is being tested at the sites. This is a continuous, iterative process. While these work packages form the basis for what we aim to trial at the sites, the limitations and opportunities that arise when we first introduce vehicles and services will create a feedback loop to the working groups within the various packages.

Work package 6 (All impact evaluation and transformation towards an AV in ITS/CCSAM ecosystem) can now begin to receive data from the actual testing of the service and will play a more significant role as the project progresses into its second half.

In summary, this report addresses the following new aspects since the previous delivery:

Common to all sites is the need to evaluate and validate various routes, define PUDO (Pick-Up/Drop-Off) points, continue working on the regulation and approval of autonomous vehicles, and discuss potential pricing strategies.

In **Hereford**, preparations are made to deploy a vehicle and start the service. As with the other sites, there are many aspects that need to be prepared and decided upon to get a service up and running. The role of safety operators, necessary infrastructure changes, universal design, app development, depot automation, and passenger monitoring are all topics being addressed.

As the project scope becomes clearer, a series of KPIs have been established for safety, efficiency, maintenance, user experience, and financials.

The sites in **Switzerland** have been expanded to include yet another area—Mandement—in addition to the two previously defined. This area is located next to Champagne, raising TPG’s ambitions to offer its services to the population.

In **Groruddalen, Oslo**, vehicles have been on the ground for almost a year. The work to validate routes and PUDO points are progressing rapidly, and the experiences have been very positive. To date, over 11,000 km have been driven, and in recent months, the proportion of driving in autonomous mode has exceeded 90%. Parallel to this, work on the customer experience is crucial, with the development of the app and onboard screen in coordination with fleet management. External test-users will soon be allowed access, with the goal of onboarding the first regular passengers before the end of the year.

Recruiting and training safety operators is central to their role as guarantors of safety, “trainers” of the vehicle, validators and verifiers of software, and, not least, as ambassadors for Ruter towards the passengers.

The work to procure additional suppliers is progressing, with continuous evaluations of and contact with the market to secure an operator.

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 <u>are not</u> driving when these automated driving features are engaged – even if you are seated in “the driver's seat”		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
	These are driver support features			These are automated driving features		
What do these features do?	These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/acceleration support to the driver	These features provide steering AND brake/acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met	This feature can drive the vehicle under all conditions	
Example Features	• automatic emergency braking • blind spot warning • lane departure warning	• lane centering OR • adaptive cruise control	• lane centering AND • adaptive cruise control at the same time	• traffic jam chauffeur	• local driverless taxi • pedals/steering wheel may or may not be installed	• same as level 4, but feature can drive everywhere in all conditions

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 decided 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 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 restrictions, 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 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 1: City crest of Herford



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.

Three areas in Herford city center have already been identified as further potential areas. The largest service area, located in the north, will focus strongly on the possible applications in very rural areas. The aim here is to provide local residents with access to public transport and demonstrate its feasibility. The vehicles will be used here in on-demand operation and must also be able to travel at higher speeds than 40 km/h. It will be important for the vehicles to have a connection point to the city of Herford's existing public transport system in order to provide a direct link to the city center and the train station located there.

In addition, further deployment potential has been identified in the south-west of the city. The main aim here will be to test the optimization of local transport connections to shopping facilities, but also to ensure access to public transport in areas that have not yet been developed. A mixture of scheduled and on-demand services will probably be used.

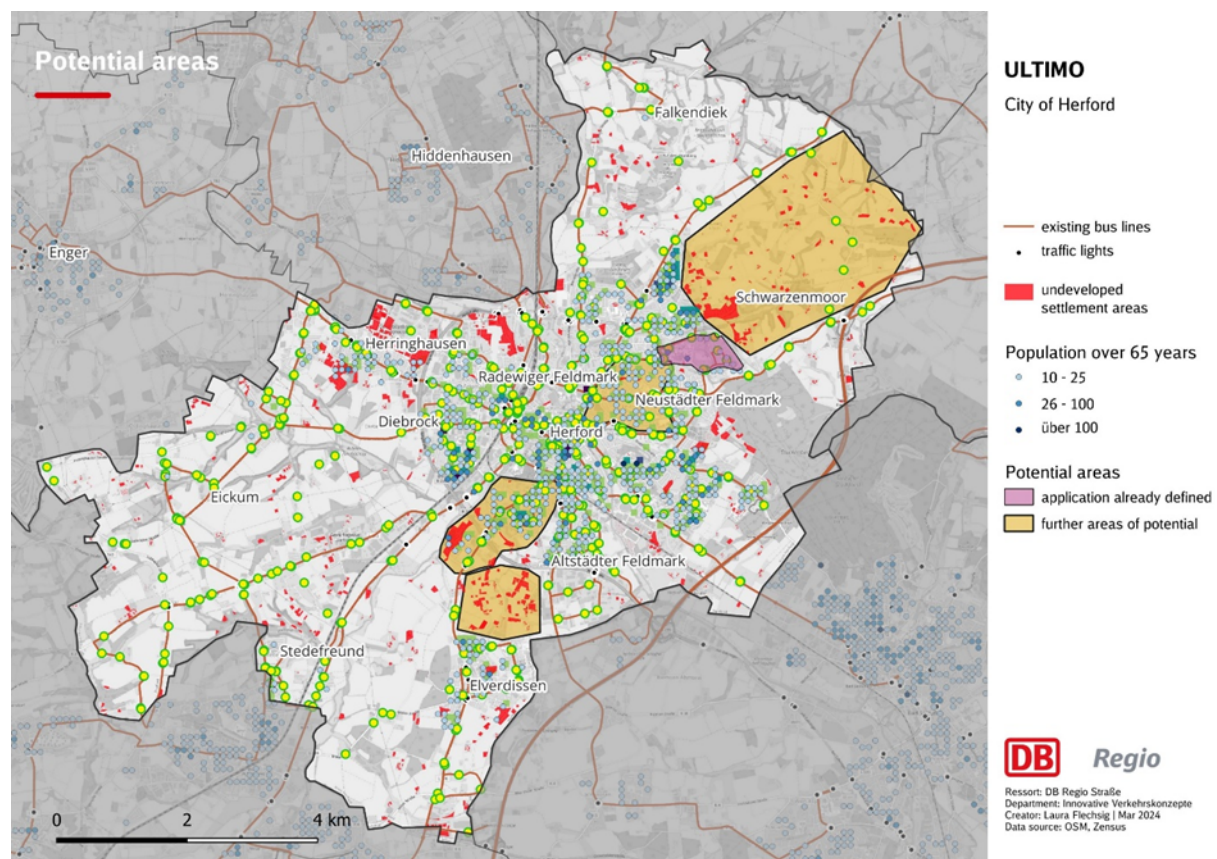


Figure 3: Project area Herford

2.1 Roadmap Until 2026

Within and after the delivery of D 5.1 we finalised the selection of the first routes to serve in 2024. 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.

Due to the continued unavailability of Level 4 vehicles from European manufacturers or vehicles from American or Asian manufacturers registered in Europe that meet our requirements, we were forced to make significant changes to our plans. We worked more intensively on defining our requirements, which are currently still being coordinated with our colleagues from Group Procurement. Developments within the project were also driven forward. Only the planned workshops with stakeholders from the city administration and PTA and the public participation workshop were held.

As we also came to the realisation in various internal discussions that, despite a new test area and different road conditions, we would not be able to learn anything new with outdated vehicles, we decided to buy just one level 3 vehicle from an unknown European manufacturer (not yet tested in our own operations) for the time being. This is enough to familiarise both the citizens of Herford and our local colleagues with the new technology. The money saved is better invested in level 4 vehicles, as it is clear that the estimated purchase or leasing costs before the project start phase have increase significantly.

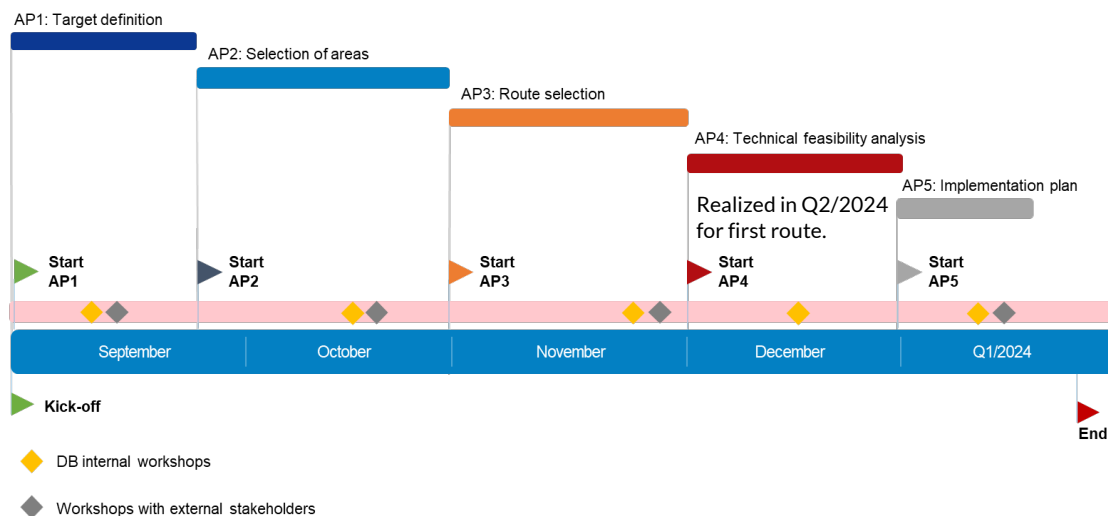


Table 2: Adjusted Roadmap Herford

A revised version of the schedule is presented below. The current status is introduced or indicated by the "→" character.

September 2023:

- Define the goals and objectives of the project. → Done.
- Identify potential areas for implementation. → Done.
- Conduct workshops with district/city/interest representatives to develop potential routes. → Realized in Q3/2023.
- Engage relevant stakeholders, including government authorities, transit agencies, local residents, technology providers, and advocacy groups, to gain support and gather input. → Implemented with city stakeholders, authorities and

ministries from Q3/2023 to Q2/2024. Continuous dialogue with relevant stakeholders has been established.

October 2023:

- Select the first routes for implementation. → Was implemented by Q1/2024 for the first route.
- Plan and schedule internal and external workshops and appointments with representatives from the city and district of Herford → Done.

November 2023:

- Finalize route selection. → Delay for Route 1 (until Q1/2024), further routes for on-demand traffic have been developed until Q2/2024.
- Select suitable autonomous vehicle technology that meets the requirements of planned routes. Analyse legal, technical, and financial considerations. → Done for route one with L3 vehicle. We are still waiting for the availability of L4 vehicles and their concrete description of capabilities to be able to select at all.

December 2023:

- Initiate a procurement process to acquire autonomous vehicles. → Specialization of the market carried out. Procurement process started in Q1/2024 for the first vehicle. Unfortunately, still ongoing, as internal specifications were changed during this process.
- Begin preparations for vehicle deployment, including charging infrastructure. → started and ongoing. Rental contract for parking space with charging station has been drawn up in July 2024 and will be signed after vehicle purchase and announcement of delivery date updated accordingly and signed.
- Conduct a comprehensive feasibility study to assess the suitability and potential benefits of autonomous public transportation. → Delayed processing. Currently in preparation together with the WP6 team of experts.

January 2024:

- Finalize procurement process → still ongoing for first vehicle, in dialogue with European manufacturers who we believe will deliver L4 vehicles during the course of the project to prepare L4 procurement process for 2025.
- Start contacting the regulatory authorities. → Completed and in exchange.
- Continue preparations for vehicle deployment, including charging infrastructure → postponed to Q3/2024 and in progress.

February 2024

- Obtain all necessary permits and licenses from regulatory authorities. → Currently being processed with a delay due to longer procurement process and more complex, as manufacture is doing this for the first time in Germany. We provide support as best as we can and carry out our tasks in this area with foresight.
- Ensure compliance with all applicable regulations and standards for autonomous driving. → Still in progress with all actively involved stakeholders.

March 2024



- Vehicle delivery → postponed to Q4/2024
- Begin preparations for HD map → postponed to Q4/2024

April 2024

- Continue mapping → postponed to Q4/2024 and Q1/2025.
- Engage in extensive communication with the public to explain the introduction of autonomous transportation and address any concerns. → Postponed to Q3/2024 and started with the citizen co-creation workshop on Monday 16th of September.
- Provide information about the new services and vehicles. → Postponed to Q4/2024 and Q1/2025.

May 2024

- Monitor and evaluate charging infrastructure. → Postponed to Q1/2025
- Obtain all necessary permits and licenses from regulatory authorities. → Postponed till Q4/2024 or Q1/2025.
- Receipt of all regulatory and approval documents. → Postponed to Q1/2025.

June 2024:

- Deploy first autonomous vehicles. → Postponed to December 2024
- Begin testing and evaluation phase. → Postponed to December 2024

July 2024:

- Continue testing and evaluation phase. → Postponed to January 2025
- Make necessary adjustments based on feedback and data collected, including any changes to charging infrastructure. → Postponed to Q1/2025.

August 2024:

- Launch public operation of autonomous shuttles. → Postponed to end of Q1/2025.
- Begin public education and outreach campaign to familiarize citizens with autonomous driving. → Postponed to Q2/2025.

September - December 2024: Will start in Q1/2025

- 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: → postponed to Q4/2025

- 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.

Q3/2024 – pro-active plan adjustment to general conditions

- Start development of building the beta version of integrated technical remote supervision for AV in MaaS.
- Select input from Herford citizen co-creation workshop with core-stakeholders for implementation in Germany and valid planning the beta-test phase with the culmination of the second citizen co-creation workshop after permission for test operation with officially registered test persons.
- The ULTIMO-WDW app V 1.0 will be made available in the app stores as an MVP at the start of operational preparations (shuttle runs on Herford soil) for the start of communication and real-time information with the public.
- Finalise detailed planning with core stakeholders for 2025 as soon as basic requirements are met (conclusion of purchase agreement and final checks on AV suitability for approval of test area and operation) in October 2024.

2.2 Stakeholder Workshops

At the German project location, we divide the stakeholders into three different groups in order to involve them in the project accordingly and to enable a high interaction-level between people. 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.

2.2.1 First Co-Creation Workshop in Herford

In May 2024, together with Open Geneva, SAAM and Siemens, we launched the concept of co-creation with citizens and stakeholders in Herford. We are taking advantage of the fact that there is still no contact with automated driving in Herford and are planning two different co-creation workshops. The first has been scheduled for 16 September 2024 and should, among other things, explore attitudes towards this technology and work on four challenges before people in Herford have ridden an autonomous shuttle. We are hoping to gain valuable insights here, particularly with regard to safety and the feeling of safety. A second co-creation workshop will then be held in the spring/summer of 2025, once the first AV is in regular operation and the citizens of Herford have had their first experience as passengers. The aim is to test implemented solutions from the first workshop as well as other in-vehicle services from the project and identify potential for improvement. It will be particularly exciting to see whether the safety services developed for passengers have the desired effect (high feeling of safety). The detailed design and planning for the second workshop will begin in February 2025, when the test operation has started, and the implementation of the services can begin.

Before we started the conceptualisation with the partners, we discussed internally why we wanted to do this and what our goals were. We then entered into dialogue with Siemens as an expert group for accessibility and asked for their ideas. Both then provided the basis for the collaborative concept development.

What do we want to learn in general?

- What is your attitude towards technology?
- How do you create a sense of security?
- How can the offer become accessible? (also for children etc.)

What do we want to achieve with the first workshop?

- We want to get to know people's views on the subject!
- We want to arouse interest in the new offer.
- Build a community that will accompany us throughout the project.
- Collect topics for in-depth discussion in follow-up workshops.

Ideas for content from Siemens

- How about "building" (e.g. with Lego) an optimal app for public transport together with sight impaired people.
- Topic „design“
 - o of the vehicle (What should a dream vehicle look like on the inside? (possibly also with Lego).
 - o a PUDO (how should it look/be labelled/how do I get information about it)
- How do I communicate with the vehicle/PTO, ... /what happens in an emergency?
- How do I register my special needs (rollator, guide dog, ...)
- Do I need a quick guide for new passengers? And what should it look like?

Rough concept for 1st workshop in June / July to present it to PTA

- Current obstacles to public transport use in general
- Attitude of citizens towards the new service? (expectations / concerns)
- General requirements for the first service route / service test
- Digital accessibility
- How do I point out my special needs (rollator, guide dog, etc.) before the trip or booking an on-demand-service?

After an initial common approach session with all partners involved in the consortium, the city of Herford was involved and asked for their ideas and wishes. From this, the challenges and topic areas were then formulated in a further working meeting and the schedule was drawn up. Open Geneva and SAAM then selected the appropriate methods and trained the moderators of the working groups.

Our common goals are:



Figure 4: Common goals for First Co-Creation Workshop

Our Challenges to co-create solutions and ideas for:

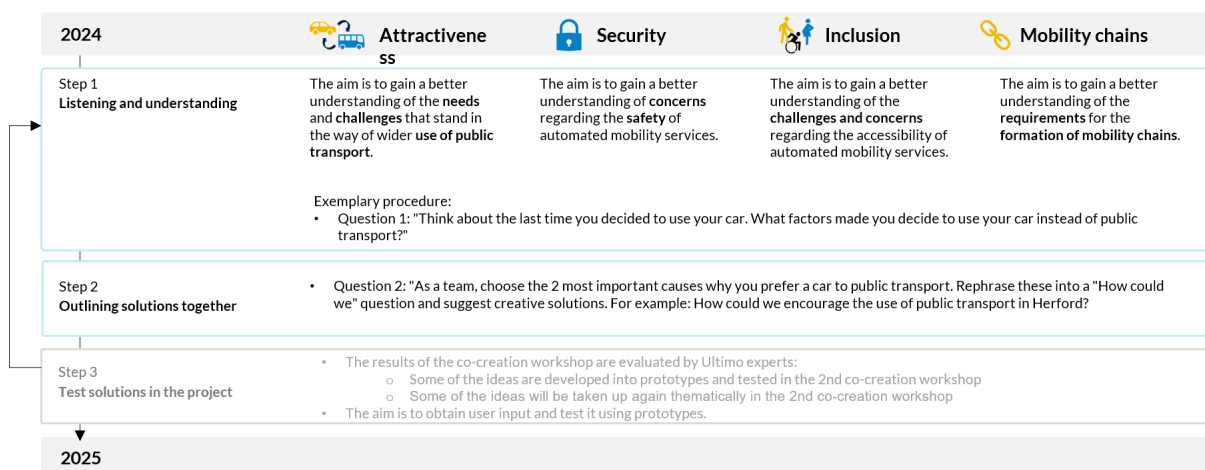


Figure 5: Steps Co-Creation Workshop in Herford



Figure 6: Working Group at 1. Co-Creation Workshop Herford

Based on this approach the workshop materials had been developed and Open Geneva with SAAM developed a workshop manual for the supporting group facilitators from Siemens and DB. With a special focus on accessible information and interaction for all attendees.

STEP 5

15 MIN



Rewrite your challenge...

...into a "how could we" question.

For the next steps, the team can decide whether to form two smaller groups, each working on one of the two biggest challenges.

Task:

- Develop at least three different "How could we" questions in the team for the voted challenge
- Write each challenge on a large green post-it note
- Discuss the various "How could we" questions as a team and vote on a final question that you would like to work on. Each team member has one vote.



Figure 7: Example of work instruction

As the workshop took place during the internal review window for D5.2 and the results have not yet been analysed, we can only provide an initial assessment of the atmosphere and perception. It was possible to reach a wide range of citizen target groups (age, use of public transport, interest groups). We also achieved a good mix with regard to the special public transport requirements of people with disabilities. The participants were enthusiastic and have a strong interest in further involvement. We have thus created a very good basis for the goal of community building.

The moderation team will now evaluate and summarise the results before moving on to the selection of ideas for implementation with the core stakeholders on site and in the consortium. This should take place by December 2024 so that implementation can begin with the launch of the first shuttle to the public.

2.3 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.

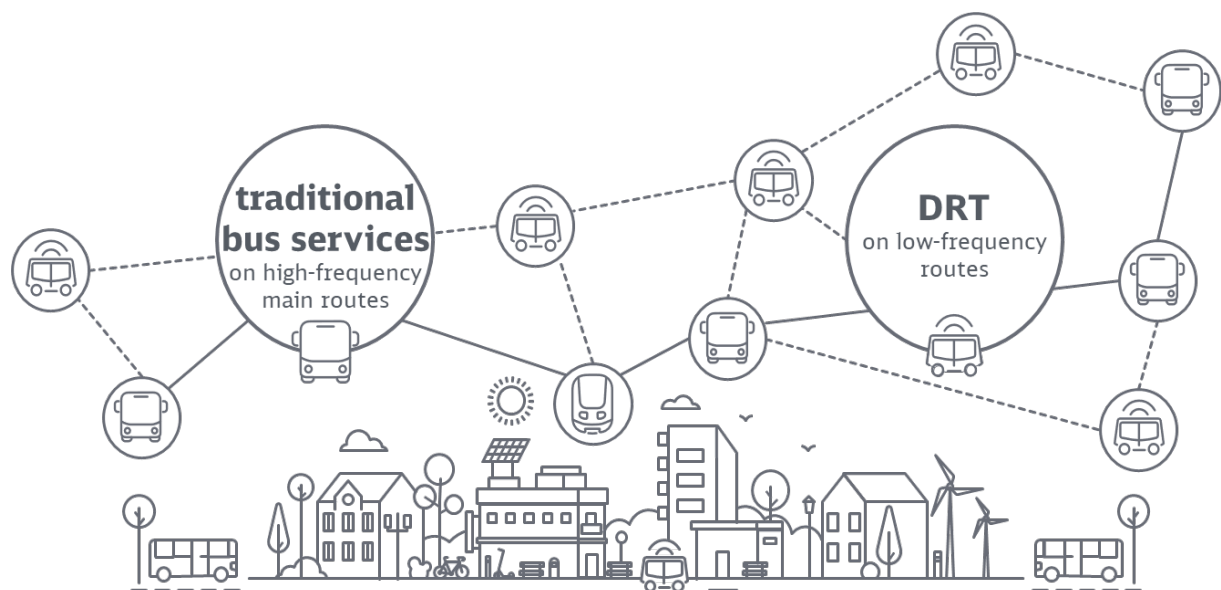


Figure 8: Integrated Mobility - A smart combination of traditional bus and DRT services in planning and/or operations

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

2.4 Problem Descriptions

2.4.1 Vehicle Availability

We have engaged in discussions with virtually all manufacturers and software providers in the field of autonomous driving. Despite these conversations, the situation has not fundamentally changed over the past few months. The reality remains that there is currently no Level 4 capable vehicle available on the market in Europe. This distinguishes Europe from regions such as the USA or Asia, where driverless vehicles have been shaping the cityscape in some cities like Guangzhou or San Francisco for several years now.

What has been emerging recently, however, are partnerships between European vehicle manufacturers and non-European autonomous driving (AD) providers. These providers have already proven outside of Europe that they can operate at Level 4. Such collaborations could expand the market in Europe and these vehicles could then also be considered for the project area in Herford. Furthermore, there are EU manufacturers who promise that their vehicle or AD software will be able to reach autonomy level 4 next year.

DB Regio AG currently has a European tender open to better understand the vehicle market. The tender involves a market survey of potential manufacturers. DB Regio AG aims to gain an overview of the Level 4 vehicles (cars, minibuses, and large buses) available on the market and the standard market parameters for their procurement. In doing so, we would like to discuss possible service contents as well as technical and initial contractual aspects with the companies participating in the request for information.

