ULTIMO

Advancing Sustainable User-centric
Mobility with Automated Vehicles

DELIVERABLE

# D6.3 – Business plans and partnerships for intelligent CCAM ecosystem – First version

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# Acronyms

| | |
|---|---|
| ADS | Automated Driving Systems |
| AI | Artificial Intelligence |
| AM | Automated Mobility |
| AMB | Automated Minibus |
| API | Application Protocol Interface |
| AV | Automated Vehicle |
| BMM | Business Modelling Manager |
| CAV | Connected and Automated Vehicles |
| CB | Consortium Body |
| CERN | European Organization for Nuclear Research |
| D7.1 | Deliverable 7.1 |
| DC | Demonstration Coordinator |
| DI | The department of infrastructure (Swiss Canton of Geneva) |
| DMP | Data Management Plan |
| DTU test track | Technical University of Denmark test track |
| EAB | External Advisory Board |
| EC | European Commission |
| ECSEL | Electronic Components and Systems for European Leadership |
| EM | Exploitation Manager |
| EU | European Union |
| EUCAD | European Conference on Connected and Automated Driving |
| F2F | Face to face meeting |
| FEDRO | (Swiss) Federal Roads Office |
| FM | Fleet Management |
| FOT | (Swiss) Federal Office of Transport |
| GDPR | General Data Protection Regulation |
| GIMS | Geneva International Motor Show |
| GNSS | Global Navigation Satellite System |
| HARA | Hazard Analysis and Risk Assessment |
| IPR | Intellectual Property Rights |
| IT | Information Technology |

| | |
|---|---|
| ITU | International Telecommunications Union |
| LaaS | Logistics as a Service |
| LIDAR | Light Detection and Ranging |
| MaaS | Mobility as a Service |
| MEM | Monitoring and Evaluation Manager |
| MT | MobileThinking |
| OCT | General Transport Directorate of the Canton of Geneva |
| ODD | Operational Domain Design |
| OEDR | Object and Event Detection and Response |
| PC | Project Coordinator |
| PEB | Project Executive Board |
| PGA | Project General Assembly |
| PRM | Persons with Reduced Mobility |
| PTA | Public Transport Authority |
| PTO | Public Transportation Operator |
| PTS | Public Transportation Services |
| QRM | Quality and Risk Manager |
| QRMB | Quality and Risk Management Board |
| RN | Risk Number |
| SA | Scientific Advisor |
| SAE Level | Society of Automotive Engineers Level (Vehicle Autonomy Level) |
| SAN | (Swiss) Cantonal Vehicle Service |
| SDK | Software Development Kit |
| SLA | Sales Lentz Autocars |
| SMB | Site Management Board |
| SoA | State of the Art |
| SOTIF | Safety Of The Intended Functionality |
| SWOT | Strengths, Weaknesses, Opportunities, and Threats. |
| T7.1 | Task 7.1 |
| TM | Technical Manager |
| TPG | Transport Publics Genevois |
| UITP | Union Internationale des Transports Publics (International Transport Union) |
| V2I | Vehicle to Infrastructure communication |

| | |
|---|---|
| WP | Work Package |
| WPL | Work Package Leader |

# Executive Summary

The ULTIMO project demonstrates the potential of automated vehicles (AVs) to transform public transport and logistics and offers solutions to current challenges such as inefficiency, high costs and environmental impacts. With a holistic approach focusing on user and society needs and cross-sector integration of businesses and public transport, ULTIMO aims to develop and implement large-scale, demand-responsive door-to-door transport services that are both economically viable and accepted by users.

This deliverable therefore outlines the methodology of the entire Work Package 6 (WP6), which serves as a strategic focal point for the development of a vision for future mobility ecosystems. This approach includes an analysis of the current state of mobility, based on the findings of previous projects such as AVENUE, as well as the joint efforts of stakeholders to develop scalable, economically viable models for the integration of AVs into public transport and logistics.

The status quo assessments from D6.5 (only briefly summarised here), conducted at the test sites in Geneva, Herford and Oslo, provide key insights into the challenges of AV adoption, including social acceptance, regulatory frameworks and environmental aspects. These assessments highlight the different needs and opportunities in each location and emphasise the importance of tailored approaches to AV integration that take into account the local context and stakeholder dynamics.

Chapters 3 to 5 of this deliverable summarise the essence of the methods, visions, strategic scenarios and business models already examined or to be analysed in the further project steps, which are essential for the integration of AVs into a user- and citizen-centric mobility and logistics ecosystem. These chapters outline a structured approach to creating a sustainable, efficient and inclusive future mobility ecosystem:

**Chapter 3: Identification of future scenarios, analysis and evaluation**

This chapter presents the theoretical foundations and practical methods for scenario planning in the context of AVs. It begins with a comprehensive overview of scenario planning and emphasises its importance for anticipating and managing future uncertainties in the mobility sector. Various methods of scenario planning are discussed, providing a framework for forward thinking and strategic decision-making. The chapter emphasises the importance of identifying future elements such as trends and alternatives, which are crucial for creating robust and adaptable future scenarios.