The sole purpose of this information request is to lay the groundwork for a potential tender preparation, if necessary, including an evaluation of the requirements for possible exceptions under public procurement law (particularly in the area of research and development). The information provided as part of the request for information represents a preliminary state of work that serves exclusively to give the participants an initial impression of the projects planned (e.g. ULTIMO) by DB Regio AG.

DB Regio AG will evaluate the information obtained during the request for information and use it as a basis for decision-making for the further design of the procurement process. If necessary, DB Regio AG will use the knowledge gained in future contract award procedures. Participation in this request for information offers participants the opportunity to position themselves as potential suppliers in this forward-looking area and to shape the future of passenger transport together with DB Regio AG. a major risk for the deployment of driverless vehicles in the final year of the project.

2.4.2 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 approval process is currently based on the degree of automation of the vehicles. A distinction is made between Level 2 (+) and Level 3/4. Based on this categorization, the necessary approval process is then defined, and various requirements are set.

Level 2

The current approval procedure is carried out via the Straßenverkehrs-Zulassungs-Ordnung (StVZO) at the responsible state authority. In addition to the operating permit, this authority also issues the approval for the track and the operating area in accordance with §21 incl. ADAS function incl. §70 for so-called exceptions. The track is checked in advance by the technical service.

Level 3 & Level 4

In the approval procedure for a Level 3 or Level 4 vehicle, the AFGBV and its requirements must be considered in addition to the StVZO. This means that the approval of the route and the granting of the operating permit is carried out by the state authority, while the test permit is granted by the KBA. As with Level 2, the vehicle is approved for operation based on §21, but without ADS functions. This is issued because of AFGBV §16. §70 is also applied here for the declaration of exceptions. The state authority is responsible for checking the route.

The requirements for a testing authorization are defined based on the Autonomous Driving Law (AFGBV), which involves various parties in the approval process. To ensure a successful application, the following must be observed, among other things.

- The application is submitted by the owner directly to the Federal Motor Transport Authority. For this purpose, an account must be applied for at the KBA
- An individual/type approval must be provided by the vehicle manufacturer
- In addition to the provision of an approval by the manufacturer, a safety and development concept must be submitted to the KBA
- The permanent monitoring of the vehicle must be ensured

- Proof of sufficient expertise on the part of the owner and personnel (e.g. in the form of training/experience) must be provided and round off the application.
 - Operating license
 - Passenger transport license (number of passengers)
 - Training and instruction
 - Proof of competence of operators and safety drivers
 - Driver's license documentation

In principle, the period of validity for such a testing authorization is four years. However, an extension is possible at any time and must also be requested the KBA.

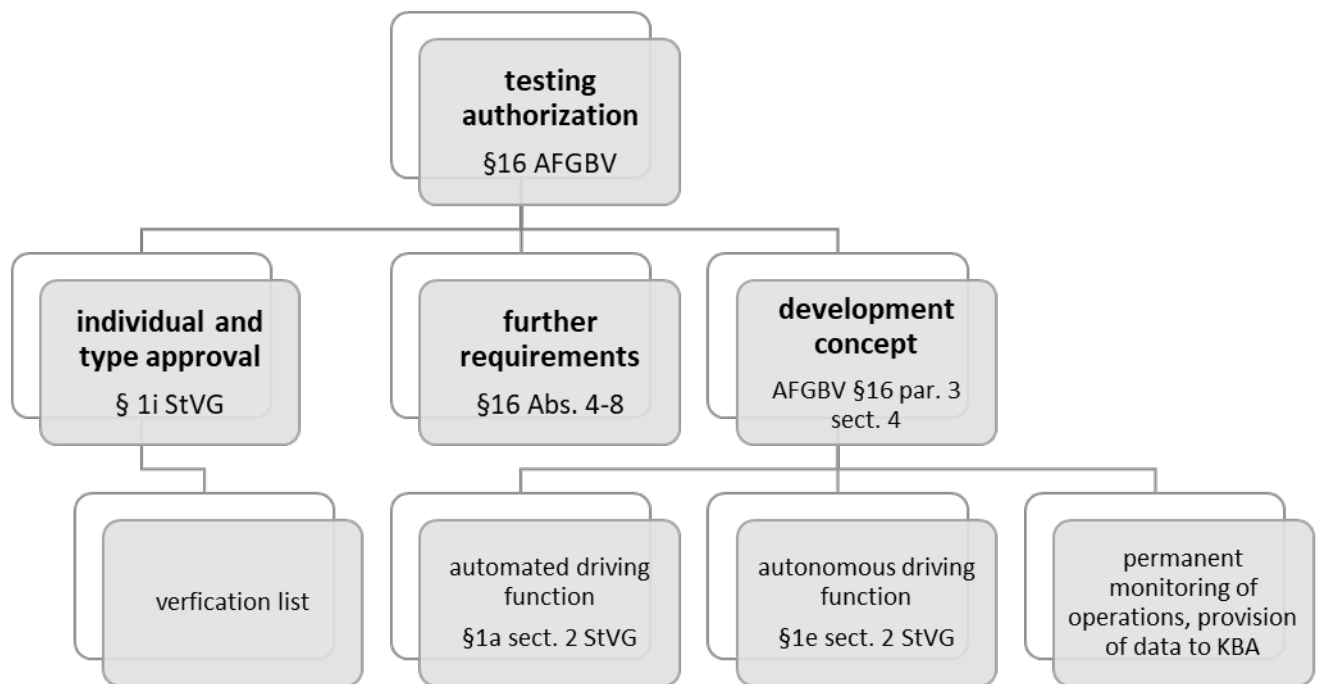


Figure 9: Approval Process in Germany

2.5 ODD in Herford

Last year, we were able to carry out detailed preparations for at least the first route with a Level 3 vehicle and also with regard to safety when driving with the vehicle capabilities. This means that we can also define a more specific ODD for this first test operation. This is still pending for further routes with L4 vehicles, as no valid concept and planning is possible in terms of vehicle suitability and specification due to a lack of availability.

2.5.1 Route Description

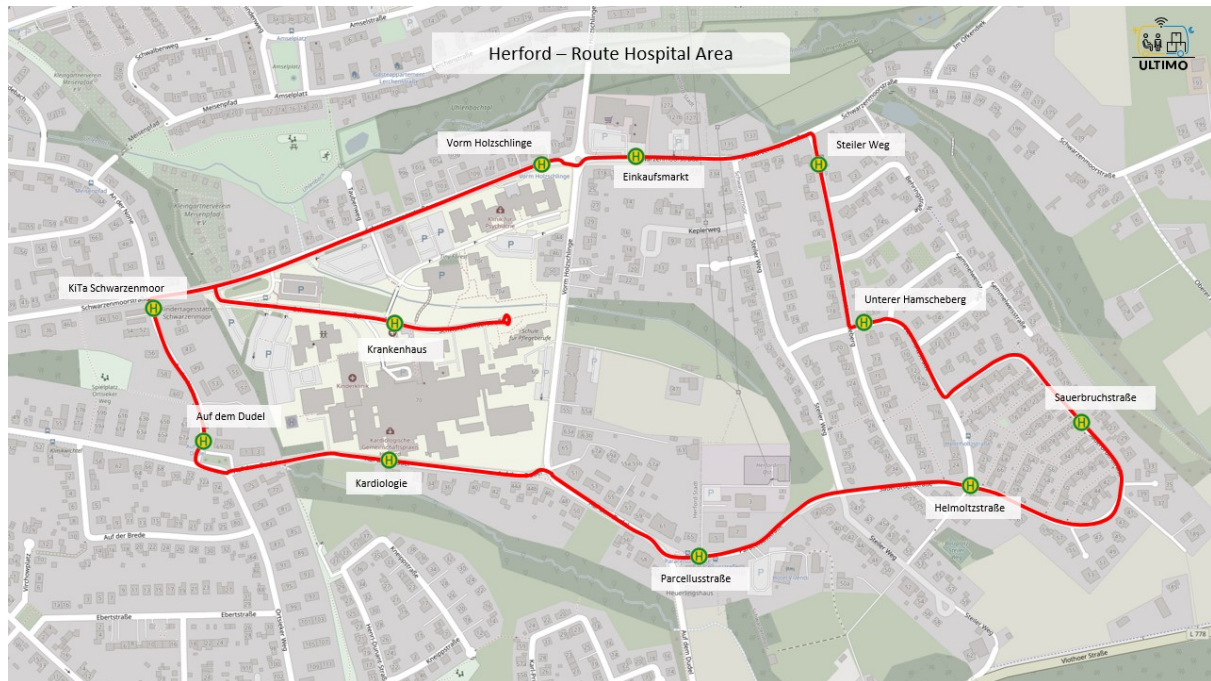


Figure 10: Herford - Route Hospital Area

The Route contains Road Profile 1 and 2 as described in chapters 9.4.2 and 9.4.3. The Starting Point of the route is the Hospital of Herford (Krankenhaus). After fulfilling the first stop the autonomous vehicle proceeds on the route towards the turning point. The entire passage of the side road with the stop “Krankenhaus” has a speed limit of 20 km/h. Exiting the side road the autonomous vehicle turns right on the “Schwarzenmoorstraße”.



Figure 11: Herford - Exit Hospital Sideroad

This turn contains the first challenge for the autonomous vehicle, since the autonomous vehicle needs to enter a road with a speed limit of 50 km/h. Following the “Schwarzenmoorstraße” the speed limit will be reduced to 30 km/h before approaching the next stop “Vorm Holzschlinge”. After the stop, the autonomous vehicle approaches its second challenge, a roundabout. The autonomous vehicle needs to enter the roundabout to continue straight on “Schwarzenmoorenstraße”. After the roundabout the autonomous vehicle approaches the third stop “Einkaufsmarkt”. At this point the “Schwarzenmoorenstraße” is quite narrow, which might be a challenge for the autonomous vehicle.



Figure 12: Herford - Roundabout “Schwarzenmoorstraße”



Figure 13: Herford - Narrow part “Schwarzenmoorstraße”

The autonomous vehicle continues on the road until “Unterer Hamscheberg”, where it makes a right turn. After the turn the autonomous vehicle stops for the fourth stop “Steiler Weg”. Following the stop, the autonomous vehicle continues on the road until the “Helmholtzstraße”, where the autonomous vehicle makes a left turn. After the turn the autonomous vehicle has the fifth stop “Unterer Hamscheberg”. The autonomous vehicle follows the road until the “Sauerbruchstraße”, where it makes a left turn. Continuing on “Sauerbruchstraße” the autonomous vehicle has the sixth stop “Sauerbruchstraße”. At “Sauerbruchstraße” the road gets narrow again, which might be a challenge for the autonomous vehicle.



Figure 14: Herford - Narrow Part "Sauerbruchstraße"

Afterwards the autonomous vehicle continues on the road until the next stop “Helmholtzstraße”. Continuing on the road, the autonomous vehicle needs to cross the road “Steiler Weg” to continue straight on to “Parcelusstraße”. Continuing straight, the autonomous vehicle has the eighth stop “Parcelusstraße”. After the stop the autonomous vehicle makes a left turn on to “Auf dem Dudel”, which is followed by another left turn to continue on to “Auf dem Dudel”.



Figure 15: Herford - Difficult Angle "Auf dem Dudel"

At this turn, the autonomous vehicle faces the challenge of a narrow downslope road, with a difficult angle to oversee traffic. The autonomous vehicle then approaches the ninth stop "Kardiologie". Continuing on the road the autonomous vehicle makes a right turn on to "An der Nene", where it approaches the tenth stop "Auf dem Dudel". The autonomous vehicle follows the road to the final stop "KiTA Schwarzenmoor".



Figure 16: Herford - Turn to "Schwarzenmoorstraße"

After the stop the autonomous vehicle faces another challenge by turning right into "Schwarzenmoorstraße", which has a speed limit of 50 km/h. Then the autonomous vehicle turns right again into the side road of "Schwarzenmoorstraße" approaching the first stop "Krankenhaus". From this point the route starts over.

2.5.2 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.

2.5.3 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.

2.5.4 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.

2.5.5 Weather Conditions

Herford, located in North Rhine-Westphalia, Germany, experiences a temperate maritime climate, which means the weather is generally mild with no extreme variations in temperature.

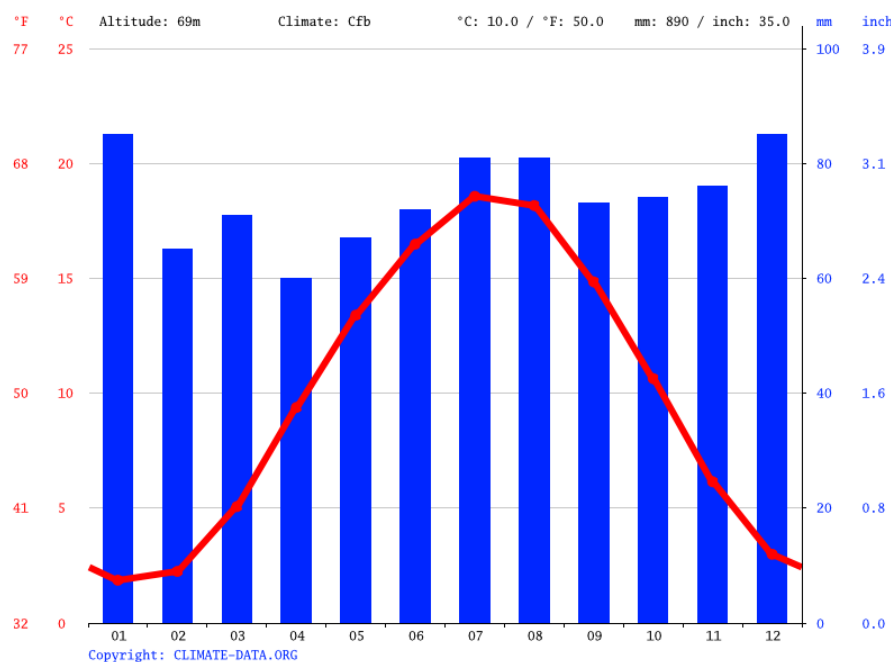


Figure 17 Weather diagram Herford

- Temperature:** The average annual temperature in Herford is around 10°C (50°F). Winters are cool, with average temperatures ranging from 1°C to 5°C (34°F to 41°F), while summers are mild to warm, with temperatures between 15°C and 25°C (59°F to 77°F). Extreme heat, as well as freezing temperatures are rare, making the city relatively favorable for year-round autonomous shuttle operation.
- Precipitation:** Herford receives moderate rainfall throughout the year, with an annual average of about 890 mm (35 inches). Rainfall is fairly evenly distributed

across the months, though January and December can be slightly wetter. Sudden rain showers are common, so the shuttle's sensors and cameras must be robust enough to handle wet conditions and reduced visibility.

- **Snowfall:** Snowfall occurs in winter, though it's usually light. January and February are the months with the highest likelihood of snow, but accumulation is generally minimal. However, icy conditions can occur, particularly in the early morning, which could impact traction and require the shuttle to have winter-specific tires or traction control systems.
- **Wind:** Winds in Herford are usually moderate, but occasional stronger gusts can occur, particularly in the autumn and winter months. Wind speeds typically range between 10-20 km/h (6-12 mph), with gusts sometimes reaching up to 40-50 km/h (25-31 mph). Autonomous shuttles should be able to handle these wind conditions without losing stability.
- **Fog:** Fog is a common occurrence, particularly in the colder months of late autumn and winter. Dense fog can significantly reduce visibility, which is a critical consideration for autonomous vehicles. The shuttle should be equipped with advanced sensors, like LiDAR, that can function effectively in low-visibility conditions.

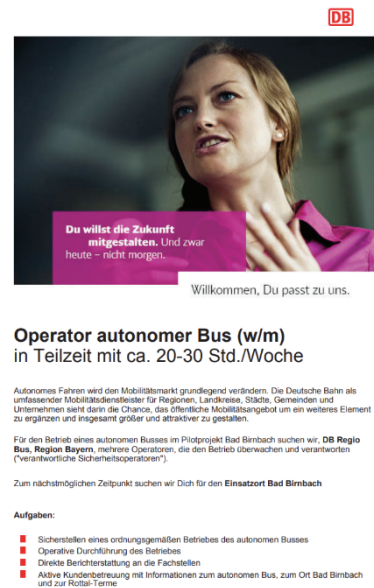
2.6 Security Operators

A security driver in an autonomous shuttle plays a critical role in ensuring the safety, smooth operation, and compliance of the autonomous vehicle (AV) system. Although the shuttle is designed to operate autonomously, the presence of a security driver provides an additional layer of oversight and intervention capability, especially in complex or unpredictable situations. The key tasks of a security driver in an autonomous shuttle include:

- Monitoring the Autonomous System
- Manual Intervention
- Passenger Interaction
- Incident Reporting
- System Feedback and Testing

The safety drivers must also have a commercial driver's license. To obtain this, the following requirements must be met:

- Driving license that is recognized in Germany (EU card driving license)
- Class B driving license, valid for at least 2 years
- medical certificate
- qualified medical certificate of mental and physical fitness
- ophthalmologist's certificate
- Police clearance certificate with document type "O"



Operator autonomer Bus (w/m)
in Teilzeit mit ca. 20-30 Std./Woche

Autonomes Fahren wird den Mobilitätsmarkt grundlegend verändern. Die Deutsche Bahn als umfassender Mobilitätsdienstleister für Regionen, Landkreise, Städte, Gemeinden und Unternehmen sieht darin die Chance, das öffentliche Mobilitätsangebot um ein weiteres Element zu ergänzen und insgesamt größer und attraktiver zu gestalten.

Für den Betrieb eines autonomen Busses im Pilotprojekt Bad Bimbach suchen wir: **DB Regio Bus, Region Bayern**, mehrere Operatoren, die den Betrieb überwachen und verantworten ("verantwortliche Sicherheitsoperatoren").

Zum nächstmöglichen Zeitpunkt suchen wir Dich für den **Einsatzort Bad Bimbach**.

Aufgaben:

- Sicherstellen eines ordnungsgemäßen Betriebes des autonomen Busses
- Operative Durchführung des Betriebes
- Direkte Berichterstattung an die Fachstellen
- Aktive Kundenbetreuung mit Informationen zum autonomen Bus, zum Ort Bad Bimbach und zur Route-Terme

Figure 18: Job advertisement

2.7 Infrastructure & V2X

No additional infrastructure measures are currently planned for Herford. The existing bus fleet is not yet able to communicate with traffic lights and therefore similar technologies are not planned for autonomous vehicles. However, it cannot be ruled out that additional infrastructure will be required in the future.

It is already evident that the old town of Herford has very narrow streets, leading to intersection situations that are difficult to navigate for both humans and, in the future, autonomous vehicles. To mitigate these challenges, the targeted use of additional sensors, such as cameras, could help to alleviate these situations.

This will likely become necessary when more autonomous vehicles cover a larger part of the urban area of Herford. However, investments in infrastructure should be kept as minimal as possible, as they significantly limit the affordability of autonomous operations. The goal of autonomous driving systems must be to operate entirely without additional infrastructure. The only exception is the network coverage with 4G or 5G, which is necessary in all areas to monitor and communicate with the vehicles at all times. In this context, there may be issues with network quality, especially in the outskirts of Herford, which need to be resolved with network operators before a larger rollout. We are also considering using local Wi-Fi networks or satellite internet, such as that offered by Starlink, to fill gaps in the network.

2.7.1 Depot Automation

The depot is equipped with its own car wash, maintenance bays, and a petrol station. Currently, the construction of charging stations for electric vehicles is being prepared. The depot, with its hall for the vehicles, is large enough to accommodate the additional vehicles that will be purchased as part of the project, and they can also be protected from cold and weather in winter. The depot in Herford currently has no automation whatsoever. At present, there are also initially no plans to introduce automation, which means that the autonomous vehicles would also be moved manually based on the driver in the first project phase at the depot. In the later course of the project and when several vehicles have been purchased, it is conceivable that, for example, the gates to the garage entrance can be opened automatically or the vehicles can also drive automatically to the charging stations. Discussions are currently underway with manufacturers about automated charging solutions. However, since the vehicles must be cleaned and checked by humans after the end of the shift anyway, the charging process can also still be initiated manually by a staff member.

2.8 MaaS Integration

The integrated solution, which encompasses all forms of transportation, should also be reflected in the digital world. The goal must be to book an intermodal trip with a single app. In previous autonomous projects by DB Regio, the autonomous on-demand services have not yet been fully integrated with the existing Mobility-as-a-Service (MaaS) offerings. For instance, a customer booking a train or bus connection is informed that autonomous on-demand shuttles are available in the respective area. However, a ride

musst be booked separately in the app. Arrival or departure times must be manually entered and are not carried over from previous searches.

This is set to change with the ULTIMO project. Here, a complete integration is planned. The major challenge is that departure times can change due to delays, even after booking. If the selected train is delayed, another vehicle may need to be booked, as the originally planned vehicle cannot wait for 20 minutes for the passenger, since other passengers also need to be transported. Implementing this requires constant monitoring of connections and access to real-time data.

To achieve this goal, the first step is to integrate ZF's fleet management system. The integration is progressing well. The API has already been successfully connected, marking a significant milestone in our project.

Recently, we conducted the first major round of presentations to showcase the proof of concept. During this session, we demonstrated the initial flow for booking an Ultimo test drive within the WDW app. This included the dynamic display of the vehicle's geolocation directly within the app.

In the near future, we plan to create a screen recording of the booking flow. Additionally, we are collaborating with ZF to finalize the exact times that will be used by the backend and displayed to the end user. We are also implementing a new type of booking number for the end user.

2.8.1 Universal accessibility

Just like in the Ultimo project, the DB Group aims to make all components of the travel chain as inclusive and accessible as possible. Unfortunately, we still have some areas where we need to catch up. However, with the help of the Ultimo project and its involved partners, we can get closer to achieving this ambitious goal.

2.8.1.1 App

Unfortunately, the “Wohin du Willst” app is currently not fully accessible. However, by mid-next year, it must meet the requirements of the Web Content Accessibility Guidelines (WCAG) 2.2.. This means significant updates and improvements are being made to ensure the app becomes accessible to all users, including those with disabilities. These changes will enhance the user experience by making features like booking processes and ticket purchases more accessible and user-friendly.

To comply with the WCAG 2.2, mobility apps must meet several key requirements. These include providing text alternatives for non-text content, such as maps and icons, ensuring that all multimedia, like route videos or audio instructions, have captions and other alternatives, and creating content that can be presented in different ways without losing meaning. Additionally, the app must be perceivable, operable, understandable, and robust. This means users should be able to perceive the content using one or more of their senses, control the user interface elements easily, understand the navigation and instructions, and access the app reliably across different devices and technologies.

In connection with the accessibility adjustments, there will also be a new app design. A special ULTIMO design is being developed for Herford.

2.9 PUDO

Demand-response services are intended to enable transport companies like us to offer user- and demand-oriented mobility services in addition to traditional public transport in order to serve previously underutilized lines more efficiently. In contrast to traditional scheduled services, these demand-response services should operate without a fixed route and only be used if ordered in advance. The rights and obligations of scheduled services also apply to scheduled services, in particular the accessibility requirements. The local transport authority can levy surcharges compared to the regular service fare. Most of the contents are fixed by law in the §44 PBefG.

Stations need to have a fixed location and be defined before the start of the service. A fully free flowing system isn't possible for now in Germany.

2.10 Passenger Monitoring

DB Regio is working with CETH to enhance interior surveillance systems. This is done in context of the activities in WP4. The aim is to integrate key priorities defined by DB Regio into CETH's development process. To ensure the right priorities are set, DB Regio conducted visits to control centers across Germany and interviewed control center personnel. These interviews aimed to understand existing systems and current communication methods with passengers.