The process of defining determinants (dimensions) and designing an appropriate model for scenarios is detailed to illustrate how these factors interact to shape a possible future of mobility. The characterisation, analysis and evaluation of future scenarios provides insights into the various possible outcomes and serves as a guide for stakeholders to prepare and influence future developments in the areas of AV integration and mobility services.

**Chapter 4: ULTIMO vision: 'Mobility for all'**

Chapter 4 describes the ambitious vision of the ULTIMO project 'Mobility for All', which aims to create an inclusive, accessible and efficient mobility ecosystem powered by AVs. This vision is based on the detailed scenarios and use cases developed in the previous chapter, which serve as a basis for imagining a future in which AV technology plays a central role in the transformation of public transport. The hypotheses presented in this chapter, such as that AVs in MaaS are a game changer and drive system innovation, emphasise the transformative potential of AVs in improving mobility services. The formulation of the ULTIMO Vision and the subsequent conclusion underline the project's commitment to realising a future in which mobility is universally accessible, integrated and tailored to the diverse needs of all users and citizens.

**Chapter 5: Development of promising future business strategies, models and cases for future intelligent, citizen-centric transport ecosystems**

This chapter focuses on the methodology for defining sustainable future business models for AVs within the MaaS/LaaS in ITS/CCAM ecosystems. It outlines a structured development process and framework for creating future business models that are economically viable, socially beneficial and environmentally sustainable. The chapter describes three levels of analysis: Fundamental Analysis, Operational Viability Assessment and Synthesis of Sustainable Business Models. Together, these levels contribute to the development of a comprehensive understanding of how AVs can be integrated into future mobility ecosystems in a way that is beneficial to all stakeholders, including users, service providers and the wider public. This chapter also discusses the next steps of the ULTIMO project, emphasising the importance of continuous evaluation and adaptation of business models to ensure their long-term success and relevance.

# 1 Introduction

During the past few years many projects and initiatives were undertaken deploying and testing Automated Vehicles (AVs) for public transportation and logistics. However, in spite of their ambition, all of these projects stayed on the level of elaborated experimentation and never reached the level of a large-scale commercial deployment of transport services. The reasons for this are many, the most important being the lack of economically viable and commercially realistic models, the lack of scalability of the business and operating models, and the lack of user oriented services required for large end-user adoption of the solutions.

The ULTIMO project will create the very first economically feasible and sustainable integration of AVs for MaaS public transportation and LaaS urban goods transportation. ULTIMO aims to deploy in three sites in Europe 15 or more multi-vendor SAE L4 AVs per site. A user centric holistic approach, applied throughout the project, will ensure that all elements in a cross-sector business environment are incorporated to deliver large-scale on-demand, door-to-door, well-accepted, shared, seamless-integrated and economically viable CCAM services. We target the operation without safety driver on-board, in a fully automated and mission management mode with the support of innovative user centric passenger services.

ULTIMO's innovative transportation models are designed for a long-term sustainable impact on automated transportation in Europe, around the globe and on society. The composition of the consortium ensures the interoperability between multiple stakeholders by making adoption of new technology at minimum costs and maximum safety. The integration of the ongoing experiments of previous AV-demonstrator projects ensures highest possible technical and societal impacts from the very beginning of the project, as well as during the project lifetime and even long after its completion.

## 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.

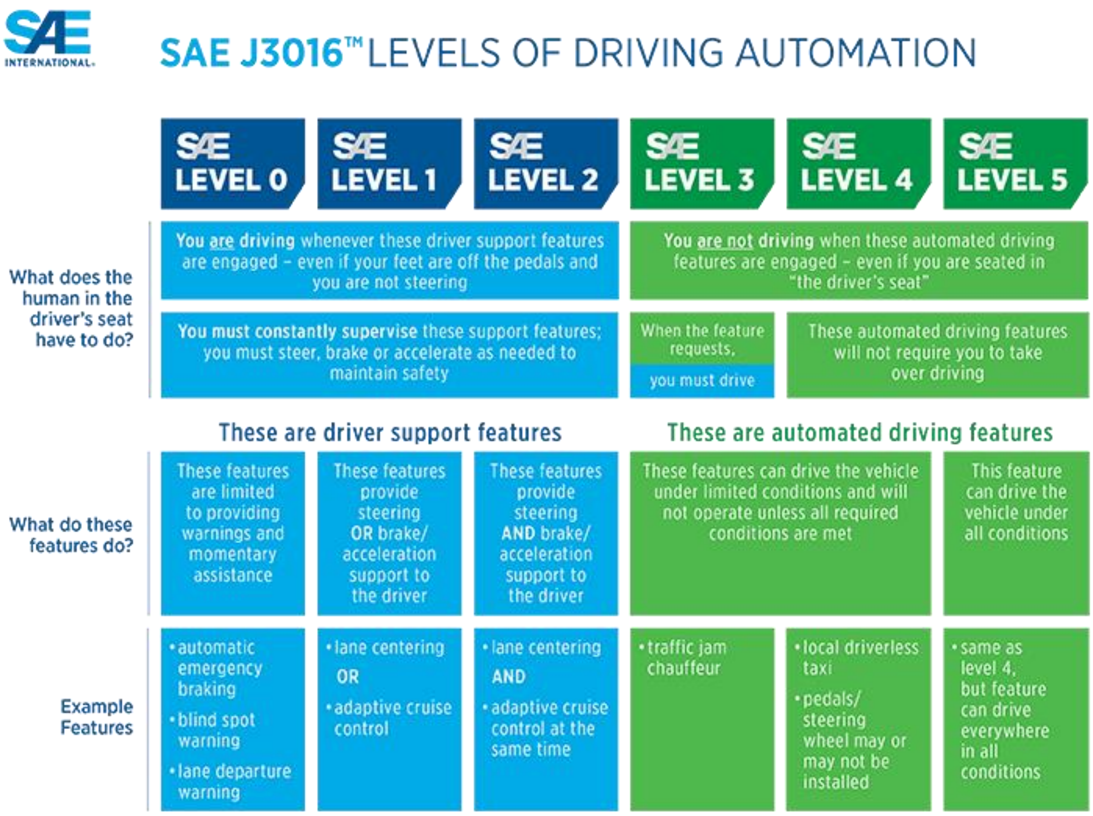


Table 1: SAE Driving Automation levels (©2020 SAE International)

## 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 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 services 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, de-pending 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 pur-chases, 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 custom-ers 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 – D6.5: Transformation guidelines towards a future transport ITS/CCAM ecosystem – First version

This deliverable outlines the goal of the ULTIMO project to integrate automated vehicles (AVs) into Mobility as a Service (MaaS) and Logistics as a Service (LaaS) across Europe, with the aim of sustainable, user- and citizen-centric mobility. It uses the findings from the AVENUE project and current analyses to develop scalable, economically viable models for the use of AVs in public transport and logistics. The strategy encompasses technical, socio-economic, environmental and governance dimensions for the transition to a future-oriented, intelligent transport system. It emphasises the importance of interoperability, safety and user engagement and proposes a visionary mobility ecosystem for 2035 that includes door-to-door on-demand services and is underpinned by cooperation between stakeholders and advances in the governance framework.

# 2 Methodology of WP6

The description of the methodology can be found in both deliverables, D6.3 and D6.5, as an introductory chapter, as both deliverables can only be understood in their entirety if the related methodology is explained. D6.1 can function as a stand-alone document, but the two tasks T6.2 and T6.3 are so closely related that this description was used for both tasks.

## 2.1 Overview WP6 concept (Big Picture)

Work Package 6 (WP6) represents a key transition point in the transformation of the mobility ecosystem and builds on the knowledge generated by initiatives and predecessor projects such as AVENUE. This section explains the multidimensional approach of WP6, which incorporates a wide range of data and other inputs, such as requirements, to formulate a strategic vision for the future of mobility.