The findings revealed that current systems are insufficient for implementing interior surveillance in Level 4 autonomous vehicles. The communication between passengers and staff remains crucial, highlighting the need for a completely new system. This new system must comply with the requirements of the German law for automated vehicles (AFGBV) and Germany's data protection regulations.

Currently, DB Regio is in discussions with various providers of interior solutions to find the most suitable system for the DB Group. Additionally, solutions developed by project partner CETH are being tested and evaluated to determine their potential for large-scale deployment after the project's conclusion.

2.11 Approach on L4 training

In past projects, such as in Bad Birnbach or the shuttle model region in Upper Franconia, we have already gained experience in the implementation of driver training and workshop personnel.

Due to the use of different manufacturers, we will initially use the training concept offered by the manufacturers in the first steps. Due to the aim of extending vehicle operation beyond the Ultimo project period, we will also be looking at in-house training programs. The aim is that at least the basic training courses can also be carried out by our own trainers. This allows for a much more flexible deployment and is therefore better suited to the rapidly changing operational environments in the public transport sector.

The differences between the training modules for existing Level 3 services and future Level 4 services are particularly important. Some areas will become much more important in the future. One of these areas is control center operations, for example, but workshop personnel and technical supervision will also have new areas of responsibility. Furthermore, some adjustments will also be necessary in the area of licensing law.

As part of the Ultimo project, our aim is also to understand the possible future working environments and develop corresponding areas. New job descriptions are also to be created for new positions, which in turn require corresponding training content.

2.12 Pricing Strategy

As the city of Herford's mobility concept also lists the introduction of driver-based on-demand transport as a measure and is currently preparing a tender, we are not yet able to make a final statement on price formation. Especially as it is not yet clear whether this new offer from the city will be implemented during the ULTIMO project period, we want to take the opportunity to develop a viable pricing strategy through automated on-demand transport by conducting test surveys and test prices. We involve internal experts who advise various passenger transport authorities and accompany feasibility studies and implementations.

In a public participation process for on-demand transport in the Berchtesgadener Land region, for example, they asked about the price range for service surcharges and fares.

Workshop interest groups

Pricing

additional service fee	1 €	1-2€	2 €	3 €	4 €	Average		
citations	3,00	2,00	5,00	2,00	1,00	2 €		
Comment	Dynamic price formation: low during the day, more expensive at night. Night-time flat rate for young people and frequent travellers. Possibly a patrol ticket							
fare	at no charge	1 €	2 €	2-3€	3 €	4 € 4-5€		5 €
citations	1	1	1	1	2	3	1	1
Comment	Recognition of free travel for the severely disabled						Average 3 €	

Figure 19: Results of a Citizen participation workshop in Berchtesgaden in August 2023 conducted by DB – topic pricing

The result is an average of €2 for the service surcharge (if you have a monthly ticket) and €3 for the fare. With this calculation, however, even automated on-demand transport is not economically viable and must be subsidised by the passenger transport authority.

In internal discussions with our local colleagues, who are also involved in the optimisation and expansion of public transport, we have developed the following approaches for developing a pricing strategy. The following aspects will be discussed:

- incorporated into the existing tariff or new tariff?
- Tariff by kilometre or honeycomb?

- Validity of existing tickets such as Deutschlandticket, Country-Ticket, etc.
- Additional service surcharge?
- Recognition of disability cards?

These issues will be discussed in the coming months with the local stakeholders, in particular with our branch. Passengers will not be charged for the initial test operation.

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 20: 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 21: 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 is 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 22: 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 23: 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.

The Champagne region has been expanded to include the Ziplo area, an industrial hub known for its high concentration of companies and manufacturing facilities. This area is also particularly attractive for on-demand transport for eventual passengers but even more for logistics purposes, thanks to its strategic location and well-developed infrastructure.



Figure 24: Ziplo industrial area

3.3 Project Site: Mandement

The Mandement area, nestled between the picturesque Champagne region and the vibrant city of Geneva, offers a unique blend of serene countryside charm and bustling industrial activity. This region is distinguished by the expansive Zimeyza industrial zone, a powerhouse that hosts over 500 dynamic companies. The steady influx of commuter's daily transforms Mandement into a lively and industrious hotspot.

A key feature enhancing Mandement's connectivity is the train station situated right in the heart of the Zimeyza industrial zone. This station serves as a vital artery, bringing in a steady stream of commuters and linking the area seamlessly with Geneva and beyond. However, aside from this train service, there are currently very few public transport facilities available, highlighting a significant gap in the region's transportation network.



Figure 25: Zimeysa area

Mandement's appeal extends beyond its scenic landscapes and industrial prowess. Its strategic location and robust infrastructure make it a pivotal logistics center. The convergence of so many businesses naturally creates a high demand for logistics and on-demand services, particularly during peak hours. This demand presents an exceptional opportunity for Ultimo to showcase its innovative solutions, including the deployment of autonomous vehicles (AVs).

Imagine a seamless integration of AVs, navigating through the intricate web of industrial and countryside roads, efficiently handling the logistics needs of countless companies. The limited public transport options further emphasize the necessity and potential impact of these on-demand solutions, making Mandement the perfect proving ground for cutting-edge technology and autonomous transportation.

Beyond the industrial zone, Mandement offers a rich tapestry of experiences. The nearby Champagne region invites leisurely exploration, with its world-renowned vineyards and charming villages, while Geneva's vibrant cultural scene is just a short drive away. This blend of business, technology, and lifestyle positions Mandement as a beacon of innovation and opportunity in the heart of Europe.

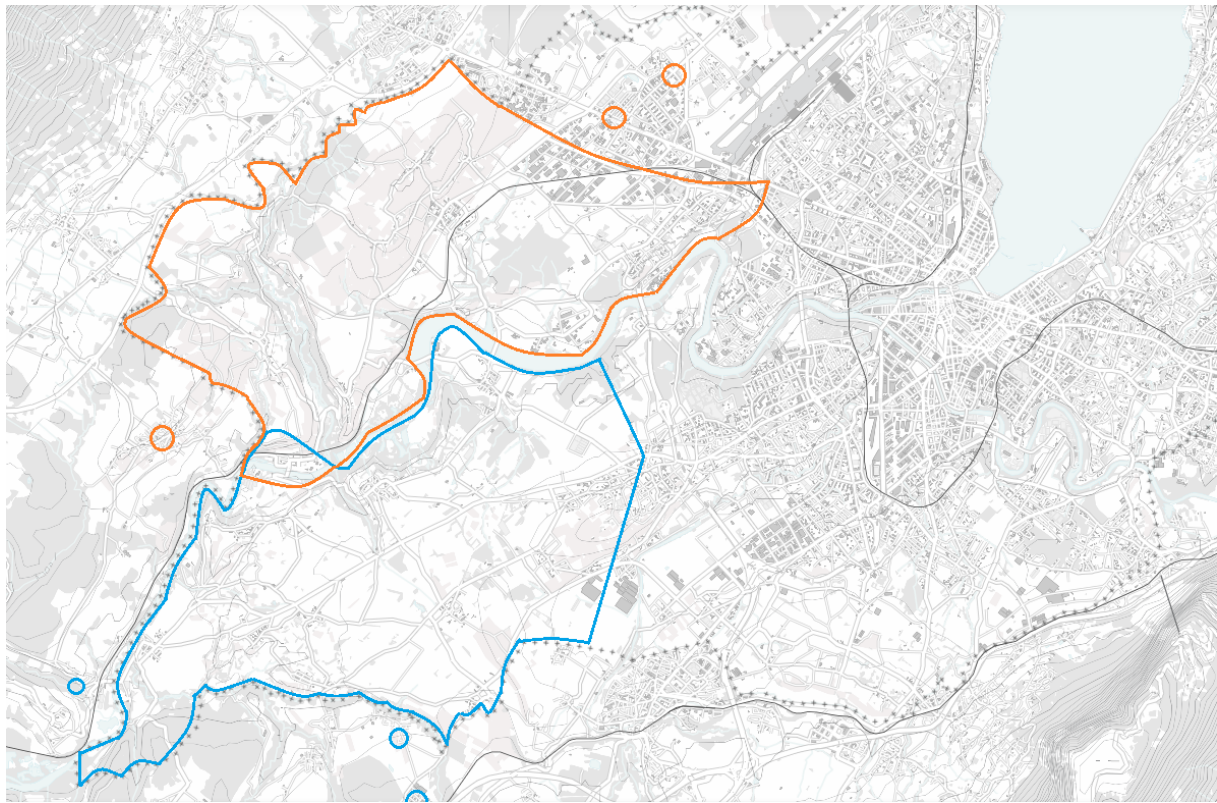


Figure 26: View of the Champagne in blue and Mandement in orange

Both the Champagne and Mandement regions each cover an area equivalent to 7'000 hectares.

3.4 Operational Design Domain (ODD) in Champagne and Mandement

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.

3.4.1 Road Profile 1



Figure 27: 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 28: Road profile 1 - Belle-Idée simple roads overview

3.4.2 Road Profile 2



Figure 29: 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.

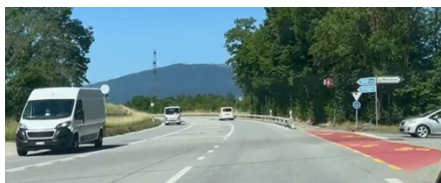


Figure 30: Road profile 2 - Belle-Idée main road

3.4.3 Road Profile 3



Figure 31: 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.



Figure 32: Route du Mandement

This Mandement road is the main road axis, with speeds between 60km/h and 80km/h, cyclists and pedestrians are safe on the sidewalk or on a dedicated line for bikes as there is here behind the hedge. But as a perfect example we can see someone working on the road.

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.

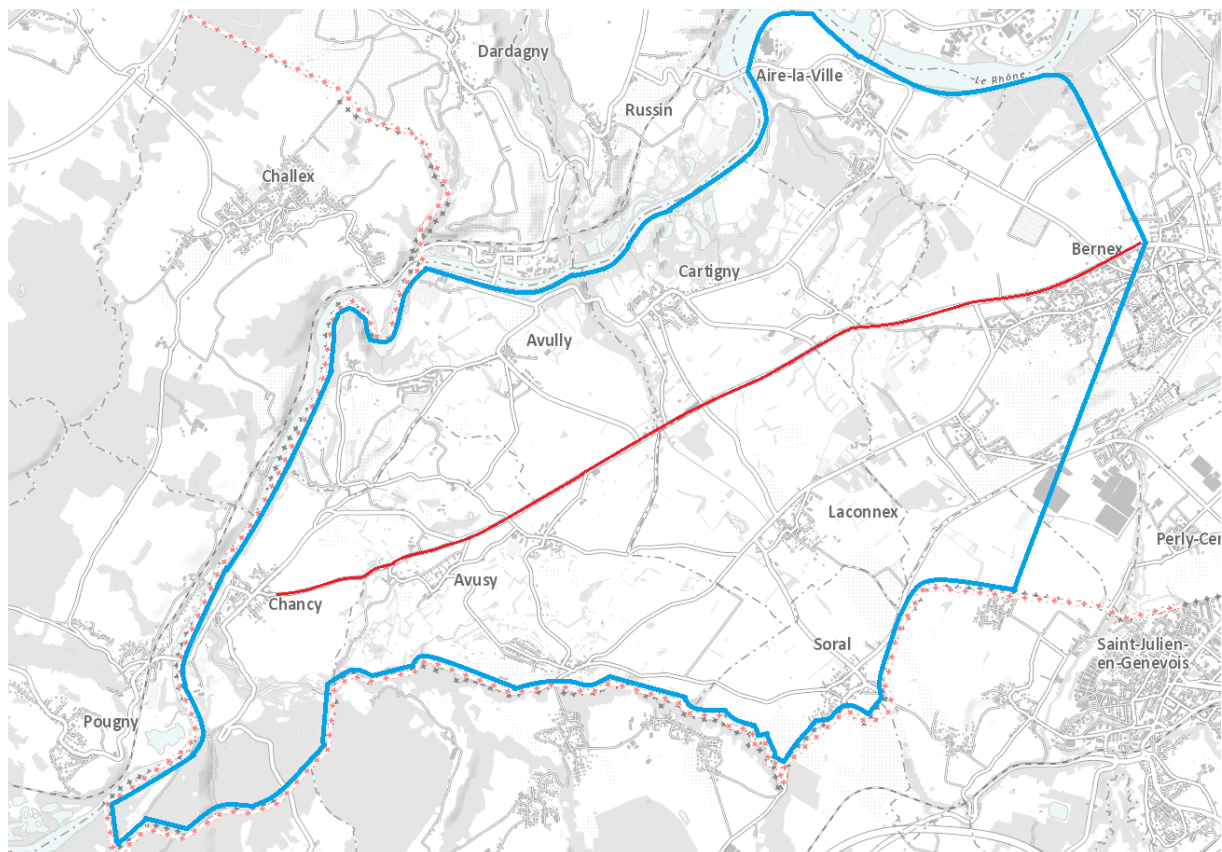
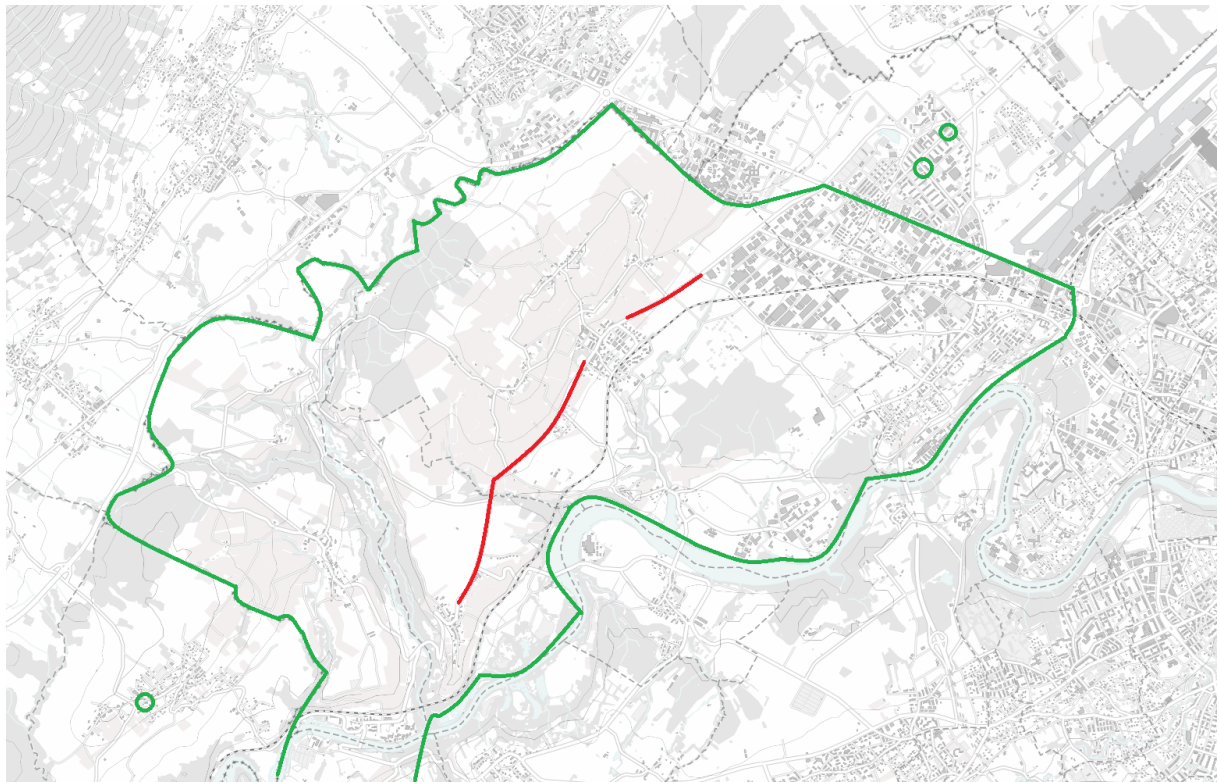


Figure 33: Road profile 3 – Champagne main clear road



3.4.4 Road Profile 4



Figure 34: 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.

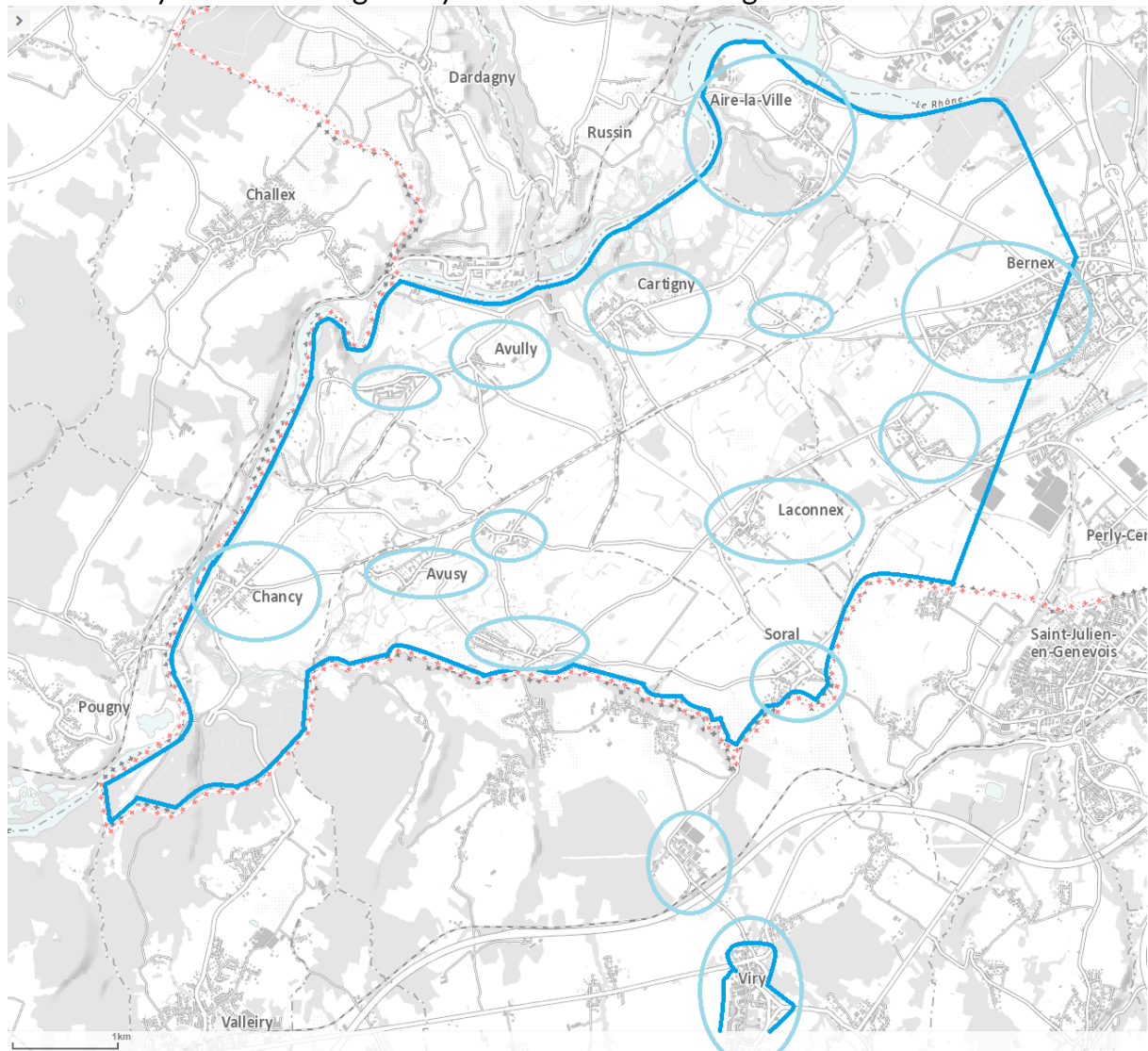


Figure 35: Road profile 4 – Champagne villages

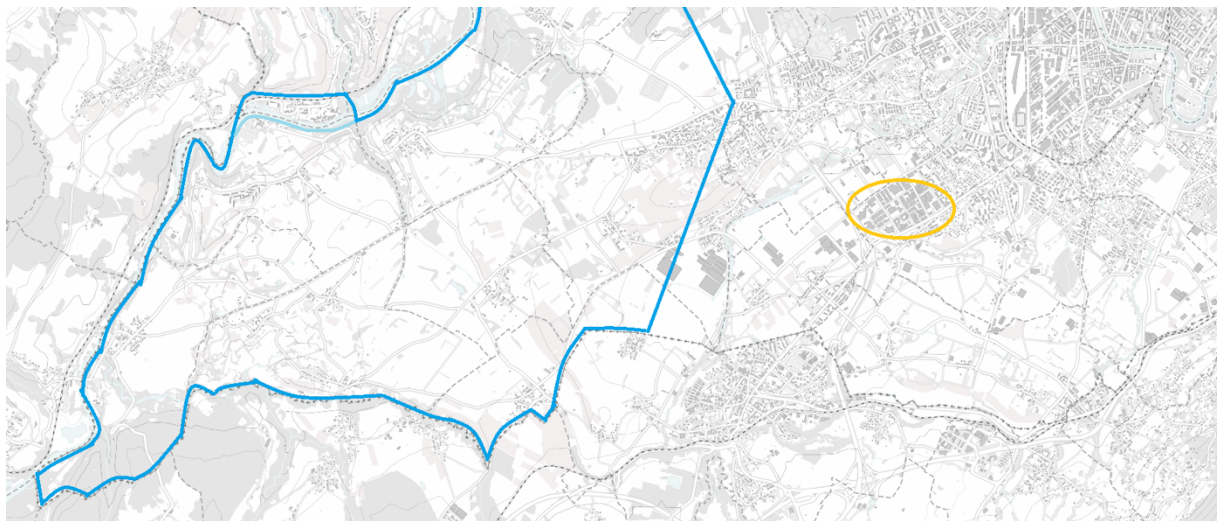


Figure 36: Extension of the Champagne area now going to the industrial area (in yellow) of Ziplo

The champagne area has been extended to reach the near buy industrial area as well as connecting to the train station (in the above picture in light blue was the previous zone).

The Ziplo industrial is of high importance for the project, so it has been included in the extension of the Champagne area.