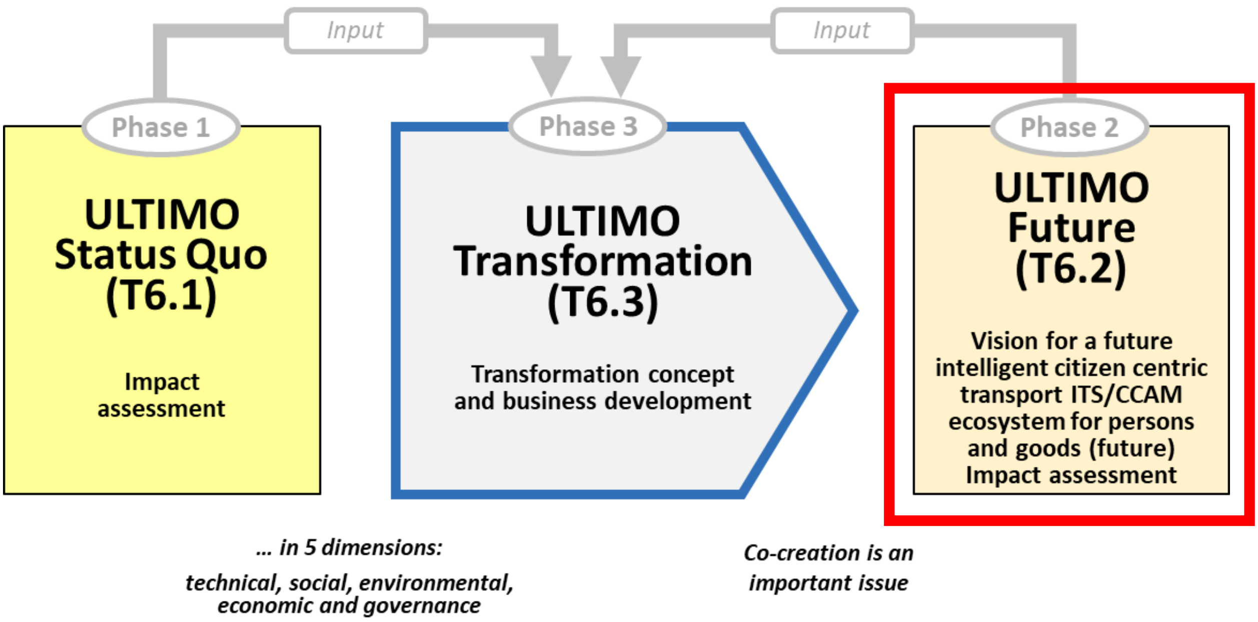


*Figure 1: Overview of the three tasks in WP6*

**Strategic Approach and Projections in WP6**

WP6 is characterised by the accurate integration of the data from work package 5 (WP5) and the differentiated needs identified in work package 2 (WP2), taking into account both the citizens' perspective and the requirements of public transport operators (PTOs) and public transport authorities (PTAs). This integrative methodology is essential for the development of a holistic strategy that takes into account the complex dimensions of a modern mobility

ecosystem. These dimensions include technical, social, environmental, socio-economic and governance facets, which are considered in detail in the analytical framework of T6.1.
Figure 1 provides a summarised overview of the complex interrelationships in the workpackage, which are briefly described below in order to follow on from the detailed description in the subsequent sub-chapters.

The strategy of WP6 is not only suitable to analyse the status quo of the actual mobility landscape, but also to predict and govern the transition towards a more sustainable and integrated future mobility ecosystem. The empirical and methodological stringency in T6.1 provides a solid foundation for the subsequent phases and ensures that the transformation efforts in T6.3 are both scientifically robust and congruent with the real-world pilot implementations.

**Analytical Framework in T6.1**
The analytical phase in T6.1 is a stringent process that involves a thorough assessment of the current status quo and its impact on both the proposed pilot sites and the overall mobility ecosystem. This phase will utilise a diverse range of research methods to gain a comprehensive and differentiated understanding of the complex dynamics. The investigation includes technical refinements, social impacts, (positive and negative) environmental impacts, socio-economic interdependencies and governance structures as well as changes. Such a multi-layered approach enables informed decision-making and the formulation of socio-political incentive structures. The integration of empirical data, citizen perspectives as well as needs and PTO/PTA requirements improves the analytical framework and promotes a strategy that goes beyond traditional boundaries.

**Visionary Conceptualization in T6.2**
T6.2 develops a future-oriented vision for mobility in urban, sub-urban and rural ecosystems. This task systematically outlines the desired future on multiple levels, including the conceptualisation of an overarching mobility vision and the strategic development of key business plans for implementation. T6.2 combines a visionary perspective with practical business planning and demonstrates a high degree of foresight and pragmatism. It serves as a critical intersection on the path to a future mobility ecosystem that integrates intelligent, citizen-centred transport systems for people and goods, while taking into account business plans and partnerships for intelligent CCAM ecosystems.

**Transformation Concept in T6.3**
T6.3 is tasked with leading a transformation blueprint to realise the vision outlined in T6.2. This concept serves as a blueprint for the development of the mobility ecosystem that is in line with the overarching vision and the previously developed business plans. T6.3 focuses on the implementation strategies, adaptive framework and targeted interventions, providing a comprehensive understanding of the practical aspects associated with the transformation of the mobility ecosystem.