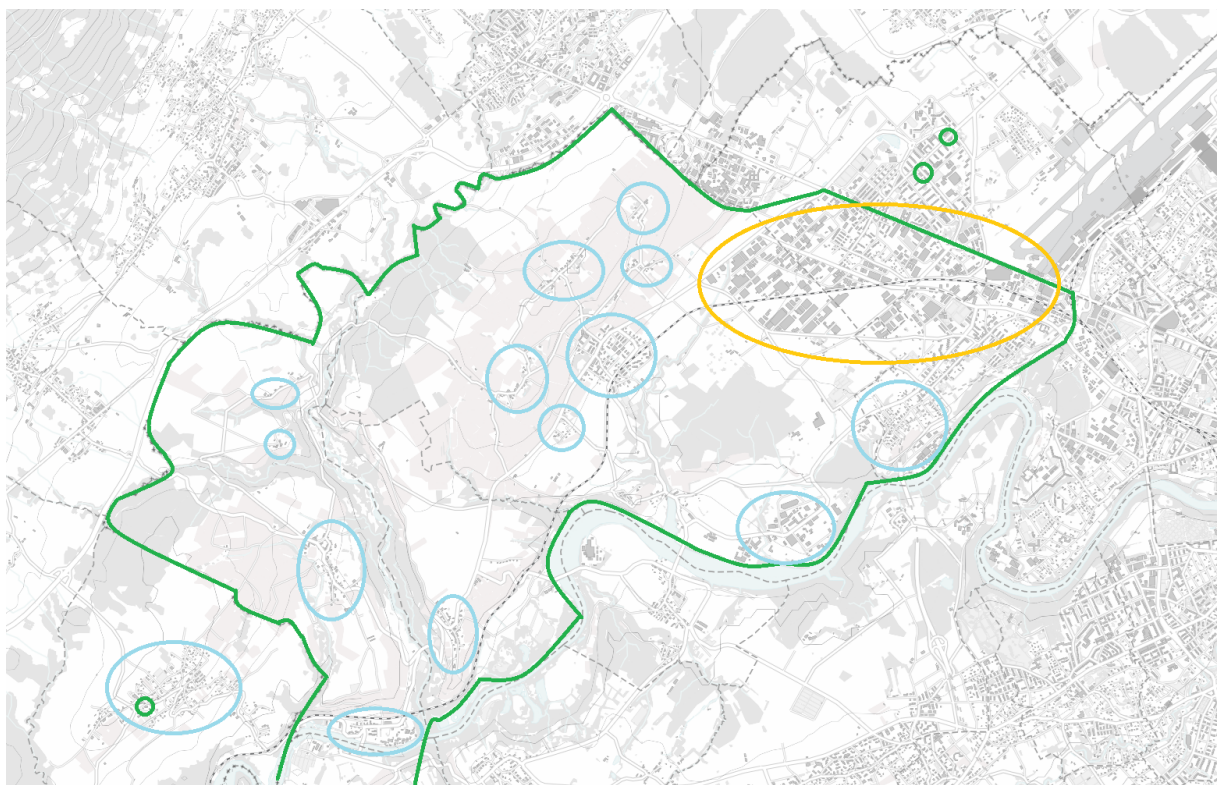


Figure 37: Mandement villages and industrial area (in yellow) of Zimeysa

3.4.5 Road Profile 5



Figure 38: 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.

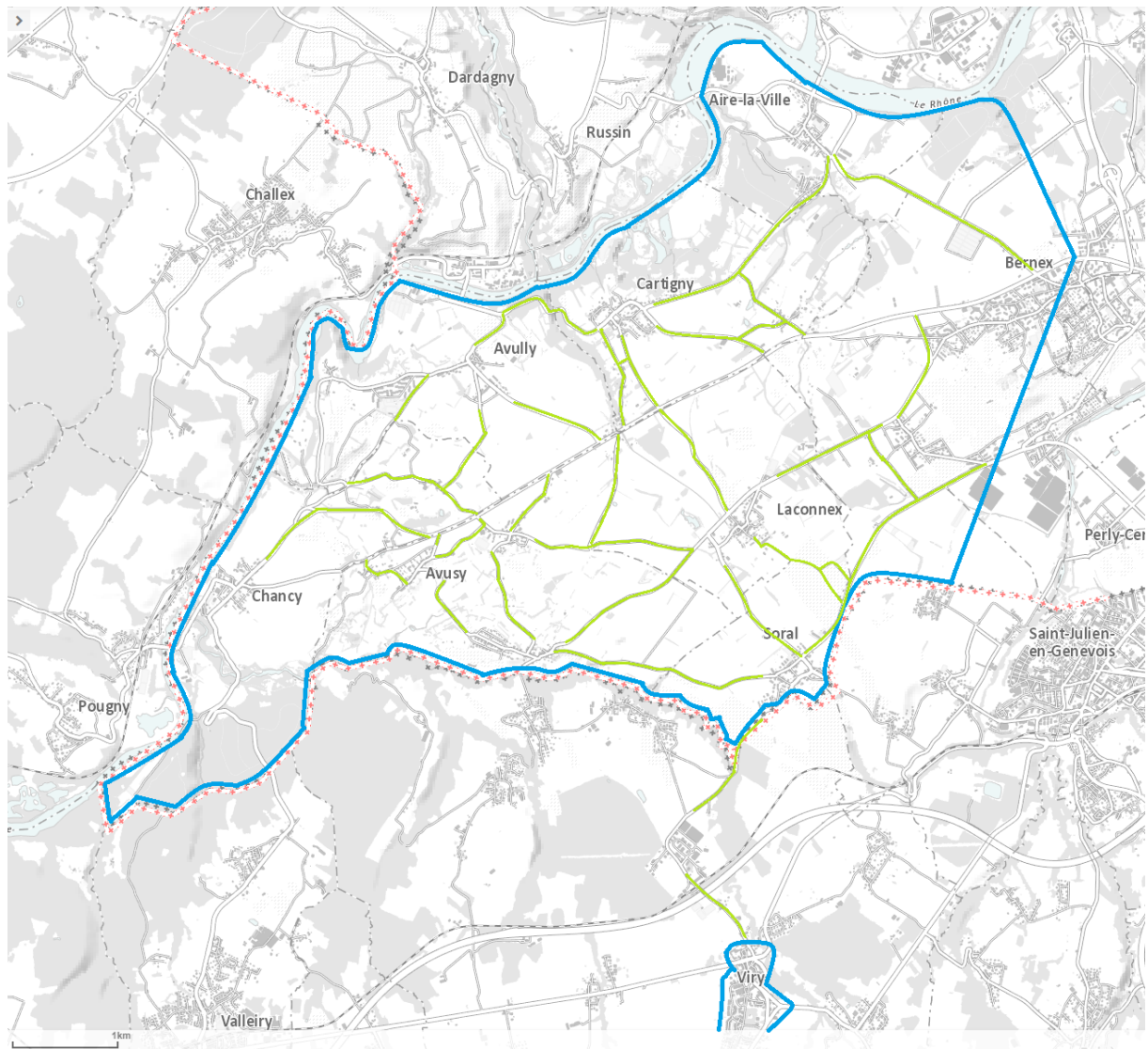


Figure 39: Road profile 5 – Champagne secondary roads

3.5 Security Operators

To ensure a smooth transition, we plan to initially employ security operators who hold valid driving licenses, with a preference for students. Given the current scarcity of drivers, this approach will address immediate needs while providing valuable experience for the students. Over time, as the need for onboard security diminishes, these operators will be phased out. In their place, remote supervisors will be appointed to monitor and manage the vehicles, intervening as necessary to ensure continued safety and efficiency.

3.6 Infrastructure

Infrastructure is a critical component of our plan, playing a vital role in the successful deployment and operation of autonomous vehicles (AVs). Establishing reliable communication between depots and AVs is essential, especially as we aim for full automation in the future. This will allow for seamless coordination, efficient routing, and real-time updates, ensuring that the vehicles operate optimally.

In addition to depot-vehicle communication, we are exploring opportunities to integrate with broader infrastructure systems, such as traffic management networks, smart roadways, and citywide communication grids. These enhancements could enable more advanced features like dynamic route adjustments, improved safety protocols, and better energy management. However, we recognize the challenges associated with this integration, as the current market is not only costly but also highly sensitive and still in the early stages of development. Despite these hurdles, we are committed to pursuing these advancements to ensure that our AVs are equipped to operate in an increasingly connected and automated environment.

3.7 Universal Accessibility

Universal accessibility is a legal obligation in Switzerland, and TPG is fully committed to maximizing accessibility across its services. However, it's important to note that TPG does not own the bus stops, road infrastructure, or similar assets. We rely heavily on the municipalities and the City of Geneva to make the necessary changes to bus stops and other infrastructure.

For the Ultimo project, our focus is on providing an on-demand transportation service that is accessible to everyone, including those in rural areas where accessibility efforts by local villages may be minimal. We aim to ensure that this service meets the needs of all users, regardless of location, by prioritizing accessibility in every aspect of its design and implementation.

3.8 App

Today, we are utilizing the Padam app, which you can explore at [Padam Mobility](#). The app has been rebranded to align with the TPG look, including its colors and branding elements. This standalone on-demand app is designed exclusively for customers who rely on its daily on-demand service.

For logistics, a separate app will be developed by ZF with guidance from OvO.

It's important to note that neither of these apps, whether branded as TPG or TPG+, the latest version, are connected to research itineraries involving fixed or existing transportation lines.

3.9 Passenger Monitoring

Passenger monitoring is a critical aspect, particularly as we aim to achieve Level 4 autonomy with no operator onboard. With the absence of a driver or supervisor, it becomes essential to ensure the well-being of passengers inside the shuttle. Any incidents should be promptly reported upon detection to minimize risks and maintain safety.

The comprehensive detection system will provide supervisors with the necessary tools to selectively and thoroughly assess situations. This is especially important as supervisors will be overseeing not just one or two vehicles, but an entire fleet.

3.10 Operations Statistics

The deployment of on-demand autonomous vehicle services represents a significant advancement toward smarter and more adaptable urban transportation. These services not only provide passengers with increased convenience but also generate crucial operational data that is vital for the ongoing refinement and enhancement of service quality. The insights derived from this data are instrumental in paving the way for future integration into the broader Mobility as a Service (MaaS) ecosystem, ultimately creating a more seamless and connected transportation experience.

To ensure the continuous success and optimization of on-demand autonomous vehicle services, a comprehensive range of operational metrics are monitored and analyzed in real-time. These statistics form the backbone of our data-driven decision-making process, enabling us to make targeted improvements. Below are the key metrics that guide our operational strategy:

Ride Requests vs. Fulfillment Rate

A critical indicator of service efficiency is the ratio of ride requests to completed trips. This metric sheds light on how well the service is meeting passenger demand. A high fulfillment rate suggests that the system can handle most requests, while a lower rate may point to the need for additional fleet resources or service expansion. By tracking peak times and locations where demand goes unmet, we can optimize vehicle deployment and improve dispatch algorithms.

Average Wait Time

Passenger wait time, measured from the moment a ride is requested to when the vehicle arrives, is a key factor in assessing service satisfaction. Minimizing wait times is a primary focus, as it leads to a more seamless and pleasant user experience. Detailed data on wait times is monitored by zone and time of day, allowing us to identify service bottlenecks and optimize routing. Additionally, machine learning models are used to predict demand patterns, ensuring quicker response times by placing vehicles strategically.

Response Time

Response time is crucial for service efficiency, measuring how quickly a vehicle is dispatched and reaches the passenger. This becomes especially important during peak demand periods or in high-density areas. Factors influencing response time—such as traffic conditions, vehicle availability, and routing efficiency—are continuously analyzed to minimize delays and improve reliability.

Trip Duration and Route Efficiency

Monitoring trip durations and route efficiency offers insights into both operational performance and the passenger experience. The aim is to provide direct, efficient routes that minimize detours or delays. Efficient routing not only benefits passengers by reducing travel time but also lowers operational costs and energy usage. By leveraging real-time traffic data and advanced mapping technologies, we ensure continuous improvements to our routing algorithms.

Fleet Utilization and Idle Time



Maximizing fleet utilization while minimizing idle time is essential for operational cost-effectiveness. Vehicle utilization rates indicate the percentage of time each vehicle is actively in service, while idle time reveals areas of overcapacity or underuse. Monitoring these factors allows us to make strategic adjustments to fleet deployment, ensuring efficient distribution of vehicles and avoiding underutilized resources.

Service Coverage and Geographic Demand Distribution

Analyzing ride requests across different geographic areas helps us optimize service coverage. Heat maps generated from ride data allow us to allocate vehicles where they are most needed. This ensures that underserved areas are adequately covered and that resources are not disproportionately focused in high-demand zones. Geographic insights also help guide decisions about future service expansions, including the potential addition of virtual stops and updates to pickup and drop-off locations.

Energy Consumption and Environmental Impact

Sustainability is a growing priority, and monitoring energy consumption and environmental impact is key to achieving eco-friendly transportation. Autonomous electric vehicles have the potential to greatly reduce emissions compared to traditional public transit. By tracking energy use per trip and optimizing routes for maximum efficiency, the service supports urban sustainability goals, reduces its carbon footprint, and contributes to a greener future for transportation.

Passenger Satisfaction and Service Feedback

Passenger feedback is a direct measure of service quality. Regular surveys, ratings, and reviews provide valuable insights into how well the service is performing. Metrics such as Net Promoter Score (NPS), average user ratings, and feedback on ride quality, wait times, and vehicle comfort help us continuously refine the service, addressing any emerging issues swiftly.

The operational statistics we gather are not only vital for day-to-day service improvements but also serve as the foundation for long-term innovation and the integration of on-demand autonomous vehicles into the MaaS ecosystem. By harnessing this data, we can explore new service enhancements and deeper MaaS integration in the following areas:

Intermodal Integration

Data allows us to explore how autonomous vehicle services can seamlessly complement other modes of transport. For example, optimizing connections between autonomous vehicles and public transit systems, such as buses or trains, enables passengers to enjoy smooth, intermodal journeys. This integration would allow for planning, booking, and payment through a single platform, enhancing the accessibility and efficiency of urban transportation.

Dynamic Pricing and Demand Management

Detailed operational data on ride requests, wait times, and geographic demand allows us to explore the potential for dynamic pricing models that can adapt to real-time demand fluctuations. Such models could help balance service load, encourage off-peak usage, and

ensure more efficient resource allocation during periods of high demand. However, at present, this remains largely theoretical, as the current pricing structure for public transportation in the Geneva area remains fixed across all services.

Sustainability and Emissions Tracking

With data on vehicle utilization, trip lengths, and energy consumption, the service contributes to broader city sustainability efforts. We can track the reduction of emissions and energy consumption per trip, aligning with environmental goals and supporting the shift toward low-emission transportation.

Personalization and Customization of Services

Understanding passenger travel patterns and preferences allows us to offer personalized experiences. This could include customized routes, preferred vehicle types, or integration with other personal mobility devices, ultimately enhancing user satisfaction and convenience.

Operational statistics are central to the evolution of on-demand autonomous vehicle services. Through continuous analysis of key metrics—such as ride requests, wait times, trip durations, fleet utilization, and passenger satisfaction—we can ensure that the service remains cost-effective, efficient, and aligned with user needs. Over time, these insights will facilitate a deeper integration with the MaaS ecosystem, providing passengers with a truly seamless and connected transportation experience.

3.11 Weather Conditions

Over the past 20 years, Geneva has experienced a variety of weather conditions, reflecting broader climatic changes seen across Europe. Here's a summary of key trends:

Temperature

Maximum Temperature: Over the last two decades, Geneva has seen a gradual increase in average maximum temperatures, particularly during summer. The hottest temperatures have occasionally exceeded 35°C, especially during heatwaves like the one in 2003 and more recently in 2019.

Minimum Temperature: Winter temperatures have also seen some variation. While it is rare for temperatures to drop below -10°C, Geneva has experienced such lows during cold snaps, particularly in the early 2000s and again in the winter of 2012.

Precipitation (Rain and Snow)

Rainfall: Geneva averages about 1,000 mm of rain annually, with most of it falling between May and September. However, the distribution of rainfall has become more erratic, with periods of heavy rainfall interspersed with longer dry spells.

Snowfall: Snowfall has generally been decreasing over the past two decades. On average, Geneva experiences snowfall for about 20 days per year, but snow accumulation has been less consistent, with notable reductions since the 2000s. Significant snowfalls still occur occasionally, such as during the cold winters of 2005 and 2010.

Winds

Geneva typically experiences mild wind conditions. However, it is influenced by regional winds such as the "Bise," a cold northeasterly wind that can cause temperatures to drop sharply. Strong Bise events have occurred periodically, particularly in winter, contributing to wind chills and occasionally causing damage.

Droughts

Geneva has seen an increase in the frequency and intensity of droughts, particularly in the summer months. The most severe drought in recent years occurred in 2018, when prolonged dry conditions affected much of Switzerland. This pattern is consistent with broader trends in Europe, where summers are becoming hotter and drier.

Extreme Weather Events

Heatwaves: Geneva has been impacted by several extreme heatwaves, notably in 2003, 2015, and 2019. These events have pushed summer temperatures to record highs and stressed local water resources.

Flooding: While Geneva is not prone to frequent severe flooding, heavy rainfall has occasionally led to localized flooding, especially in areas near the Rhône River.

Climate Trends

Warming: The overall warming trend in Geneva reflects global climate patterns, with average annual temperatures increasing by about 1°C to 1.5°C over the past 20 years.

Changing Precipitation Patterns: There has been a shift towards more intense but less frequent rainfall, with potential implications for agriculture and water management.

General Observations

Geneva's weather patterns over the past 20 years highlight the growing impact of climate change, with more frequent extreme weather events, higher average temperatures, and shifts in precipitation patterns. These changes are consistent with those observed across much of Europe, where warming temperatures and changing rainfall patterns are becoming more pronounced.

These observations are based on meteorological data and climate studies conducted over the years, reflecting broader environmental trends. For more detailed and specific data, including annual statistics, consulting Swiss meteorological services and climate reports would be useful.

3.12 Approach on L4 training

Achieving Level 4 (L4) autonomy without an operator is TPG's foremost objective. While we've successfully implemented L4 with an operator at Belle-Idée, our next critical milestone is attaining full autonomy without the need for an onboard operator. We have developed tools to ensure maximum safety for passengers, while also enabling supervisors to communicate effectively with those onboard and make real-time decisions when necessary.

Internally, TPG has a dedicated operator who has undergone L4 training, bringing valuable experience to our team. Additionally, TPG has prepared the necessary legal frameworks to facilitate L4 operations with operators, particularly in collaboration with students. However, our primary focus remains on reaching L4 autonomy without an operator as swiftly as possible.

3.13 V2X

Vehicle-to-Everything (V2X) technology is poised to revolutionize the future of transportation by enabling seamless communication between vehicles, infrastructure, and other systems. As we move toward smarter cities and more autonomous systems, V2X will play a critical role in simplifying and enhancing road interactions, improving both safety and traffic efficiency.

Our vision is for V2X to become a core component of everyday road networks, facilitating real-time data exchange between vehicles, traffic lights, road signs, and other infrastructure. This will enable dynamic traffic management, reduce congestion, and even support emergency services by prioritizing traffic flow where needed. V2X could also contribute to a safer driving environment by preventing collisions, alerting drivers to potential hazards, and enabling smoother interactions between autonomous and human-driven vehicles.

At present, the adoption of V2X technology is primarily focused on depot automation, where it's being used to improve fleet management and streamline vehicle operations. These early applications demonstrate the power of V2X to enhance operational efficiency, but the potential goes far beyond this. Our goal is to push the boundaries of V2X deployment by integrating it into public infrastructure, particularly through communication with traffic lights and other critical traffic management systems.

However, the integration of V2X into broader traffic networks has been a slow and incremental process, largely due to the need for widespread infrastructure upgrades, regulatory alignment, and coordination across various stakeholders. This complex landscape means that while the technology is available, its widespread implementation will require time and significant collaboration between public and private sectors.

Nevertheless, we are at the starting point of what promises to be a transformative journey. With continued investment in V2X technologies and infrastructure, we can envision a future where vehicles and cities are fully connected, offering safer, more efficient, and more environmentally friendly transportation systems. From reducing fuel consumption and emissions to supporting autonomous vehicles, the potential for V2X to change the way we move is immense—and with the right support, we can drive this evolution forward.

3.14 PUDOs

Currently, Pickup and Drop-Off (PUDO) points are predominantly located at existing bus stops, with Demand-Responsive Transport (DRT) seamlessly integrated into the established bus network. This approach ensures that DRT services align with the traditional transit system, offering greater convenience for passengers.

In the Belle-Idée area, the introduction of virtual bus stops was tested, providing valuable insights into how flexible and dynamic stop locations could benefit the network. However, when considering the Champagne area, it has been decided that existing bus stops will be shared between DRT and regular bus lines. This decision is aimed at avoiding disruption to established customer habits and ensuring a higher level of safety and consistency for passengers.

3.15 Approval Process

Approval for the road and area Operational Design Domains (ODDs) from the Swiss road authorities is currently being pursued to facilitate operations in the Champagne and Mandement areas. The process is encountering delays due to the extensive coverage of over 7,000 hectares, which features a wide range of diverse configurations. Comprehensive assessments of the varied terrain and infrastructure are essential to ensure full compliance with regulatory standards.

In addition to the ODDs approval, securing vehicle authorization, obtaining permits for passenger transport, and acquiring approval for supplementary materials are critical steps required to progress towards our long-term goals and vision. These approvals are also pivotal for advancing our logistics operations and ensuring seamless integration into the existing transport network.

3.16 Pricing Strategy

Due to political considerations, the pricing strategy is not currently prioritized. In Geneva, public transport fares are standardized, with a single pricing structure applied to both traditional and on-demand transport services. The only exception to this uniform approach is the exclusion of the three-stop ticketing option for on-demand services. This standardization aims to maintain equitable access to public transport, despite the differences between operational models. While pricing strategies remain a valuable area for gaining knowledge and may become relevant in the future, they are not currently considered an added value for TPG in the near term.

3.17 Depot Automation

Depot automation is steadily progressing and continues to be a top priority for TPG. This initiative is crucial for enhancing operational efficiency. However, progress has been temporarily slowed by the departure of YoGoKo, a key partner whose expertise in V2X (Vehicle-to-Everything) technology was integral to the project. Despite this setback, efforts to advance automation are ongoing, with new partnerships and solutions actively being explored to ensure the successful implementation of this essential feature.

3.18 Status on Vehicles

A vehicle manufacturer has been successfully selected to support comprehensive recollection efforts, and steps are being taken to ensure these vehicles receive approval for operation in both Switzerland and France. This is essential, as the current on-demand transport system frequently crosses into neighboring France, necessitating seamless integration on all roads, efficient logistics, and secure passenger transport. These are critical prerequisites for advancing the project.

To formalize this partnership, a Non-Disclosure Agreement (NDA) with the Original Equipment Manufacturer (OEM) will soon be finalized. Following concrete confirmation and guarantees of operational feasibility, the acquisition of the vehicles will proceed, marking a significant milestone in the project's development.

3.19 Market Elaboration

A comprehensive market analysis has been meticulously conducted by Jeroen Beukers for TPG, with ongoing updates ensuring its relevance and accuracy. This effort includes regular reviews of various aspects such as Swiss and European regulations, advancements in vehicle technologies, automated driving systems, and other pertinent factors. The analysis serves as a dynamic resource, reflecting the current market landscape and anticipating future trends, thereby providing TPG with a strategic advantage in a rapidly evolving market.

3.20 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 safety 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.

3.20.1 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.

3.21 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

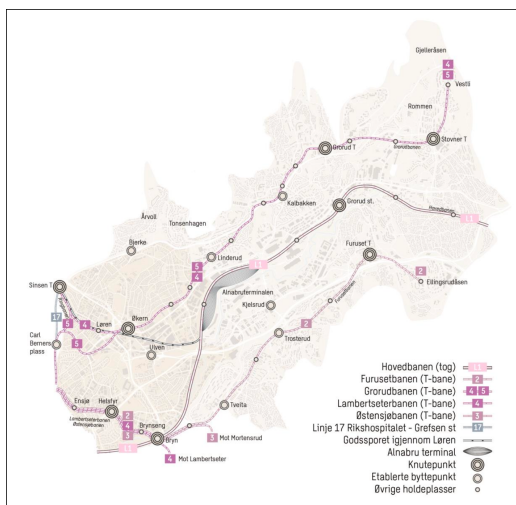


Figure 41: Metro and train in Groruddalen, Oslo

- 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.

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.

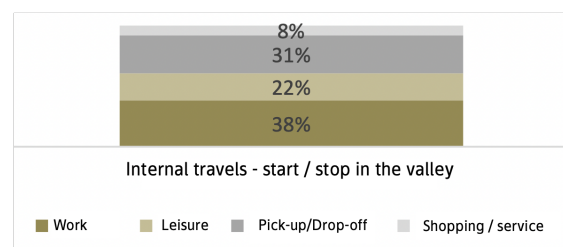


Figure 43: Internal travels in Groruddalen, Oslo

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.

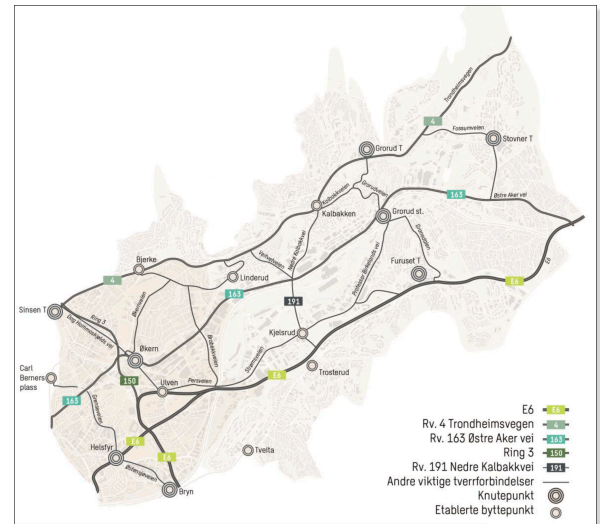


Figure 44: Highways and roads in Groruddalen, Oslo

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, ODD and Risk Assessment

Comparing the roads of Groruddalen to ODD of the MobilEye ADS resulted in a subset of roads in the area. In order to describe an ODD according to ISO 34503, 3 top level classifications; scenery elements, environmental conditions and dynamic elements are used. The ISO 34503:2023(E) defines the 3 elements as such: *The “scenery elements” attribute (in the context of defining an ODD) shall consist of the spatially fixed elements of the operating environment (e.g. roads, traffic lights, etc.), relative to the ego vehicle (in terms of position of the elements). The “environmental conditions” attribute shall consist of weather and atmospheric conditions (including information technology connectivity). The “dynamic elements” attribute shall consist of the movable elements of the ODD, e.g. traffic, subject vehicle.*

At the top level Scenery elements should at least be classified using the following attributes:

- a) zones;
- b) drivable area;
- c) junctions;
- d) special structures;
- e) basic road structures;
- f) temporary drivable structures.

Each of the above attributes has up to 3 additional lower level classifications connected to them, enabling the road configurations to be very specific.

Environmental conditions include at its highest level attributes like the weather, particulates, illumination and connectivity present in the given area. These tend to have a high degree of variability over time and distance and should moreover be considered in combination with dynamic elements in each other (e.g rain and wind).

Dynamic elements can overall be classified into 2 attributes on the highest level, being

- a) traffic agents
- b) subject vehicle.

Traffic agents refers to all other traffic in the ODD, this includes what type of agents are present as well as the density, volume and flow of traffic.

With the available data from the Norwegian authorities, some ODD elements as defined per ISO 34503 could be derived. However to enable methodological and more accurate assessment of the pilot area a road profile classification has been applied. The road

profile classification is comparable to an inclusion-based restrictive ODD definition according to ISO 34503 taxonomy.

Here, data regarding one-way streets, speed limits, sidewalks, round-about etc. has been extracted from the Nasjonal Vegdatabank (NVDB) and visualized 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.

Though the data available in NVDB is generally thorough and updated, the resulting analysis did result in some faulty categorisation. As intersections (both 3- and 4-way intersections) are not stored as separate features in NVDB. Hence, some manual validation of the road links' road profile, sidewalks, speed limits as well as 3- and 4-way intersections was required. Based on a professional assessment of virtual and physical inspections, some automatic categorisations were altered or removed and points or links were manually added to the map.

As an example for private driveways, a lot of these were automatically categorized as 3-way intersections, as the driveway-links were stored as road-links in the NVDB. These 3-way intersections have to be manually changed to driveways and removed from the 3-way intersection layer. This change of categorisation was done based on a definition that a 3-way intersection can not be where sidewalks are crossed, are by a driveway leading to a single family house (or similar) or entrances to parking lots etc.

	
Figure 45: Correct T-intersection	Figure 46: Faulty categorized T-intersection

Table 3: Example of faulty automatically categorized three-way intersections

Additionally, the data regarding private and municipal roads is limited in the National Road Database (NVDB). This required manual reclassification of roads, particularly smaller ones, that had been categorized as being without sidewalks. This manual process is crucial in creating an accurate representation of the risk in the area, especially on narrower roads where the lack of separation between pedestrians and vehicles increases the risk.

4.2.1.1 Road Construction Work

During the assessment and data collection, some roads in the network were undergoing construction. As a result, these features were labeled with information about the work going on at that specific time of execution. To keep track of the progress, these links were tagged individually and risk analyzed, just as they were before the construction began.

When a large construction project is finished, the road should be re-assessed to ensure that the risk assessment is up-to-date with newly added safety measures such as sidewalks and one-way regulation.

4.2.1.2 Risk Identification

To identify the risks associated with the ME equipped NIO ES8, workshops and brainstorm sessions with all relevant project stakeholders were conducted. Based on experience from driving in Israel with ME equipped NIO ES8 and past experience with autonomous vehicles, a risk register was created to highlight the ODD specific-, third-party specific- and traffic congestion risks expected in this project.

It is important to note, that the risks that were considered in the area risk assessment did not include technical risks such as fire in the car battery, as this is considered to be part of the hazard and risk analysis conducted separately. It is therefore solely operational risks regarding traffic congestion and third-parties. Also, only risks that are expected to be unique for the ME retrofitted NIO ES8 are considered. Risks that are found to be the same for other vehicles were not included. As for instance, situations with higher traffic density will generally increase the amount of potential accidents, this does not however necessarily have anything to do with the autonomous vehicle.

Risks in the whole operational area were considered. The risk causes were vehicle behavior and external conditions based on assumptions from the information provided by Mobileye.

4.2.1.3 Risk Matrix

A risk matrix is commonly used when dealing with incidents related to some uncertainty. For that reason a risk matrix is used to determine the criticality of a potential risk. The criticality is defined as the product of probability and the severity of an incident.

To characterize the probability and severity of a potential incident, the risk matrix shown in the table below was used. The rows in the risk matrix represent the likely severity of a potential incident ranging from A. Negligible to E. Catastrophic. The columns in the risk matrix represent the probability of a potential incident occurring ranging from 1. Very unlikely to 5. Very likely.

Severity		Probability [incident / kilometer driven]	
Negligible	- Minor inconvenience such as unnecessary slow down. - Traffic congestion less than 2 minutes.	Very unlikely	1 / 1,000,000
Low	- Inconvenience such as an unnecessary stop.		

	- Traffic congestion between 2 and 5 minutes.	Unlikely	1 / 500,000
Moderate	- “Near-incident ¹ ” scenario - Traffic congestion between 5 and 15 minutes.	Moderate	1 / 250,000
Serious	- Reversible injury to the third-party - Traffic congestion between 15 and 30 minutes.	Likely	1 / 100,000
Catastrophic	- Death or irreversible injury to a third-party. - Traffic congestion of more than 30 minutes.	Very likely	1 / 10,000

Table 4: Definition of severity and probability

The probabilities in the table above are for single vehicles. As more vehicles are added, the probability will increase. However, as the area of operation in this project was fairly large, it is expected that the amount of vehicles present would not increase the probability of an incident.

All risks identified in this assessment were evaluated based on the below risk matrix. The risk reductions will be implemented using the ALARP (As Low As Reasonably Practicable). Risks that are found to be in the green part of the matrix are considered to be acceptable risk and no risk reduction will be considered. Risks in the yellow part are considered tolerable, but will be reduced unless the cost of doing so is disproportionate with the actual reduction. The red part of the risk matrix identifies unacceptable risks that need to be reduced with active mitigations.

Risk matrix						
		Probability of incident occurring				
		1. Very unlikely	2. Unlikely	3. Moderate	4. Likely	5. Very likely
	A. Negligible	1A	2A	3A	4A	5A

¹ When an undesirable event occurs and damage is narrowly avoided.

Likely severity of incident	B. Low	1B	2B	3B	4B	5B
	C. Moderate	1C	2C	3C	4C	5C
	D. Serious	1D	2D	3D	4D	5D
	E. Catastrophic	1E	2E	3E	4E	5E

Table 5: Risk Matrix

As the yellow risks in the risk matrix above are considered to be tolerable risks, it is also the acceptance criteria used for this methodology. It is important to emphasize that all risks come with uncertainty and therefore all risks should be continuously evaluated based on the PDCA principle that has been introduced in the Continuous Risk Evaluation section, especially during a validation period.

4.2.1.4 Risk Analysis

Data was used to assess the entire area of Gorrudalen Valley as it is simply not possible to assess every road by visual inspection. However, with the wide variety of roads in the area, concluding that a certain risk would be present on every road in the area because of its presence in one spot would be misleading. To accommodate this, the roads in the area were divided into so-called road profiles (RP) reflecting the variety of roads in the area.

All roads were divided into road profiles according to defined risk related parameters. The parameters used to determine the level of risk are shown in the table below.

Risk Parameters	
Considered	Monitored
AADT	Pedestrian crossings
Speed	Bicycle lanes
Sidewalks	Roundabouts
One-way regulation	Three-legged intersection
	Four-legged intersection
	Traffic light intersection

	Mergings
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Table 6: Risk Parameters

By far the greatest contributor to traffic risk is traffic density and speed. Traffic density is measured as Annual Average Daily Traffic (AADT), which describes average daily traffic based on the total annual traffic. Speed is by far the greatest factor when it comes to the severity of an accident, where even small increases in speed will cause the severity to rise exponentially. Therefore, road profiles ranking from 1 to 6 have been created to reflect the increase in risk that exists on roads with higher traffic density and speed. Furthermore, one-way regulation and sidewalks have been used to distinguish between RP1 and RP2. The classification can be seen in the table below.

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 7: Road Profiles

The coloring in used to address the criticality of an incident in the specific road ranging from dark green to red. The criticality of an incident is higher in RP6, than it is in RP1.

4.2.1.5 General Risk

Relevant to all investigated RPs, the identified general risks were considered associated with putting NIO ES8 ME equipped vehicles on the road alongside regular vehicles. To accommodate the identified risks, appropriate mitigating actions were identified and presented. General risks were characterized by being valid and applicable for the entire service area, as they represent limitations of the autonomous vehicle and its driving system, relevant for the entire area of operation.

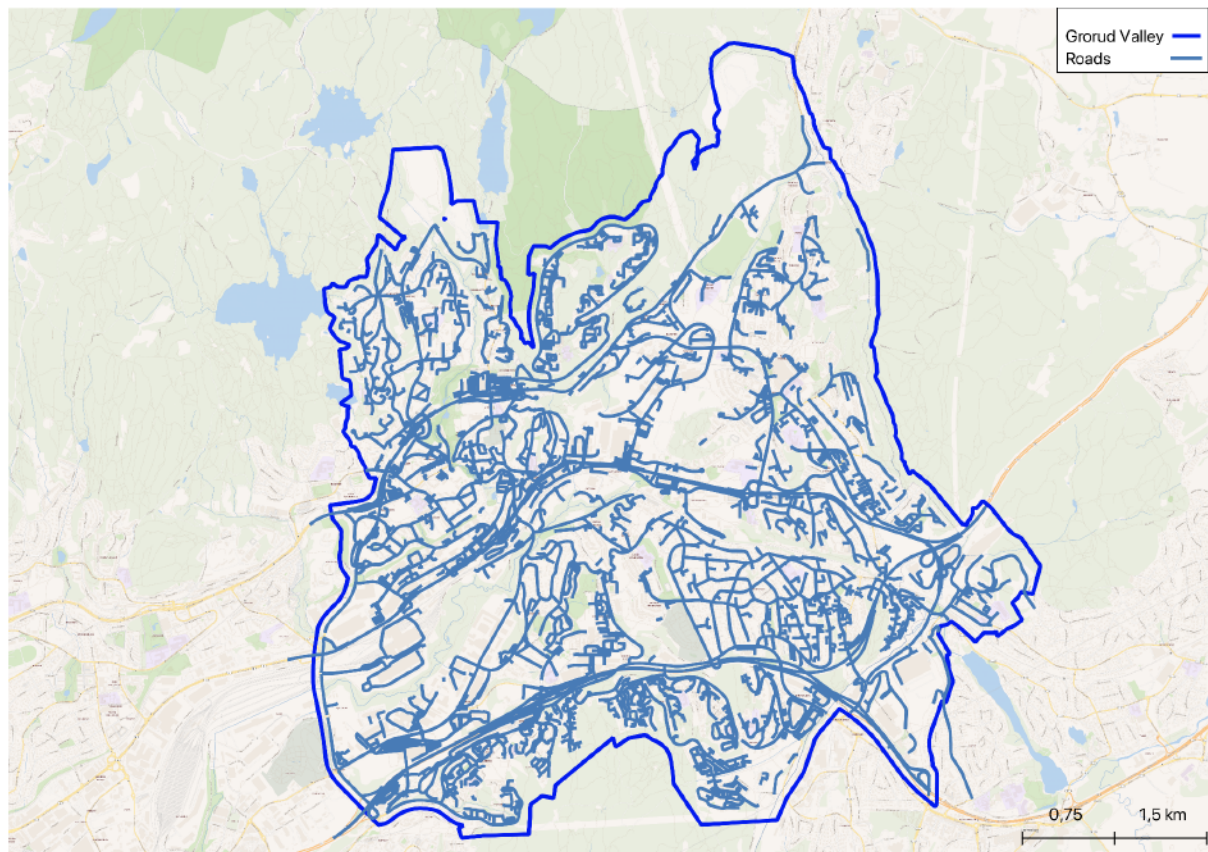


Figure 47: Roads in Groruddalen

By using the data available in NVDB, all the roads in Groruddalen have been categorised into one of the six road profiles presented in Table 8 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 8: Road profile with total length

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 9: 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.

For a more extensive general elaboration on the ODD we refer to the work done in WP2.2 “Definition of vehicle capabilities and ODD”.

4.2.1 Description of Operational Area / Service Area

4.2.1.1 The Route Area

Groruddalen Valley presents a challenging environment with intricate road networks, varied traffic conditions, and seasonal weather changes, including icy roads, heavy snowfall, and low winter sun. These factors make it an ideal testbed for refining the ADS technology. The pilot aims to validate that autonomous vehicles can safely and efficiently operate at speeds of up to 90 km/h, navigating multi-lane highways, roundabouts, pedestrian crossings, and incorrectly parked cars.

The area is diverse, with large residential neighborhoods, business parks, and industrial zones. Spanning approximately 22 km², Groruddalen Valley has around 560 km of roads and a population of about 140,000. While three larger highways connect the valley to Oslo, the majority of roads in the area are smaller residential streets, unsuitable for city buses. Currently, residents rely heavily on buses to reach the single train line to Oslo, but the introduction of smaller on-demand vehicles would significantly enhance local transportation options, reducing the need for personal vehicles and alleviating traffic congestion.

The Description of Operational Area / Service Area Operational Design Domain 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.

4.2.1.2 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 48: 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.

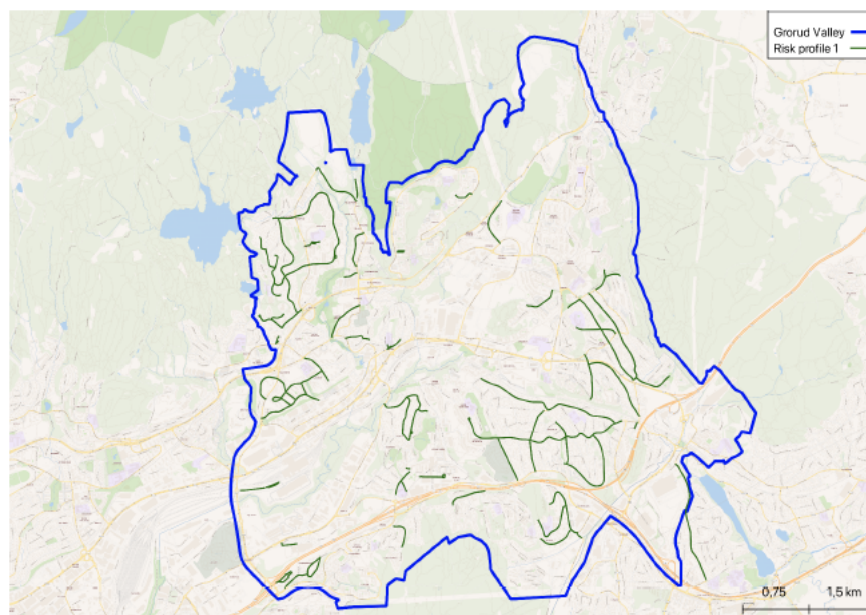


Figure 49: Groruddalen region roads with road profile 1

Specific risks to this particular RP include risk stemming from the narrow nature of the roads in these areas. This alongside the fact that the programming of the vehicle prohibits illegal maneuvers such as driving onto a sidewalk. This despite the fact that this is a common maneuver used in everyday situations in order to safely pass other vehicles or parked cars.

4.2.1.3 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 50: 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.

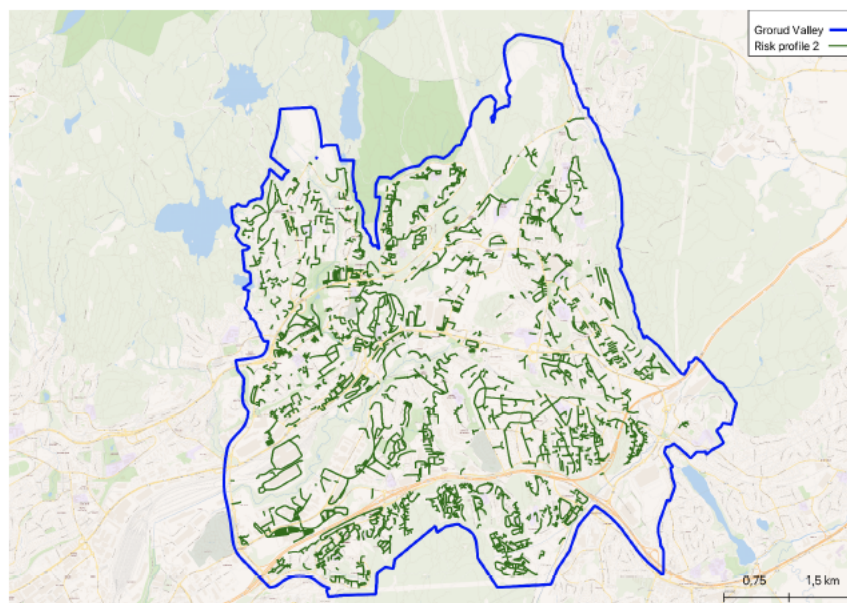


Figure 51: Groruddalen region roads with road profile 2

4.2.1.4 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 52: 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.

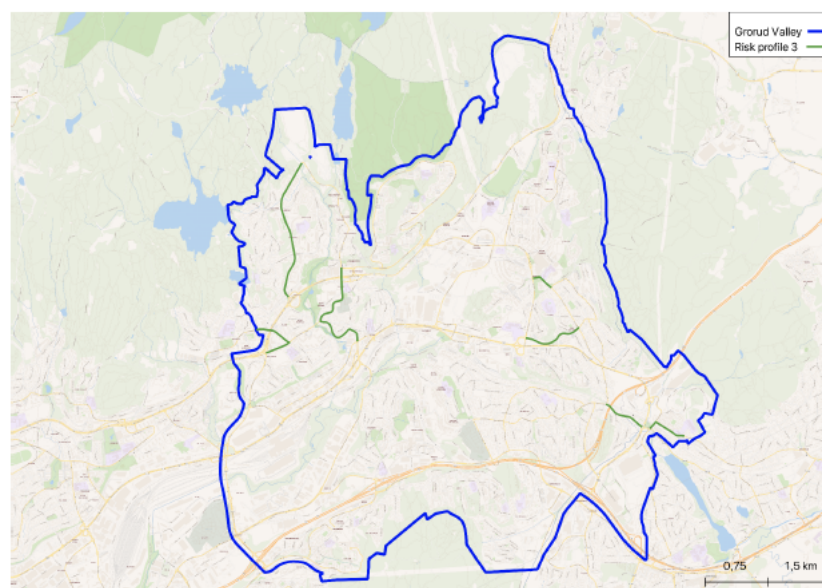


Figure 53: Groruddalen region roads with road profile 3

4.2.1.5 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 54: 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.

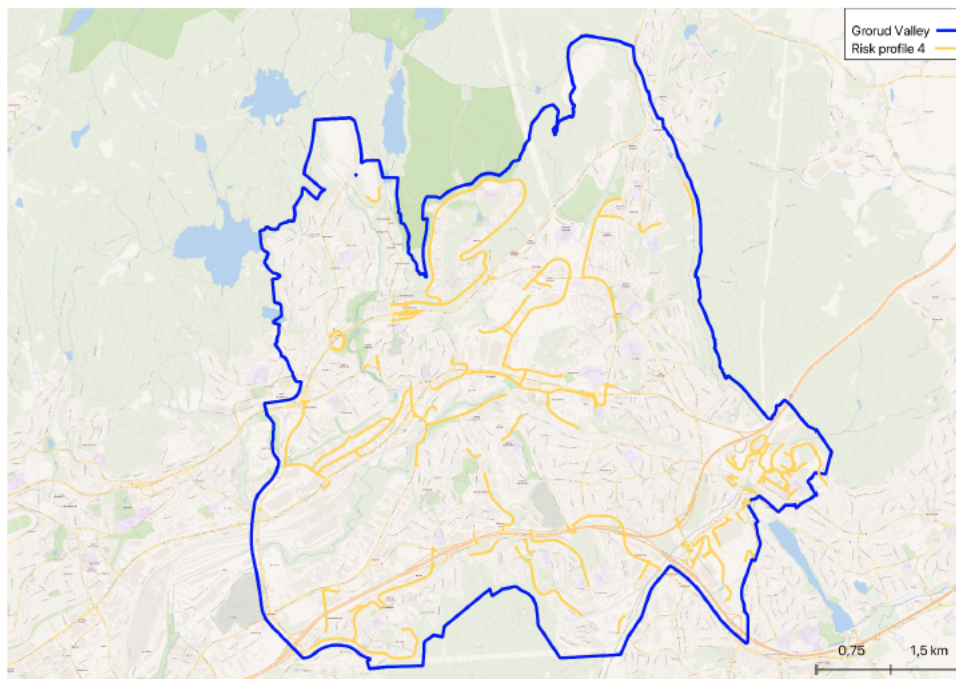


Figure 55: Groruddalen region roads with road profile 4

4.2.1.6 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 56: 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.