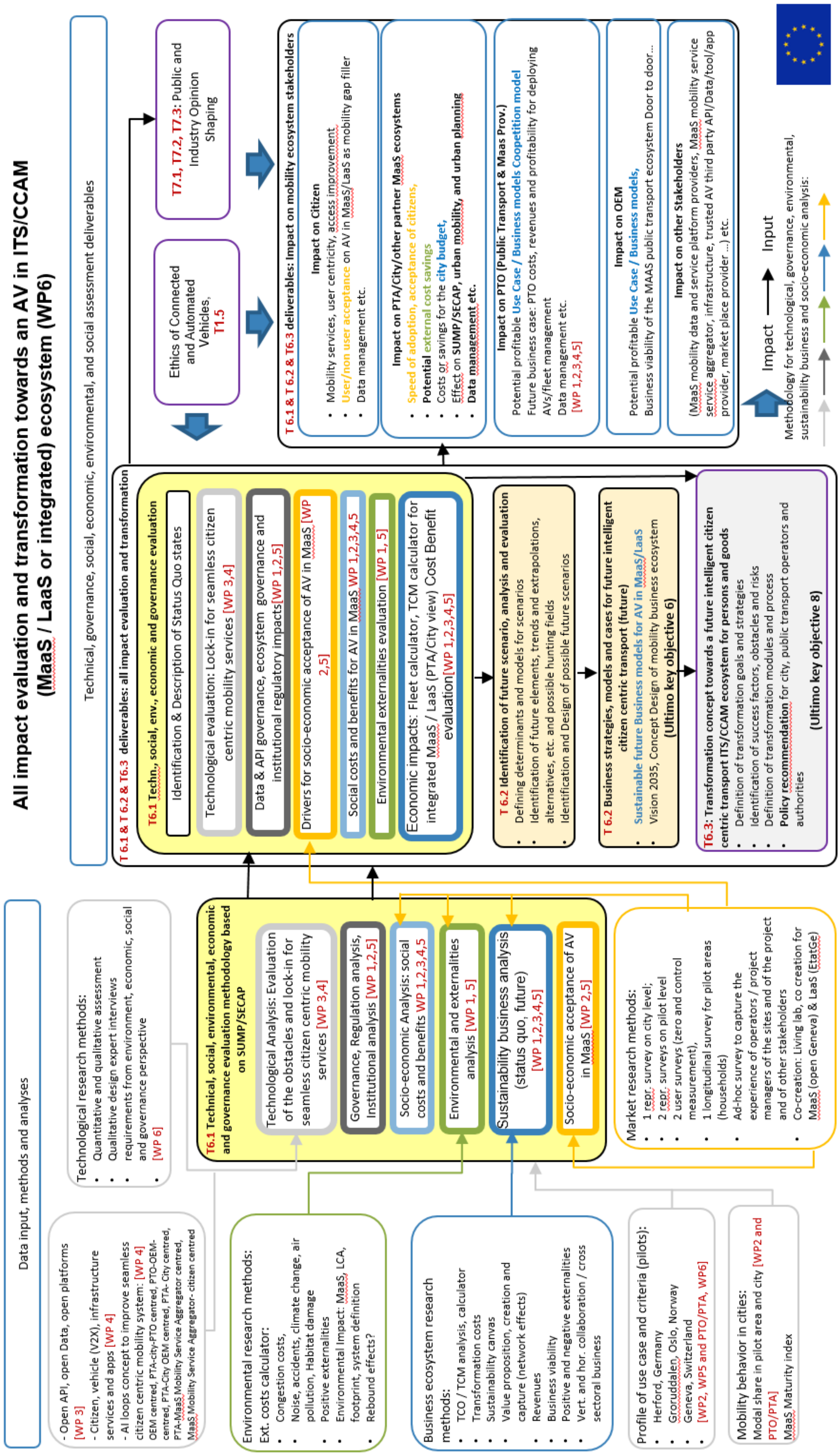


*Figure 2: Big picture*

## 2.2 Goals of the Big Picture

Figure 2 above illustrates WP6's comprehensive framework, highlighting its structured interconnections. This visual unfolds the ecosystem's intricate relationships and processes: On the left, it shows incoming data, methodologies, and analytical procedures, representing WP6's scientific foundation.

Figure 2 provides a visual guide to the big picture of workpackage WP6, illustrating its complex structure and interrelationships. It shows how diverse data and qualitative information are analysed rigorously using specific tools to transform raw data into refined insights for decision making. The right-hand side of the figure shows the envisaged results of WP6, highlighting their development and impact on the wider mobility ecosystem. At the centre of Figure 2 is an illustration of the internal logic of WP6, including methodological details and links to other work packages. It is essential for understanding the structure of WP6 and its three main tasks, which involve numerous ULTIMO partners and four PhD theses, among others.

The core of Figure 2, which is also presented in more detail in Figure 3 below, focuses on six analysis methods for five impact dimensions on automated vehicles (AVs) in intelligent transport systems (ITS) and Mobility-as-a-Service (MaaS) ecosystems. T6.1 covers technical, social, environmental, socio-economic and governance analyses, with each dimension divided into sub-factors. These analyses build on previous results from the AVENUE project and incorporate new data from the ULTIMO pilot sites or new analyses from the ULTIMO partners. The figure also shows the work packages contributing to T6.1 as well as the methods and data input on the left to provide a comprehensive overview of the WP6 research process.

The right-hand side of Figure 3, marked by black arrows, illustrates that the results of these comprehensive analyses, carried out by a team of more than ten scientists in collaboration with various partners, form the basis for all the results of the work package. This important aspect of visualisation underlines the integral role of these detailed studies in shaping the content of the individual work steps within WP6. These results, which are essential to the overall project, embody the concerted efforts and insights gained from this collaborative scientific endeavour.