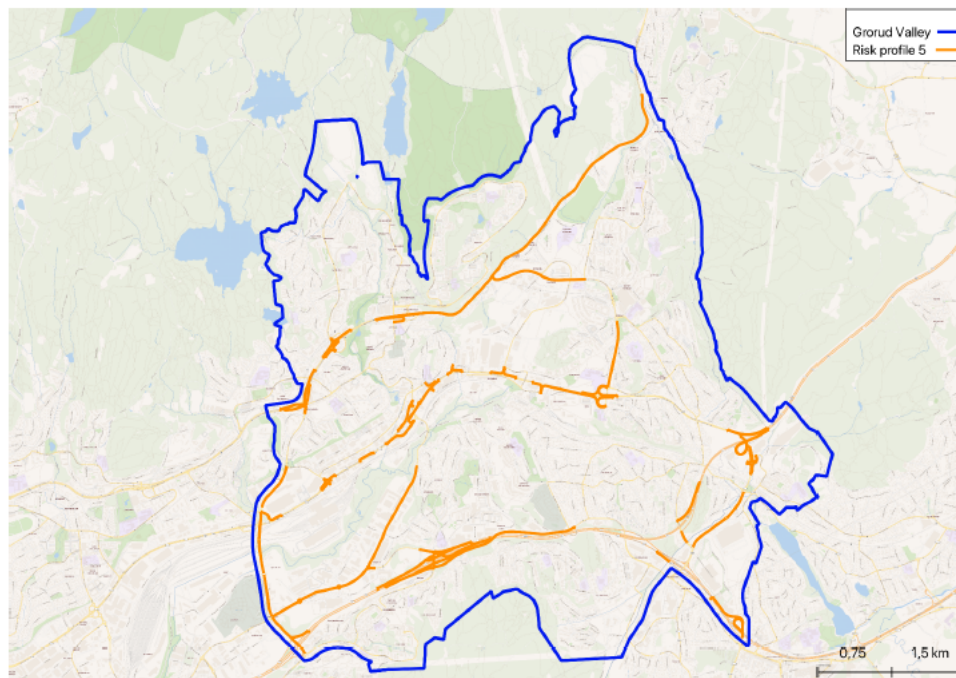


Figure 57: Groruddalen region roads with road profile 5

4.2.1.7 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 58: 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.

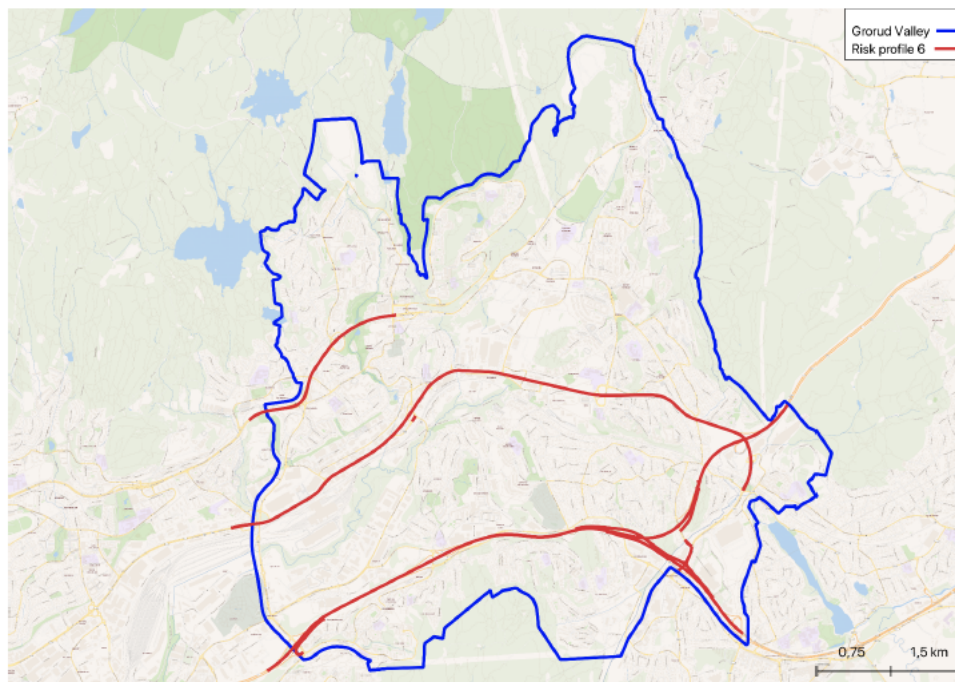


Figure 59: Groruddalen region roads with road profile 6

4.2.2 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.

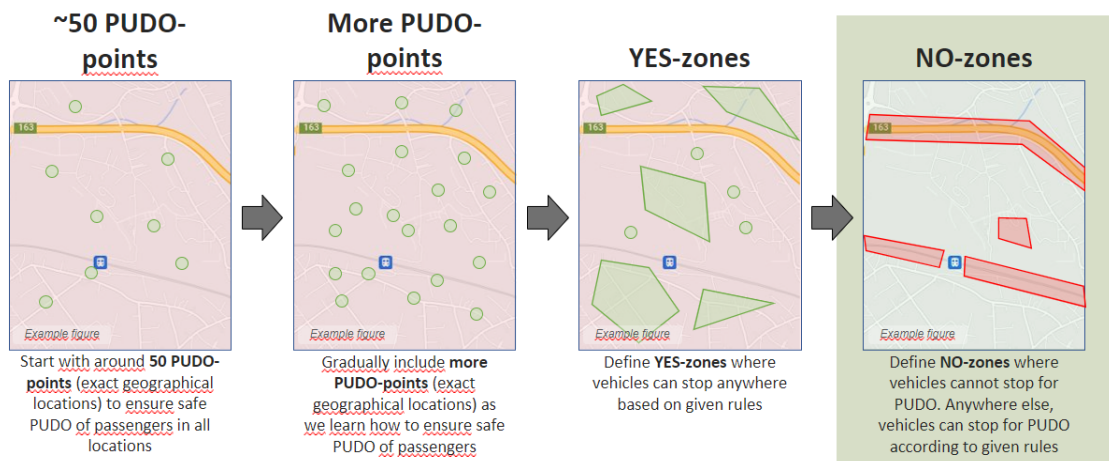


Figure 60: PUDO points evolution

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 10: 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).

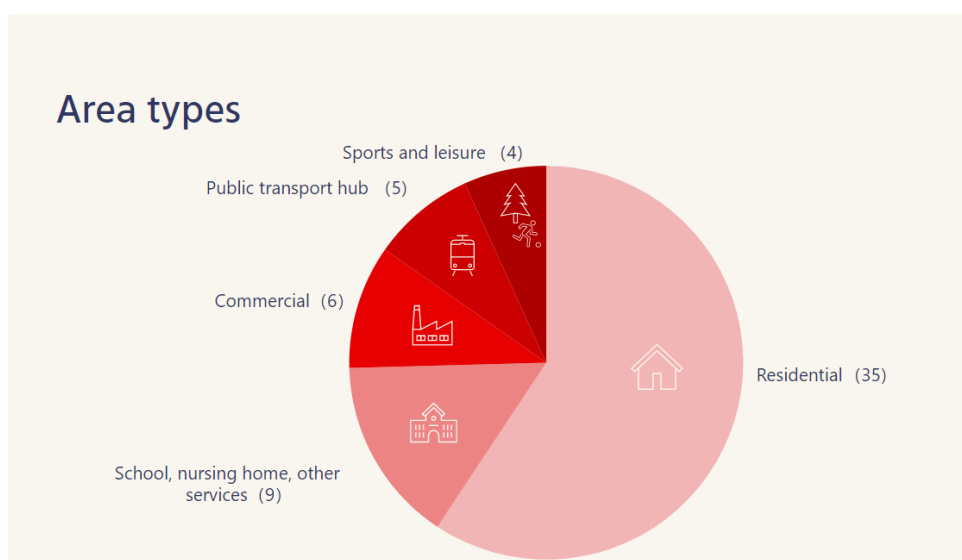


Table 11: The number of Pick-up and drop-off points grouped by area type.

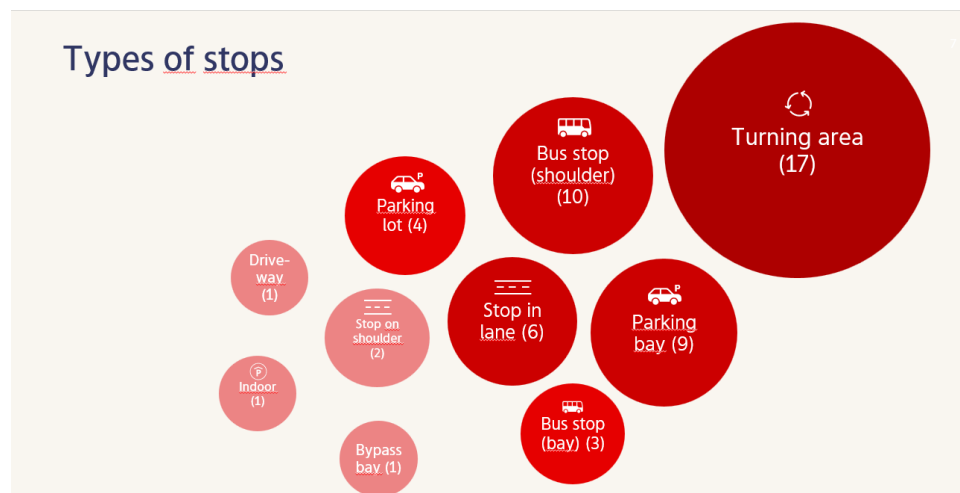


Table 12: The number of Pick-up and drop-off points grouped by stop type

In addition to pick-up and drop-off points there will be a smaller number of break stops (facilities for safety drivers) and holding areas (in between trips, when 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

4.2.2.1 Results From “Hent” – Automating Identification and Elaboration of Pudos

Ruter has several initiatives running in parallel with our pilot project in the Groruddalen valley, where needs assessments and opportunities for PUDOs are a central theme. There are crucial learning points from this collaborative work, which will affect how approach scaling up the number of PUDOs in any given area.

“Hent” is a staffed on-demand transport service that Ruter will launch in the fall of 2024. The purpose of initially launching Hent with a driver on board is to gain insights and experience for a future autonomous service. The Hent pilot will run concurrently with the Groruddalen Valley Pilot, which will test autonomous vehicles for on-demand transport. The area borders the pilot area of Groruddalen, southwest of the valley and closer to Oslo city center. The area covered is approx. 22 km², nearly similar to the pilot area’s 20 km², with a population of 131 000 compared to Groruddalen’s 82 000.

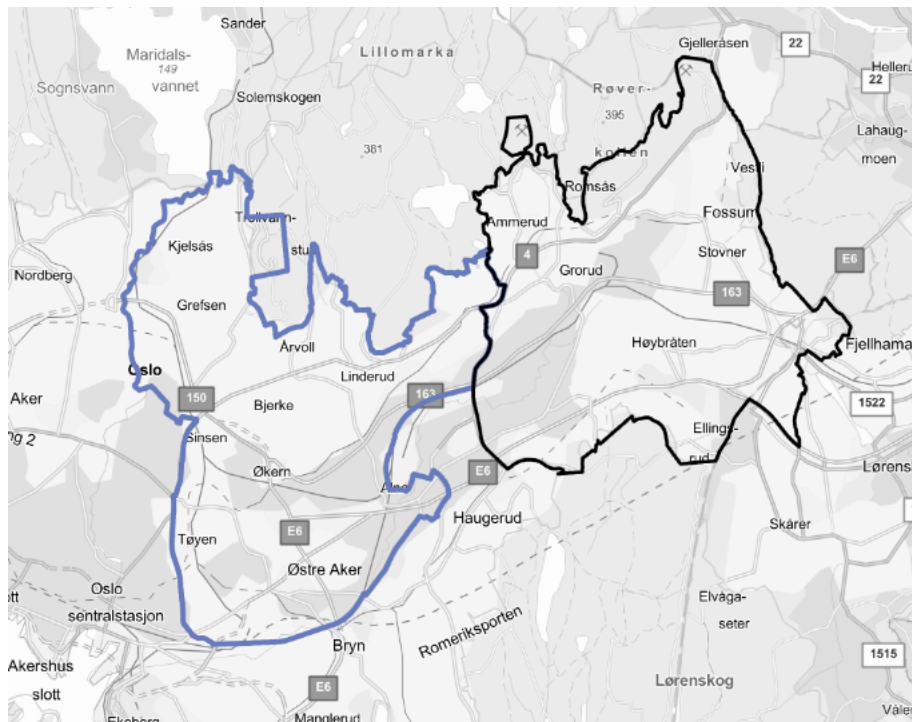


Figure 61: Operational area of "Hent" and the Groruddalen pilot

The development of this service is being carried out in close collaboration with the Groruddalen pilot. The roadmap is the same, and the service will be autonomous in the future. Therefore, the insights and collaboration between these two projects are crucial.

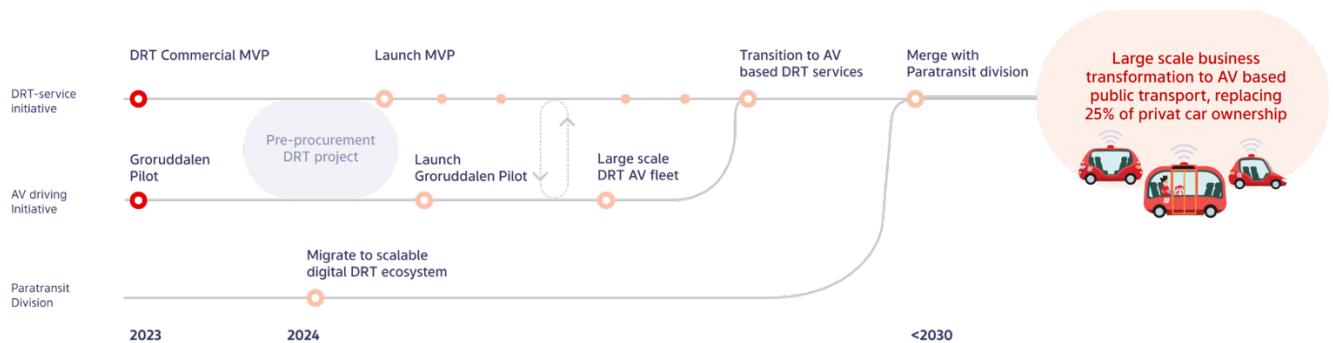


Figure 62: Ruter roadmap - DRT & AV

In addition, Ruter has an ongoing “Pre-procurement DRT project” to prepare all departments in the company for a procurement of autonomous on-demand transport – the next step after the Groruddalen pilot is completed. In this project, expertise from infrastructure and analysis is engaged to explore various needs. Among these are analyses of needs and consequences for the number of PUDOs, so that the user experience becomes “from where I am to where I need to go.”

The vehicles will be in operation to varying degrees throughout the day. To minimize the need for empty trips, different parking solutions will be required.

The customers' ability to pre-book trips in addition to short-notice bookings will make traffic planning easier, and good positioning can be undertaken for the most rational driving routes. Good positioning can reduce the need for empty trips but will also lead to a greater need for short-term parking.

Initially, PUDOs should primarily be virtual to reduce the extent of interventions and costly infrastructure. It should however be considered to use existing stops for boarding and alighting, provided there is available capacity and that stops do not impede traffic flow.

There is a need for more insights and experience from services like Hent to assess the required number of PUDOs.

From the customer perspective, minimal walking distance is desired, meaning as many PUDOs as possible.

The process of identifying and elaborating possible PUDOs gives important input for future scale-up of our AV services as well. This process needs to be more dynamic and automated than we have in our pilot. This approach has been done in the Hent-project. One can imagine that the complexity of elaborating specific PUDOs for automated vehicle brings across additional complicating factors.

In the operation area for Hent, 2677 virtual PUDOs were automatically identified using the DRT software solution in Ruter (Via). Applying specific policies / restrictions and analyzing the results reduced the possible amount to 1082.

Restriction (buffer-zone)	Number	Percentage
Road with speed limit 50 km/h (13m)	427	15,95%
Road with speed limit $\geq$ 60 km/h (25m)	115	4,30%
Proximity to tram line (12m)	93	3,47%
On and off ramps (10m)	48	1,79%
Roundabout (20m)	56	2,09%
Private road (7m)	900	33,62%
Existing bus stop (0m)	282	10,53%
Roadwork (3m)	75	2,80%
Bike path (10m)	264	9,86%

Table 13: PUDO restrictions analysis

With the revised PUDO network, it is estimated that 91% of the population lives within a 250-meter walk to the nearest PUDO, and only 0,7% are located more than 600 meters from the nearest PUDO.

4.2.3 Elaborations On Route Selections

The project aims to provide a service that can pick up and drop off passengers on all roads in the pilot area to cover real travel needs. To achieve that, all roads needs high-definition (HD) digital maps. Furthermore, both the HD maps and the driving policy of

the self-driving system needs to be validated on all of the roads, making sure that everything is working as intended.

Currently, roads between 12 prioritized PUDOs have been validated, as shown in Figure 63.

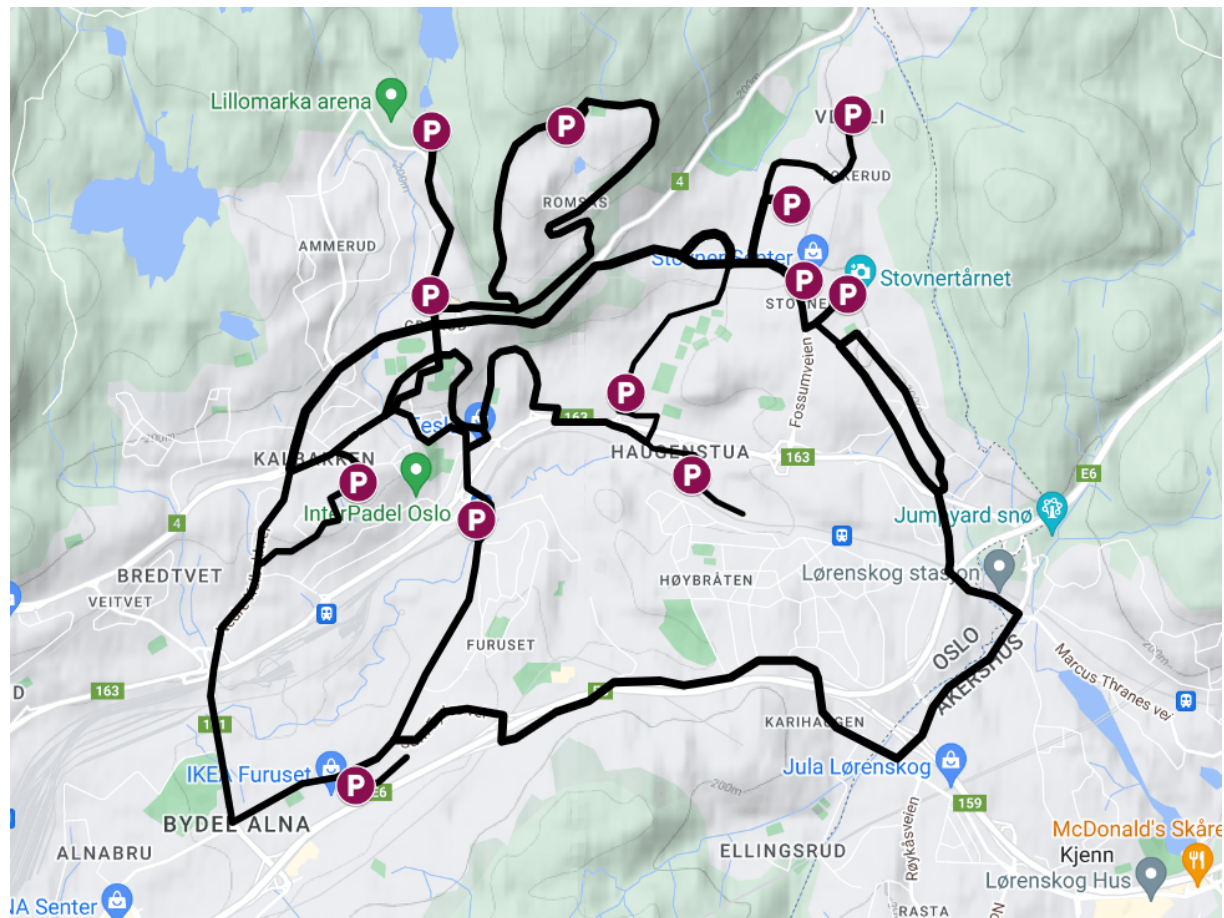


Figure 63: Roads and PUDO locations (P) that have been validated.

The importance of high-speed motorway operation

Currently the fleet is approved for operation in speeds up to 60 km/h. While that covers most of the roads in the pilot area, it's crucial to be able to drive on the motorways to provide real customer value compared to the private car. The pilot area consist of 2 motorways with speed limits up to 90 km/h (E6 and 163 in Figure 63), as well as one other major road with partially speed limit of 80 km/h (4 in Figure 63).

Figure 64 shows a good example of why it is so important to reach higher speed limits. Instead of driving on the motorway (grey road), we currently have to use a sideroad (black) to travel between the two PUDOs (P). The sideroad is in this case a narrow road with parked cars effectively making it a one-lane street, and with oncoming traffic. Using the sideroad is both uncomfortable for passengers, and almost doubles the travel time between these two PUDOs (a train station and supermarket in this case).

The project is aiming for approval for 90 km/h within short time.

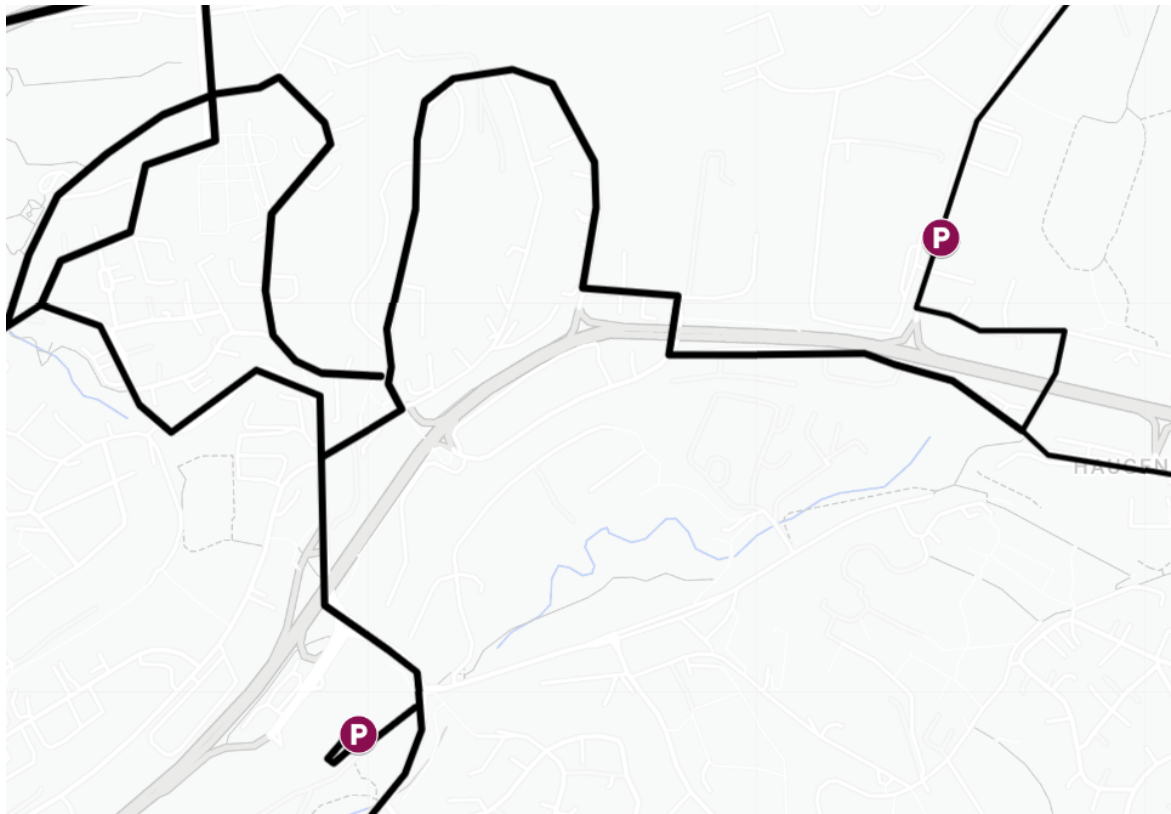
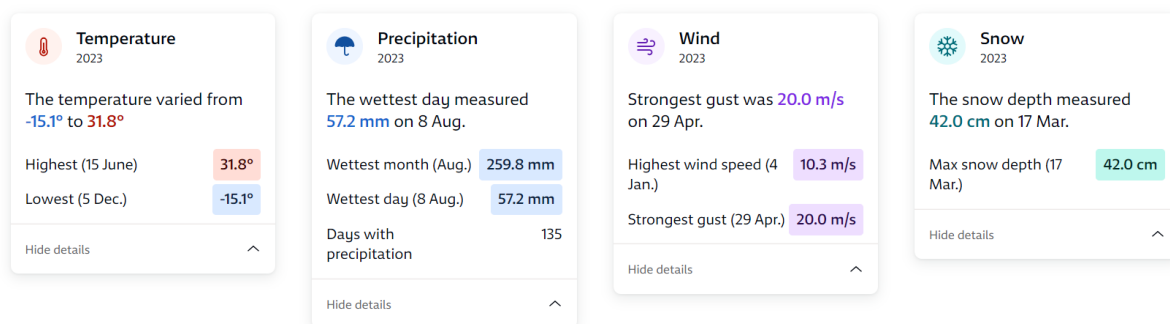


Figure 64: Major detour on operational route (black lines) when not allowed to drive on the motorways (grey roads)

Next steps will be to validate more PUDOs and the roads connecting them. The 12 first PUDOs were chosen to make a quick path to a road network where we could start testing a DRT service between multiple locations. However, this is far from a sufficient amount to cover real travel needs. We currently have identified 150 PUDO locations that will be validated in prioritized order, based on customer travel needs (based on data from national travel surveys (RVU) and mobility data from telecom operators).