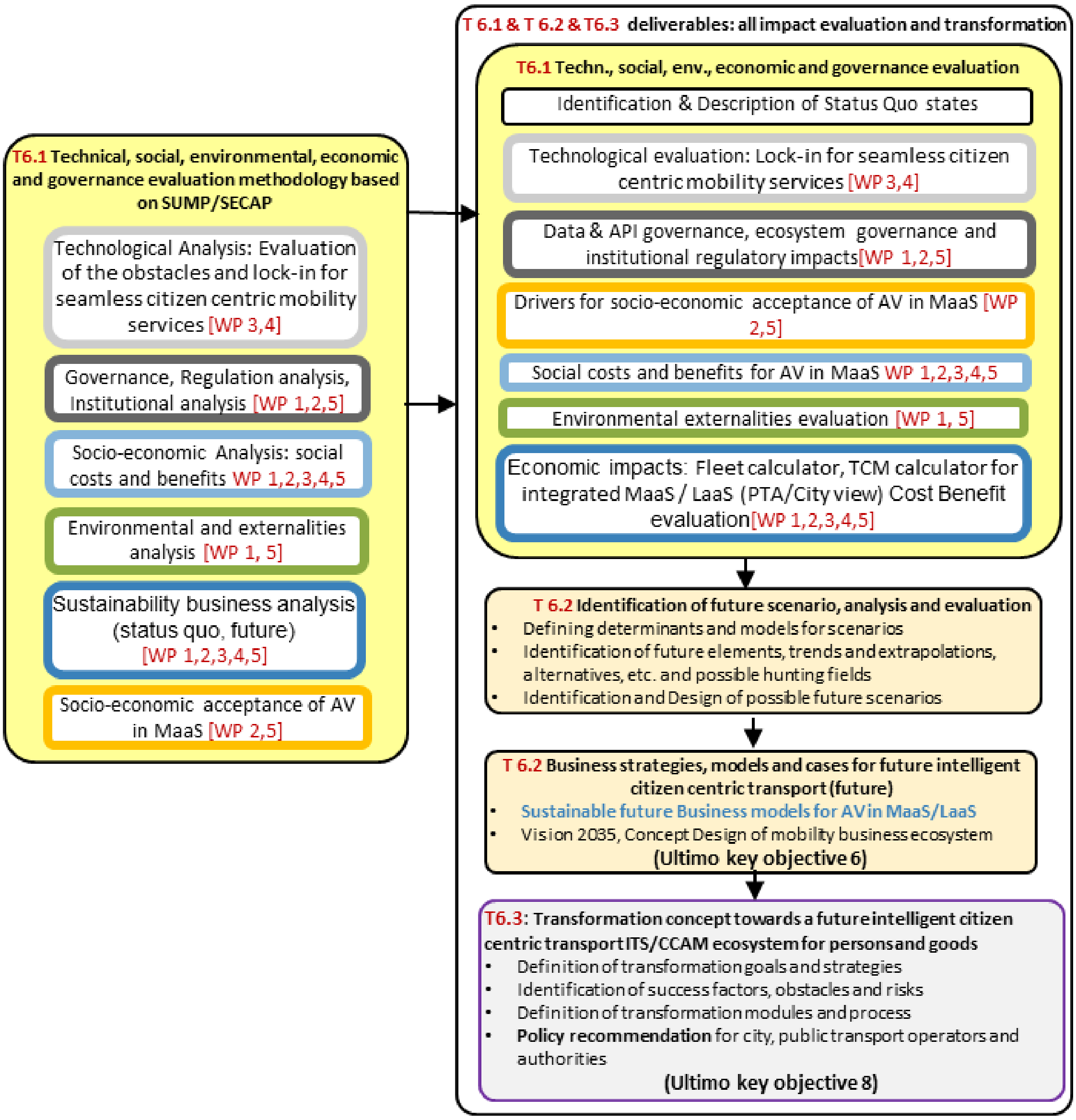


*Figure 3: Central pillars of the Big Picture with the transition from the analysis to the deliverables*

Each of the resulting six deliverables, the planned content of which is briefly summarised below, represents a specific aspect of the project and reflects the objectives and commitments set out in the grant agreement. The following summary highlights the key elements that were carefully defined and mutually agreed at the outset of the project. These include a range of themes and potential outcomes, all of which have emerged or will emerge from the rigorous analytical processes and collaborative efforts of the scientists and partners involved in WP6. Together they provide a comprehensive picture of the scope of the project and the specific focus areas that will be carefully addressed in the deliverables in accordance with the terms of the grant agreement:

**T6.1: Technical, social, economic, environmental, business and governance evaluation of seamless transport of persons and goods**

**D6.1 & D6.2 – Multivariate evaluation of ULTIMO CCAM ecosystem - First version & Final version**

Report on technical, social, economic, environmental and governance evaluation activities. The first version of the deliverable consolidates the knowledge gained from past projects and from the existing project deployments, of the technical, social, economic, environmental and governance impacts, of a seamless transport of persons and goods within an integrated approach. The final version of the deliverable provides a detailed assessment, based on objective measurements from the deployment sites and operations, of the technical, social, economic, environmental and governance impacts, of a seamless transport of persons and goods within an integrated approach.

**T6.2: Concept and operating models and business development for a future intelligent citizen centric transport ITS/CCAM ecosystem for persons and goods**

**D6.3 & D6.4 – Business plans, and partnerships for intelligent CCAM ecosystem – First version & Final version**

These deliverables will develop a complete business plan for an efficient, safer, carbon-free, inclusive, and sustainable transport in cities, suburban and rural areas deployment of MaaS and LaaS based on automated vehicles. The first version will consolidate knowledge from past projects and from the project deployments and provide a roadmap, identifying the data that will be needed from the project sites. The final version of the deliverable will provide a detailed and optimal design process that can be applied to any design of a smart transportation eco-system aiming at maximizing a performance vector made of the 5 defined pillars and the acceptability of the users.

**T6.3: Strategy for Transformation towards a future intelligent citizen centric transport ITS/CCAM ecosystem for persons and goods**

**D6.5 & D6.6 – Transformation guidelines towards future transport ITS/CCAM ecosystem – First version & Final version**

The target of this deliverable is to elaborate and present description and scenarios for future deployment of MaaS and LaaS service, analysing a stakeholder approach, identifying transition goals and elaborating transition strategies and business models. The first version of the deliverable consolidates existing knowledge from past projects and the project deployment sites and establishes a roadmap and date requirements towards the final deliverable targets (that is, an overall implementation plan and a transition into practice (EU market) measures roadmap towards a sustainable intelligent future citizen centric ecosystem for persons and goods). The final version of the deliverable provides an overall implementation plan and a transition into practice (EU market) measures roadmap towards a sustainable intelligent future citizen centric ecosystem for persons and (small size) goods.

**Summary of the deliverable relationships from T6.1 to T6.3**

In the deliverables D6.1 & D6.2 for T6.1, the results of the detailed analysis of the evaluation are identified and described as status quo states, e.g. possible lock-in effects for seamless citizen centric mobility services are examined (the rest is explained in more detail below). The results of these comprehensive analyses are then incorporated into Deliverables D6.3 & D6.4 of T6.2, in which not only future scenarios are analysed and evaluated, but above all sustainable future business models for AV in MaaS/LaaS are developed and described in detail in order to achieve a Vision 2035 for a future mobility business ecosystem. This vision of the future corresponds to ULTIMO Key Objective 6 (KO#6: Develop and validate cross-sectoral business models) from the Grant Agreement. These results are then incorporated into deliverables D6.5 & D6.6 for T6.3. In these, a transformation concept towards a future intelligent citizen centric transport ITS/CCAM ecosystem for persons and goods, i.e. this Vision 2035, is defined and success factors are identified. At the end of WP6, D6.6 contains policy recommendations for cities, public transport operators and authorities and thus the ULTIMO Key Objective 8 (KO#8: Realistic, long term transition planning design for the deployment of AVs in MaaS and LaaS).

## 2.3 Logic of the Big Picture

### 2.3.1 Data input, methods and analyses

**Technical data input and technical research method:**

The technical dimension of the integration of AVs into a transport and mobility ecosystem is designed, analysed and evaluated using the results from AVENUE and the work in all the other WPs. By taking into account both the functional and non-functional requirements, the assessment/evaluation focuses on safety (vehicle safety, in-vehicle passenger safety, off-vehicle road-user interaction safety), security (in-vehicle security, cybersecurity, interaction with online supervisors, interaction with other road users), technical performance (reliability and availability), maintainability and serviceability. Previous experiences with deploying AVs in public transport systems resulted in insights into technical barriers and opportunities for technical innovation.

The current need for of an on-board safety operator, mapping & modification of routes, access for disabled and elderly persons without human involvement as well as cyber security challenges are addressed. In addition, this part evaluates system integration and efficiency through the integration of AVs into existing and upcoming innovative mobility platforms as well as the integration of AVs into the infrastructure. This also includes the technical assessment and design of interoperability, intermodality, open data, open software and API, and open protocols to ensure an integrated feasibility of technical components and a user centric approach and single point of contact through combining several modalities towards a seamless transport for users in urban, suburban and rural environments.

For this purpose, the AI loops, which are described in detail in Fournier et al. (2023), are analysed using qualitative expert interviews in addition to input from the other four dimensions and all available quantitative data from the pilot sites.

**Socio-economic data input and socio-economic research method:**

The aim of the socio-economic analysis is to identify requirements for AVs as a technical system (1) and for AVs in the MaaS system (2) so that they function as a citizen centric approach. The analyses demonstrate under which circumstances high level of acceptance among potential AV users and high level of satisfaction among users can be translated into regular, intensive use and thus a substitution of private cars. In particular, the acceptance of AVs in MaaS is being analysed: Previous studies have shown in AVENUE, for example, that almost half of drivers in Lyon, Copenhagen, Luxembourg and Geneva are "willing" or even "very willing" to give up their own car to use AVs in a MaaS.

However, the resulting potential can only be exploited if the service is user- or/and citizen-centric. The goal is to assess how mobility behaviour changes if AV service is offered, especially focussing on reduce of private car usage. The question why mobility behaviour will change or not will be explored in detail. In order to obtain a comprehensive picture, quantitative and qualitative methods are of course required: several surveys will be carried out, representative at city level in the three participating cities, representative at regional level on the pilot sites, user surveys of actual passengers travelling in the tested vehicles and ad-hoc surveys of stakeholders. In addition, co-creation will be used and a possible incentive system will be developed using living labs, for example.

The following are particularly important contents analysed:

**Waiting time:** A key factor influencing the acceptance and efficiency of AVs in a MaaS context is the waiting time for services. It is crucial to assess the acceptable waiting times for users and how these expectations influence the willingness to use AVs. A waiting time calculator is being developed to predict and optimise service response times with the aim of minimising user waiting times and increasing the acceptability of services.

**Ridesharing willingness:** The willingness to rideshare plays a crucial role in the success of AVs within MaaS systems. This analysis examines the willingness of the population to share rides with other passengers, which can significantly contribute to reducing the number of vehicles on the roads, lowering emissions and improving transport conditions.