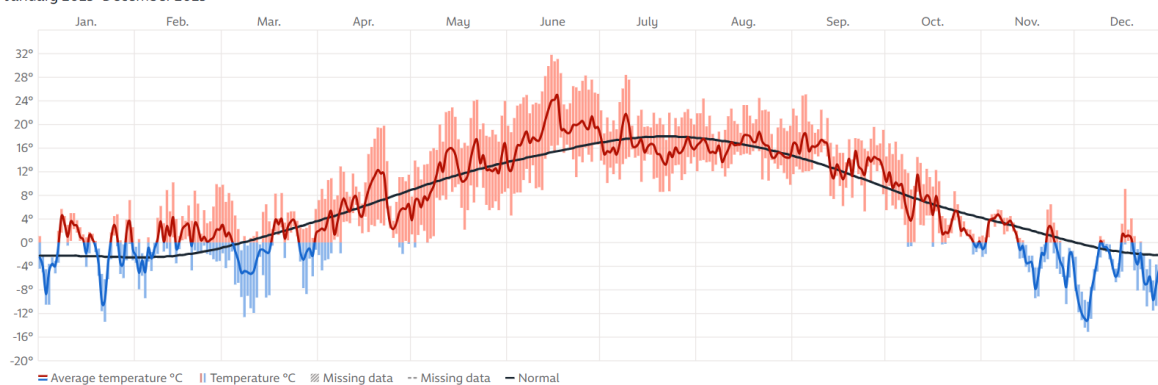
4.2.4 Weather Conditions

Operations in changing weather conditions throughout the year, particularly in cold and snowy winters is a major area for learning. Below is a meteorological overview of a full year in the pilot area (year 2023). So far in 2024, Oslo has experienced a winter with even more snow than normal, with the lowest temperature has been -23,1°C and a maximum snow depth of 52 cm.



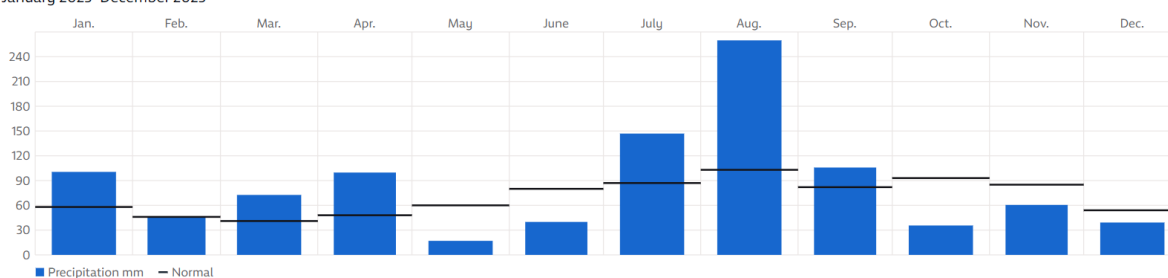
Temperature

January 2023–December 2023



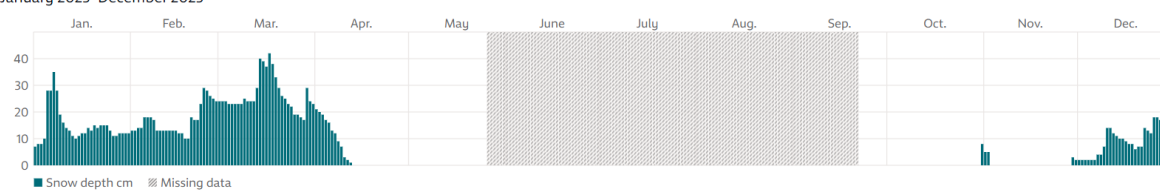
Precipitation

January 2023–December 2023



Snow depth

January 2023–December 2023



Wind

January 2023–December 2023

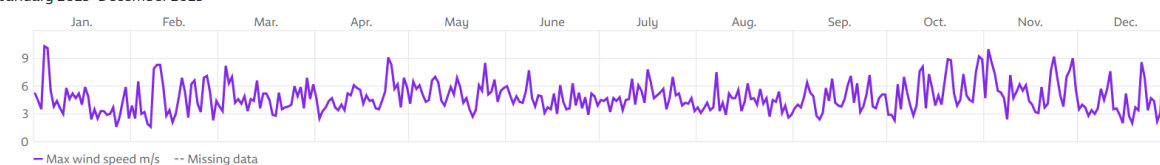
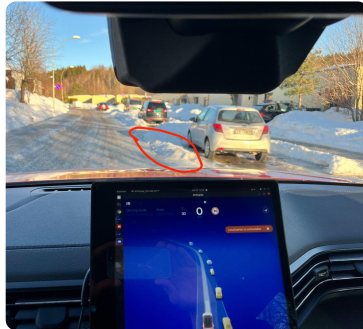


Figure 65: Weather conditions throughout a year in Oslo, 2023. From yr.no

The extraordinary snowy winter has been a great opportunity for learning about winter operation, test the current capabilities of the technology, and about challenges that still needs to be solved to provide a stable and safe service in Scandinavian winter conditions.

Main winter challenges:



Difficult driving conditions with high number of snowbanks in different sizes and shapes

Table 14: Main winter challenges in Oslo



Lanes are disappearing and vehicles park halfway on the road, due to snowbanks.



Even normal vehicles get stuck on icy roads, creating significant challenges for the performance of the AV.

Challenges related to hardware/software:

- Sensors getting covered by snow when around 0 degrees - melting snow attach to the sensor surfaces
 - Sensors need to be coded or cleaned by safety operators during operation
- Heavy wet snow not being filtered out on the LIDARS (cold powdery snow didn't give us problems)
 - Sensors need to be calibrated to handle falling snow better
- Sensors and cameras need to be able to detect and categorise snow banks and piles of snow
 - Decision engine should be able to handle different types of snow banks and act accordingly



Figure 66: Snow covering sensors

Challenges related to driving policy:

- Driving policy has to be more dynamic between icy roads with snow and normal weather conditions
 - The vehicles have to be able to change and offset parameters in the driving policy to

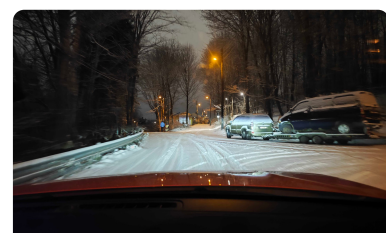


Figure 67: Snow on roads

be able to handle icy roads versus normal dry roads.

- Traction conditions change due to weather (for rain and not only snow/ice)
 - Should be dynamically adjusted with the decreased coefficient of friction
- The vehicle has trouble with deviating from the preset drivable path (which is necessary when 2-way roads have become 1-way roads due to snow)
 - The vehicle needs the capability to adjust its behavior and drivable path positioning



Figure 68: Calculating drivable path

Experiences from last winter will be explored more the coming winter 2024/2025, with planned testing of improved winter driving policy, explore issues with PUDOs and roads that are less accessible because of snowbanks, and user testing of the complete service in winter conditions.



Figure 69: Winter conditions 2023/2024



Figure 70: Winter conditions 2023/2024

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 Groruddalen 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 71: NIOs at the garage in Groruddalen

4.3.2.1 Branding

The vehicles are branded according to Ruter's official profile and stand out well in traffic. During the testing phase (without passengers), we have a clear message indicating that the vehicles are self-driving, creating a 'teaser' with the message 'Soon you can ride.'



Figure 72: Branding of the vehicles before open service

When the vehicles are ready to take passengers, we will replace this message with an invitation to try it out and book a ride through our app.



Figure 73: Branding of the vehicles when service is open for general population

4.3.3 Groruddalen Demo Site Statistics

Operation from the demo site is collecting large range of statistics, ranging from kilometers driven autonomous mode, geo-located events, to user-centric experience data. The data is varying from stage to stage in the pilot, servicing operational needs at current stage.

4.3.3.1 Statistics HD-Map Coverage (REM)

HD-map for the pilot in Groruddalen is based on the technology provider Mobileye's technology and requirements. This is named "REM", Road Experience Management and must be prepared before automated operations. As preparation an enterprise using 5-6 vehicles with Mobileye 8 Connect devices and collect REM data over a period of three months was needed. This data collection was one of the sit operator, Holo, main responsibilities.

Mobileye's approach to REM is built on crowdsourced, continuously improving and updating mapping data. This makes the Mobileye REM-data:

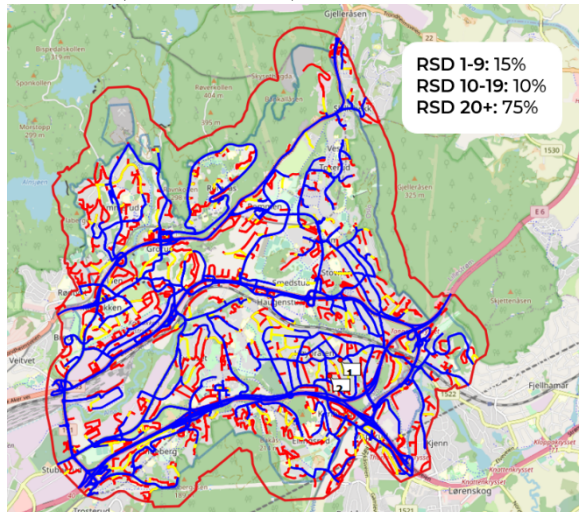
- Scalable by design
- Fully automated
- Real time updating
- Superior in local accuracy
- Based in rich semantic layers of understanding

The work for executing RSD collection was split into three phases, with continuous learning flow:

Planning	Setup	Supervision
Route planning to ensure an efficient and high-quality data collection. Including plans for the data collection in detailed steps to ensure timely completion of deadlines	Configuring the existing toolsets for use in a new service area. Training of drivers in the use of necessary tools, processes and local driving style.	Continuous monitoring, tracing and reporting processes. Supervision support available at all times to drivers for support - ensuring high uptime Mobileye supported validating of REM-data quality and map-making.
Continuous learning and exchange of experiences Throughout the process, partners will work together to optimize the various steps, keep all stakeholders informed and document learnings for future projects.		

The REM-data statistics of quality was measured before and after the REM-campaign:

Before: (17.07.2023)



After: (28.08.2023)

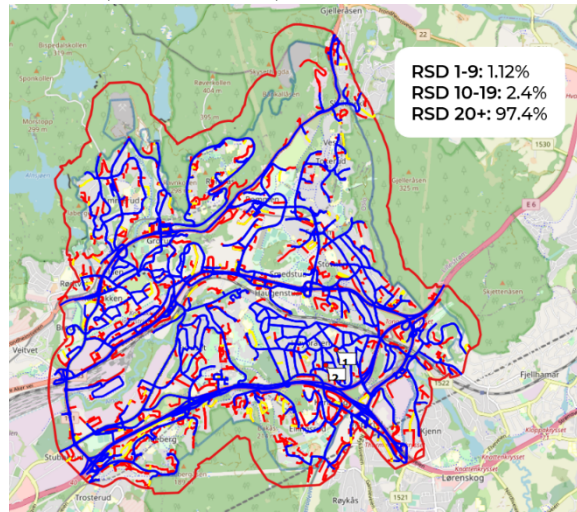


Figure 74: REM-data statistics of quality was measured before and after the REM-campaign

Statistics indicate a highly successful and efficient REM-campaign, moving from an RSD 20+ quality of 75% to an RSD 20+ quality of 97,4% for the whole service area. This level was determined as sufficient to start the next phase of the pilot project.

4.3.3.2 Operational Data Collection and Analysis From Preparational Phase, Prior To Accepting Customers

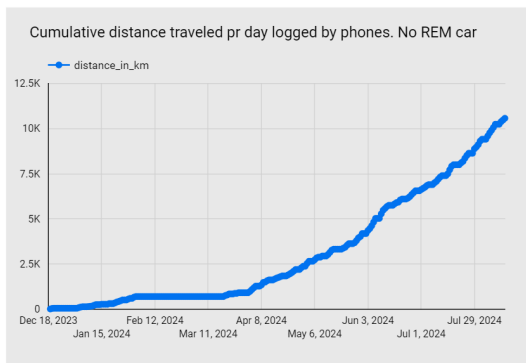
All data required when monitoring operation and assisting the safety drivers is stored and visualized in our dashboards. This data is assessed on a regular basis to ensure the best operational performance, and to get a full understanding of how the route and vehicles perform - and what to change, if necessary.

Data collection projects include:

- Monthly uptime reports detailing all downtime causes
- Comprehensive dashboards providing a full overview of the performance of the route, vehicles and project
- Thorough data collection of all route issues and time driven

Key statistics from dashboards:

Cumulative distance driven



Cumulative hours driven (d.d)

Km driven - All dates

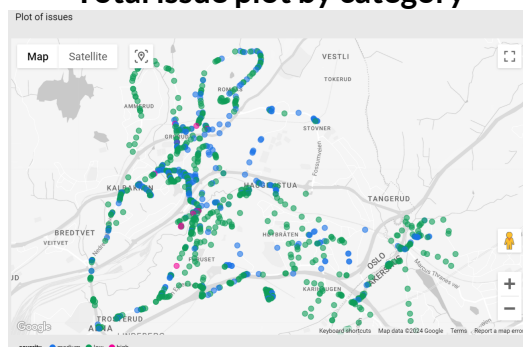
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Monthly up-time tracking

Total uptimes per month in the current year

Month	Total hours
January	31:45:31
February	06:57:52
March	22:22:40
April	73:24:30
May	76:04:13
June	118:01:13
July	158:29:55
August	92:17:29

Total issue plot by category



Total issue plot by heat-map

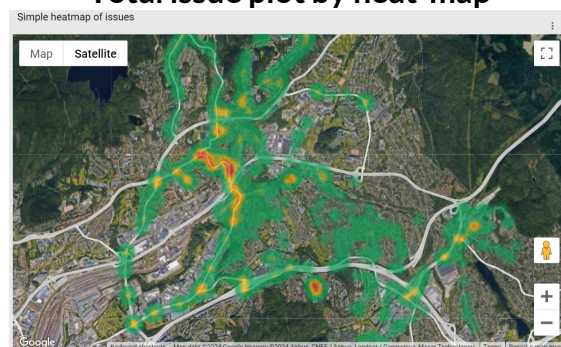


Figure 75: Key statistics from dashboards

4.3.4 User Testing

Since May 2024, we have conducted three rounds of user testing, each lasting two days. The tests were designed to comprehensively evaluate various aspects of our service, encompassing the user experience from initial onboarding to ride completion, as well as interactions with the app and vehicle interfaces.

After each user test session, we conducted in-depth interviews with the participants to gather qualitative insights into their experiences. These interviews provided valuable feedback, helping us to understand user perceptions, identify pain points, and uncover areas for improvement. Since we are still awaiting the necessary permits to include external passengers, all testers were internal employees of Ruter, giving us the opportunity to fine-tune the service in a controlled environment.

User Journey (simplified)

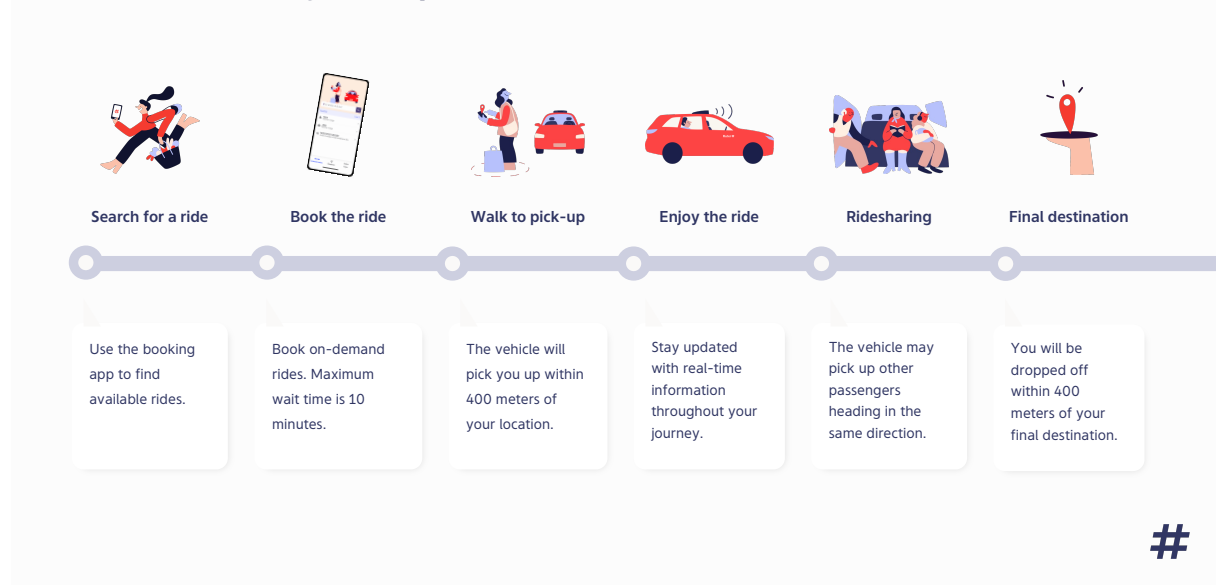


Figure 76: Simplified user journey

1.3.4.1 Key Insights

Overall, the feedback from our testers was overwhelmingly positive, with many expressing enthusiasm for the technology and confidence in the service's potential. Testers were impressed by the smoothness of the rides, the vehicle's handling in traffic, and the clear, user-friendly onboarding process. However, several key areas of improvement were identified, which are crucial to refine before full-scale implementation of the service.

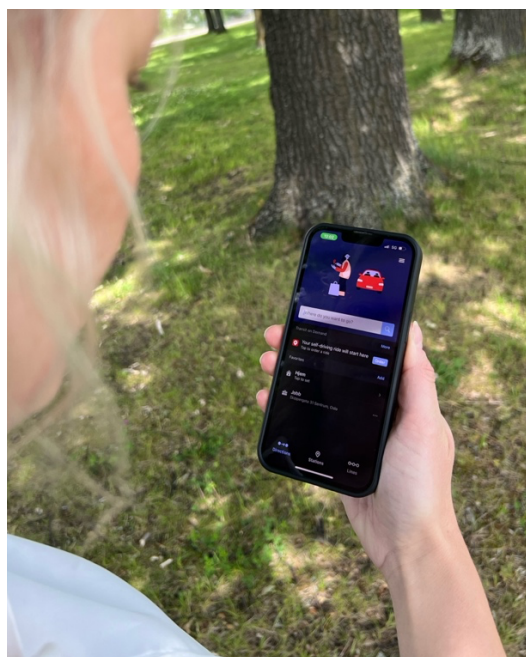


Figure 77: Booking app

1. Booking app usability:

- **Navigation:** Users encountered issues with the app's navigation, particularly the lack of a clear route on the map and difficulties in locating the PUDO points. The absence of a compass and the lag in the location marker were noted as significant pain points. Some users preferred using Google Maps due to these limitations.
- **In-App interactions:** The booking flow was interrupted by unnecessary prompts, and users found the icons and instructions unclear, leading to confusion during the boarding and deboarding processes.



Figure 78: Passenger Screen

2. Passenger screen experience:

- **Information display:** Testers expressed a need for a detailed route map on the passenger screen to enhance their sense of security. The inconsistency in Estimated Time of Arrival (ETA) information between the app and the passenger screen led to confusion.
- **Communication:** There was a noticeable disconnect between the app and the passenger screen, with users preferring to receive all essential notifications directly on the passenger screen to avoid distractions.



Figure 79: Ride experience

3. Ride experience:

- **Driving style:** When users know they're in a self-driving car, they often expect cautious behavior and scrutinize the vehicle's actions more closely, particularly in complex scenarios like roundabouts. While the car's smooth handling was praised, some users noted that its roundabout maneuvers could be adjusted for a more balanced approach.
- **Comfort and safety:** The presence of a safety operator somewhat detracted from the autonomous experience. Additionally, concerns were raised about the sensory experience inside the car, with noises from sensor-cleaners and fans being distracting.



Figure 80: PUDO & Navigation

4. PUDO & Navigation:

- **PUDO location:** Users were often confused by the placement of PUDO locations, with some finding them too far from convenient spots. Clearer instructions and better communication regarding these locations are necessary.
- **Deboarding process:** There was uncertainty about whether the ride was over, and the "end ride" button was not always intuitive. Users also missed the navigation to their final destination after deboarding.

1.3.4.2 Focus Areas for Further Development

As we move forward, it is essential to address the following areas based on the insights gained from these tests:

Enhanced navigation and clear communication:

- Improve the app's navigation features, ensuring that routes are clearly displayed, and users are accurately guided to PUDO points and their final destinations.
- Synchronize ETA information between the app and the passenger screen and ensure that all critical notifications are communicated seamlessly across both platforms.

Refinement of in-vehicle experience:

- Adjust the vehicle's driving style to be less aggressive in situations that may cause discomfort to passengers.

- Minimize distractions caused by sensory equipment and improve the reliability of detection systems to prevent false alerts.

Ridesharing implementation:

- Although ridesharing functionality has not yet been tested, feedback on concerns such as passenger visibility, space management, and the impact on timeliness must be considered in the development process. Users expressed a desire for transparency about whether others are already in the vehicle and how ridesharing might affect their travel experience.

Passenger comfort and safety:

- Ensure that the passenger experience is both comfortable and safe, particularly when carpooling with strangers. Addressing the placement of safety operators and refining the sensory environment within the car will be vital.

1.3.4.3 Next Phase of User Testing

With the completion of these initial rounds of testing, we are now ready to enter the next phase, which will involve testing newly developed features. These include:

- **Ridesharing functionality:** We will introduce and evaluate the ridesharing feature, allowing multiple passengers to share a ride, and assess how this affects the overall user experience.
- **Updated passenger screen interface:** The passenger screen interface has been enhanced based on previous feedback, and we will test its effectiveness in providing relevant information and improving passenger comfort.
- **Booking app in production environment:** The booking app will be tested in a production environment to ensure its reliability and usability under real-world conditions.

This upcoming phase is critical in fine-tuning the service as we prepare for a broader rollout and the eventual inclusion of external passengers. The insights gained will guide our final adjustments, ensuring that the service meets the highest standards of user satisfaction and operational efficiency. Further information on the user testing processes and insights can be found in the documents summarizing our work in WP2/WP6.

4.3.5 Approach On L4 Training

4.3.5.1 Safety Operator Recruitment, Training, and Operations

The safety operator obviously has a very important role in preparing, validating, and “training” the vehicles for our operational area. Ensuring safety is, of course, the highest priority. Equally important is the operator’s role in observing, recording, testing, and providing feedback to the technology provider to enable continuous development and improvement of the software and map updates.

The safety operator thus has many roles. The requirements are high. It requires a high ability to handle the vehicle with the level of attention that is necessary. Additionally, the operator must have sufficient technical competence in their role as an observer in a validation and testing regime.

One might think that such a role is temporary. However, this role will be needed for the foreseeable future. As operations scale up, there will be a need for the validation of new operational areas, and software updates will need to be tested.

In order to conduct safe operation in the project, the operator (Holo) and Mobileye ensures that Safety Operators are trained properly and with a clear understanding of their safety responsibilities. Holo and Mobileye apply a trainer's training concept, where only Trainers who have completed the trainer's course will be allowed to afterwards conduct training of Safety Operators.

Recruiting Safety Operators

When we search for a safety operator, we are looking for candidates with specific broad competence and experience, combined with a personality suited to the role, with a focus on responsibility and ambassadorship. They are responsible for a variety of tasks related to operating the fleet, such as

- Ensuring the service of the autonomous vehicle in a large suburban area
- Provide detailed feedback on driving experience, safety performance, security, passenger impressions and other topics of interest to internal departments
- Collect and upload data and log files
- Light user maintenance of the vehicles
- Be part of a team of safety operators in a time-sensitive and demanding environment
- Handling of any incident as defined in relevant training
- Hosting passengers and explaining about Holo and related technologies

In the job postings, we look for the following:

- Proficient driver experience. Experience from advanced driving, such as go-karting, professional driving, racing, etc.
- Ability to stay calm under pressure, anticipate failures, appropriate maneuvers and mitigate risky situations before they appear.
- Affinity for technology

Safety Training Programme

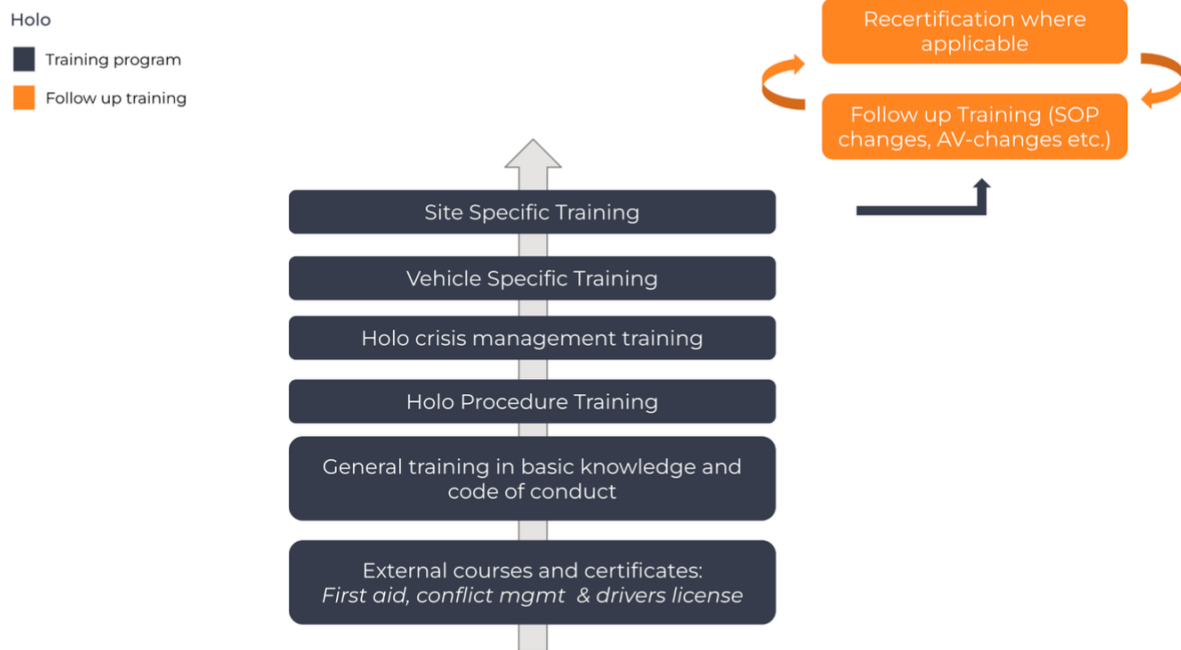


Figure 81: Overview of Safety Driver training programme

The purpose of the programme is to provide Safety Operators with the knowledge, skills, and competences needed to manage both manual and autonomous driving in any conceivable traffic situation. Additionally, Safety Drivers shall be able to apply relevant procedures and incident management processes both in daily operations and in the case of an incident.

Service Specific Education

In addition, all safety operators take part of an education program specifically targeting service related topics. While Holo, as the operator, is responsible for recruiting and training safety operators in safety and operations, it is Ruter as the PTA and responsible for the service towards customers that conducts the service specific education. The education consists of three main topics:

- 1. Introduction to Ruter and the pilot service**
Understanding of Ruter's vision for a shared, automated DRT service, its importance in the mobility of tomorrow, and learning objectives for the Groruddalen pilot project.
- 2. The ambassador role and passenger interaction**
Perception of safety, understanding the ambassador role as a safety operator, and learn how to handle passengers and other road users.
- 3. The role as an observer**
How to exploit the safety operator's valuable insights when driving with passengers, what to look for, and how to share insights and feedback with Ruter's project team to improve the service in different parts of the customer journey.

4.3.6 Status On Vehicles

4.3.6.1 Additional Vehicles and Technology Provider

Ruter has explored partnerships for service delivery rather than technology procurement, focusing on adapting and implementing AV technology within a public transport framework.

The description of our operational area in 4.2.1 Description of Operational Area forms the background for the requirements we set for vehicle and technology suppliers' ability to deliver a service that, during the pilot period, can operate at L4 without a safety operator, and follow the traffic pattern in the area.

In the AV domain and related technical stack of required capabilities, while supporting the 2030 objectives and targets, there is unfortunately an absence of competitive European solutions for autonomous operation.

Therefore, while continuing to have an open mind and broad horizon, Ruter currently is mainly working with non-European technology providers in the Groruddalen pilot. Ruter however believes Europe is well-positioned on the OEM front and is particularly ahead in adapting services to what we are convinced is a sustainable option for society. Technology is, of course, an important link in this chain, but not the only one. And the market is moving quickly forward.

Ruter has a contribution to make in this regard, but we need to know what to request now. By the time we are ready to initiate an innovation procurement, the supplier market – including the European one – will hopefully be able to deliver the service for public transport, for a sustainable society with mobility for all, as set forth above.

For over a year, we have been engaged in an ongoing procurement process for new research and development partners, so that we can acquire an additional 1-2 solution providers for the autonomous service in the Groruddalen pilot.

The above-mentioned procurement process has concluded in a Letter of Intent with a large land-based transport group in the Nordic countries.

Their pursuit of advanced autonomous mobility solutions has led them to engage with many suppliers in and outside Europe.

An R&D agreement with the above-mentioned group will enable us to expand the service with a fleet of 3-5 vehicles from their sub-supplier. The vehicles will operate throughout the existing pilot area at speeds up to 90 km/h and, after approximately 12 months of operation, will operate without a safety driver on board.

4.3.6.2 Market Elaborations

We continuously monitor the market. It is rapidly evolving, both in terms of technological development, vehicles and form factors, business models, and value chains.

We need to find suppliers who can offer a service that both matches the area's requirements for ODD capacity and aligns with the service offering we are planning – seamless point-to-point flow within our defined area.

Many vehicle technologies may work – or have the potential to work – excellently in other operational areas with different ODD requirements. We have our starting point and baseline, so to speak, when setting up evaluation criteria.

Our ongoing evaluation is based on the following criteria:

- **Technological Maturity** – How “tech ready” is the autonomous driving technology? Specifically, we assess:
 - L4 readiness, without a safety operator. At least demonstrating driving in parts of the ODD.
 - Speeds up to 90 km/h
- **Market Readiness:**
 - Vehicle platform
 - Specially designed for autonomous driving, without a driver's seat
 - Optimized for DRT and sharing (3-8 passengers), with flexible configuration
 - HQ location and ownership
 - Input for geopolitical assessments and reputational capital risks
 - Mass production readiness
 - Ability to deliver at scale
 - Financial health

4.3.7 Approval Status

4.3.7.1 The Norwegian Legislative Framework For Autonomous Pilot Projects²

In Norway a proposal on new legislation with regards to autonomous vehicles was made in June 2017. The law was reviewed throughout 2017 and in January 2018 the law took effect (Lovdata). Approval to conduct projects with autonomous vehicles is granted as one approval related to the route(s) and time period described in the application. The approval/permit will be granted by the Norwegian Public Road Administration,

² Felthaus, Fridberg, Green, Holo (12/2021). APPROVALS OF AUTONOMOUS PILOT PROJECTS IN THE NORDICS. AUTOPIA.
<https://www.arcgis.com/home/item.html?id=da30edb2648540d586592528bb3a4aed>

hereafter referred to as NPRA. The vehicles are registered and specifically linked to the time and place of the permit and registration runs out when the permit runs out.

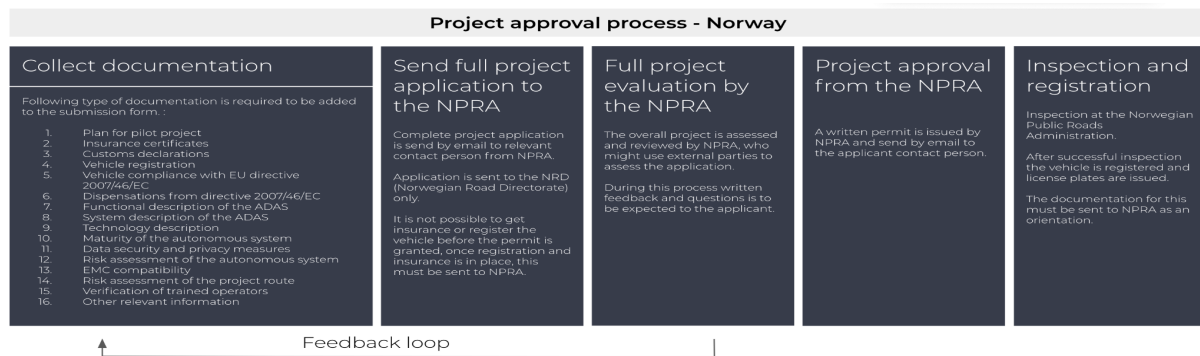


Figure 82: Project approval process in Norway

All documentation illustrated is sent to NPRA for review and approval. NPRA will assess all documentation and if necessary send questions and requirements for further explanation, documentation or potentially third party validation of technical or autonomous functionality. This feedback loop is characterized with a high degree of dialogue between applicant and approver, meaning the NPRA makes key personnel available for questions, follow up and in some cases recommendations.

As part of the registration process, all vehicles will go through inspection. The inspection will ensure compliance with the technical requirements described in the project application and will be conducted by the NPRA.

The application consists of an overall application form with 16 attachments where the technology and project risks are described in depth

4.3.7.2 Approval Process and Status In Gyoruddalen

The application and approval process for the pilot project in Gyoruddalen follows the Norwegian legislation. In the time of writing the project has received approval for driving with safety operator on all roads in the service area with speed limits 60km/h or less. Next steps in the process it so receives approval for:

- Driving in speeds up to 90 km/h on local highways.
The technology has demonstrated safe operation at these speeds in Israel, Germany and US. Our technology partner Mobileye will perform break tests according to UN Regulation No. 157 - Automated Lane Keeping Systems (ALKS)³ before final approval.
- Driving in the Service Area with customers.
Before accepting customers at the service in Gyoruddalen the project will have

³ <https://unece.org/transport/documents/2021/03/standards/un-regulation-no-157-automated-lane-keeping-systems-alks>

to document the level of interaction between safety operators and the vehicles. This is done by geotagging all disengagements with severity and evaluate if the expected workload for the operators is below an acceptable level of distributions.

4.3.8 Price Strategies

Our ongoing work on pricing strategies has focused on understanding customer willingness to pay and identifying suitable pricing models. Through a series of interviews and surveys, we've gathered insights on what potential users expect in terms of pricing and payment options for the service.

1.3.8.1 Key Insights

- **Willingness to pay:** Customers are willing to pay for convenience and time savings, particularly for leisure and time-sensitive trips.
- **Specific pricing model:** Based on our research and customer feedback, we propose a distance-based pricing model with a base fee of 40 NOK plus 10 NOK per kilometer traveled. This model was favored for its simplicity and fairness, as it directly correlates cost with distance, making it easy for customers to understand and accept.
 - **Comparison to taxis:** For example, a 3 km trip would cost 40 NOK + (10 NOK/km * 3 km) = 70 NOK, which is significantly lower than typical taxi fares for similar distances (e.g., around 140 NOK for a 1 km trip and increasing with distance). This competitive pricing aims to position the service as an affordable alternative to traditional taxis.
- **Pricing alignment with customer insights:**
 - **Fairness and transparency:** Customers appreciate the straightforward nature of the 40 NOK base fee plus 10 NOK per kilometer, as it provides clear and predictable costs. However, they prefer not to see the detailed pricing model behind the calculation, but instead want the final price of the ride to be presented upfront.
 - **Subscription considerations:** While the distance-based model works well for single trips, there is interest in incorporating this service into monthly subscription packages. However, initial feedback indicates a low willingness to pay an additional fixed fee for monthly access, suggesting that a km-based addition to existing monthly public transport subscriptions might be more appealing.
- **Discount expectations:** Customers expect discounts for ridesharing, group bookings, and frequent usage. While there is a strong desire for group discounts, we currently face technical limitations that prevent us from offering these discounts in the app.

1.3.8.2 Further Work

As we move forward, our focus will be on validating the pricing hypotheses and refining the pricing structure to ensure it aligns with customer expectations while remaining financially viable. The next steps include:

- **Testing the proposed pricing model:** We will pilot the 40 NOK + 10 NOK/km pricing model in a real-world setting to gather more accurate data on customer behavior and price sensitivity. Initially, the price will be displayed but crossed out, with a 100% discount applied. This allows customers to see the original pricing while experiencing the service at no cost, helping us assess the model's competitiveness against other transport options like taxis and car-sharing services.
- **Exploring subscription models:** Further research will be conducted to determine the attractiveness of integrating a km-based addition to existing monthly public transport subscriptions. This model could provide a flexible and cost-effective option for regular users of the service.
- **Implementing discount mechanisms:** We will explore technical solutions to offer group discounts, even within the limitations of the current app infrastructure. Offering discounts for families and group bookings is particularly important to make the service more accessible and attractive to those traveling together.

The pricing strategy for the pilot centers on a 40 NOK base fee plus 10 NOK per kilometer traveled, aligning with customer preferences for simplicity and fairness. This model not only positions the service competitively against traditional taxis but also meets the expectations of various customer segments identified in our research. Moving forward, real-world testing and further refinement will be crucial to ensure the pricing structure supports both customer satisfaction and the long-term sustainability of the service. Additional details and ongoing developments in our pricing strategy can be found in the accompanying documents from WP6.

4.3.9 Industrial Research

We have a number of research projects that use ULTIMO's pilot in Groruddalen as a platform for their research. This will be discussed in more detail in WP7, but it is worth mentioning briefly in this report as well.

- **Institute of Transport Economics⁴: Traffic safety**
 - They conduct research on traffic safety in interactions between the tested vehicles and other traffic participants, using external video observations on selected locations. The aim is to improve the technology and operation of the vehicles and gain insights that extend beyond the vehicles' performance, helping to better understand the dynamics of mixed traffic environments.
- **Institute of Transport Economics: AutoMaaS**

⁴ TØI: <https://www.toi.no/english/>

- The R&D objectives of AutoMaas is to explore and design methods and measures to enhance acceptance of autonomous vehicles, with particular focus on the social situation arising in shared, on-demand fleets of stewardless shared autonomous vehicles. Anticipated results include:
 - Novel insights into the mechanisms that influence user acceptance
 - Development of psychological interventions that increase willingness to use steward-less shared AVs
 - Testing different AV-designs that improve perceived security and comfort
 - Application of insights into real life demonstrations of autonomous busses
 - Development of a template for future implementation of shared AVs to the general public
- **Cicero, Center for International Climate Research⁵:**
 - CICERO will use qualitative and quantitative research methods to verify the extent to which the technology meets the expectations and mobility needs of key user groups. This will be crucial knowledge for developing the service for shared public transport.
- **Collaboration with the University of Oslo** regarding Master's students. The first thesis has been written, and several students have shown interest in topics related to our pilot.
 - As of May 2024, one student has submitted his Master thesis:
 - «Bil eller blikkboks – Å skape handlingsrom i uforutsette situasjoner for reisende med delt selvkjørende bestillingstransport» («Car or Tin Can – Creating Room for Action in Unforeseen Situations for Travelers Using Shared Autonomous On-Demand Transport»)⁶

4.4 Plans Forward, Roadmap Next 12 Months

4.4.1 Recap From D5.1 One Year Ago

In our former delivery a year ago, we had recently started a more operational phase of the pilot project. Throughout July and August 2023 all roads within the pilot area had been digitally mapped, and the first AVs arrived in Oslo in October 2023.

Following here a recap of the 12 month plan presented, and the status as of today:

⁵ Cicero: <https://cicero.oslo.no/en>

⁶ Kristian Arnesen Vik, 'Bil eller blikkboks? Å skape handlingsrom i uforutsette situasjoner for reisende med delt selvkjørende bestillingstransport' (Universitetet i Oslo, 2024)
<https://www.arcgis.com/home/item.html?id=f47d8094648e4c47831c6aa2a81df4ea>.

Planned activity per September 2023	Status per August 2024
Preparation of operation	
Finalize digital mapping of the pilot area	Done
Vehicle shipment to Oslo	Done
Registration, vehicle inspection and wrapping	Done
Permit for operation with safety drivers	Done
Preparation of garage facilities	Done
Finalization of trainers training / safety driver education	Done. Program extended to include education on ambassador role, intervention cases, etc.
Hiring and training of safety drivers and supervisors	Framework processes established. Ongoing recruitment process. 5 security operators recruited per date.
Start validation driving in the pilot area	Started according to plan. Still ongoing.
Testing and validation of platform for fleet management	Ongoing.
Collaboration with emergency services	Ongoing.
Industrial research	
Video analysis of high-risk situations in parallel with adaption of the technology to Norwegian conditions (TØI - Institute of Transport Economics)	Ongoing. Data is captured, and will continue until April 2024. Research and analysis to be performed.
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)	Planned. Waiting for service to be available for common users.
Customer journey and service definition	
Continue definition of service parameters	Established for the pilot phase.
Scenario testing and user interviews	First test users onboard in June 2024. Will increase amount of target groups in months to come.
Design and customization of customer app and in-vehicle screens	Soon to be publically released (August 2024). Continuous refinement and updates.
PUDO testing and validation (locations and physical/digital visibility)	12 PUDOs validated and tested.
Prioritization of use cases and adaptations for PRMs given pilot restrictions	
Customization of physical vehicle interior	Some customization possible in terms of information stickers, etc. Otherwise, the current vehicles do not have the necessary configuration opportunities as we foresee future vehicles.

Planned activity per September 2023	Status per August 2024
Testing and validation of customer app	First version finalized and to be released in August 2024.
Customer service setup	Workgroup in Customer service dept. established. Ongoing work to establish roles, division of labor with the operator, messaging, systems setup, etc. for the customer service center. This will be tested when the first test users enter the vehicle.
Definition and testing of different price models	Ongoing. See elaborations above.
First limited user tests (spring/summer 2024)	Done.
Public service	Estimated start Q1 2025.
Interoperability/standardization	
Conclusion of process for additional R&D partners	Procurement still ongoing. A Letter of Intent signed with a major Norwegian transport provider.
Planning and preparation of testing interoperability with multiple AVs and fleet management systems	Still in planning phase, identifying necessary architectural principles. See work in WP3. Also, very dependent on the supplier(s) we will be able to establish in addition to current.
Communication and involvement	
Communication activities, including showcasing vehicles/service for the public	Multiple activities. Described in the Dissemination overview in WP7.
Involvement of residents and stakeholders	Comprehensive plan and principles established. There is an increasing amount of interest from residents, press, and stakeholders all across the board, national and international.

Table 15: Planned activities vs actuals - Ruter

4.4.2 Plans Next 12 Months

Preparation of operation

- Increase service area with validation of new PUDOs and roads
- Implement two-way communication between passenger and customer service using MobileThinking's SW solution.
- Testing of improved winter driving policy.
- Opening service for external test users (October 2024)
- User testing of a stable service with limited users (November 2024)
- Service available for general public (TBD 2025)

Customer journey and service definition

- Launch a campaign to recruit a diverse group of participants for the initial testing phases of our service.
- Implement a series of controlled tests internally to evaluate the basic functionality and safety protocols of the system.
- Following internal testing, we will conduct external user tests to gather insights on the user experience and system performance in real-world conditions.
- Design and integrate a clear and accessible emergency stop mechanism to enhance our vehicle's safety measures.
- Refine and optimize the operating hours of our service to maximize efficiency and customer satisfaction.
- A comprehensive training program for customer service will be developed to ensure our staff can provide high-quality service and resolve problems effectively.
- Safety operator training will be upgraded to focus on emergency management and optimal customer interaction.
- Design and print instructional stickers to place inside the vehicles for clear communication.
- Information brochures will be created and placed in the vehicles to educate users about the service features, usage guidelines, and safety measures.
- An informational website will be set up to provide detailed information about the service, answer FAQs, and offer real-time support.
- PUDO user testing and experimentation with signs/road markings.
- Test and establishing procedures for incident handling including two-way communication.
- Exploring architecture and technical viability for connection between different fleet management orchestrators

Introducing additional vehicles and technologies

- Introduce additional vehicle

4.5 KPI Updates

The Grant Agreement, Annex 1 – Description of the action (part B) states an number of KPIs for the Gorrudalen pilot. Below is an updated status on these:

KPI	Status
Introduce SAE level 4/5 vehicles from tier 1 AV technology provider	5 vehicles on the road from MobilEye, ongoing validation.
Local engagement and acceptance of new technology-based services	See dissemination tracker. Baseline survey conducted among target group.
More than 20 schools and numerous pre-schools will be visited with a Ruter branded AV, to introduce and explain the service, and provide an opportunity to learn and experience the future of mobility	“Kickoff” in the largest High School in the area, showcasing the vehicles and the project. Dialogue with parent-teacher boards. Once service is introduced to the general public, visits will be performed.

Continuous spatial planning and modernization of city stations, and flexible virtual pick-up and drop-off locations	Topic on the agenda in Ruter, in all relevant departments. Close collaboration and common roadmap with DRT service development. Methods for identifying and validating PUDOs in large scale developed.
Acceptable detour time for users	To be validated.
AVs will be dispatched in near real time	To be validated.
Safe operation	Operational framework established by the operator, ensuring quality and consistency in pre- and postcheck routines and a zero acceptance level for security incidents.
Interoperability	Moovit app does not integrate multimodal travel options with AVs, but the tickets are planned to be interoperable.
Cost competitive services	To be validated.

Table 16: Ruter KPI updates

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).