**Willingness to give up private vehicles:** It is crucial to understand the conditions under which people are willing to give up their private cars. This includes examining factors such as service reliability, coverage and cost and how these elements influence the attractiveness of AVs as an alternative to private car ownership.

**Intermodality and economic demand:** A key aspect of this study is to assess people's willingness to travel intermodally, i.e. to use multiple modes of transport for a single trip, and the economic impact of such behaviour. It also analyses how much people are willing to pay for intermodal solutions and how these preferences influence the demand for integrated mobility services.

Furthermore, the socio-economic analysis looks at the changes that will occur in the labour market, not only in general due to automated driving, but especially due to the future scenario of an AV in MaaS ecosystem in Europe, but above all in the three participating regions/countries in which the test sites are located. For this, two macro-level models show, on the one hand, quantitatively which changes can be expected on the labour markets due to automated driving on the basis of existing data, and, on the other hand, qualitatively explain/evaluate not only these in detail, but above all expected changes that cannot yet be quantified due to non-existing data. The available information is used to elaborate predictions about expected changes on the labour market, covering expected job losses, expected job gains, and expected jobs no longer to be filled that were vacant due to a shortage of skilled workers. For the three test regions involved, approximate expected net changes in the labour market are given at the end. In a transition between socio-economic and environmental analyses, the social costs and benefits resulting from the other dimensions, especially the environmental dimension, are also presented.

**Environmental data input and environmental research method:**

The present environmental impact assessment, undertaken in this study, investigates the external costs connected to automated vehicles (AVs) operating within the framework of Mobility as a Service (MaaS) and Intelligent Transport Systems (ITS), which constitute a part of the mobility ecosystem in the three case studies of the ULTIMO project. The three test sites combined with different future scenarios allow for a more nuanced understanding of the sustainability implications of AV technologies in various contexts. Even potential rebound effects that may result from the implementation of AVs are to be accounted for. In addition to environment-related external costs such as climate-relevant emissions, particulate matter, and noise, the assessment will evaluate social factors that affect various stakeholders, including accidents or discrimination, as well as socio-economic factors like congestion costs. To this end, a Life Cycle Sustainability Assessment approach is adopted, which is based on the triple bottom line sustainability framework encompassing the three aforementioned aspects: environmental, social, and economic. This methodology can function as an indicator to show the impact on the Sustainable Development Goals (SDGs) by covering all three dimensions. Life Cycle Sustainability Assessment is a comprehensive approach to evaluate the impacts of a product or process throughout its entire life cycle. It allows for a holistic understanding of the potential sustainability implications of a product or process, taking into account all stages from raw material extraction, manufacturing, use, and disposal. In the context of automated vehicles together with a new mobility system such as MaaS, a life cycle sustainability assessment can provide valuable insights into the overall sustainability performance of AV technologies compared to the status quo, a traditional mobility system with private vehicles.

In this part of the study, only external economic costs are assessed to avoid interference with the economic impact assessment. The primary objective of this assessment is to bring to light the concealed costs of the mobility ecosystem for society. By employing a holistic life cycle thinking approach, the study evaluates the extent of potential positive and negative externalities associated with the deployment of AVs at various sites and for the overall integrated system. The distinctiveness of this study lies in its exploration of external costs for different governance scenarios, including those focusing on the integrative transport of small-size goods using automated minibuses.

**Sustainability business data input and sustainability business research method:**

The sustainability business analysis evaluates appropriate innovative models for value creation for citizens, PTOs/PTAs, city governments and other stakeholders. Investigated models for value creation will focus on both, mobility of persons and where applicable, integrated transportation of (small size) goods. Based on these models, this task analyses the horizontal and vertical business models for focused value chains that could be implemented for the deployment of a seamless transport of persons and goods into practice. Special attention is paid to the possibilities of a citizen-centric mobility ecosystem that contributes to the vision of a purpose economy.

Several integrated calculators are provided and enable the calculation of fleet sizes, transformation costs, Total Costs of Ownership (TCO) and Total Costs of Mobility (TCM) and much more. This is important because beyond the TCO methodology, the more comprehensive and relevant approach of TCM[1] combined with revenue estimations is combined to a concept of calculating economic benefit (profitability) to include an integrated on-demand and door-to-door (citizen) journey. Up to a certain point, environmental and social impact assessments can be monetised and taken into account in the business models as much as possible to make them more sustainable. Of course, the results of the environmental and externalities analysis are also incorporated at this point. In this way, an economic valuation of an AV in MaaS ecosystem is achieved for the relevant stakeholders (e.g. users, PTOs/PTAs, OEMs, service providers, city managers) that takes into account all their interests and issues.

These analyses, which are close to the methods of impact finance, make the financial conditions of projects more relevant for the entire mobility ecosystem. Particular interest is being paid to tariffication and cross-sector business models, whereby, for example, possible integration with logistics concepts and results from the ALICE programme such as synchro-modality, hubs and urban logistics or from SHOW for LaaS are being investigated. To this end, suitable business concepts will be developed that integrate the role of users, PTOs/PTAs, OEMs, data and other service providers (e.g. software apps, passengers, vehicles) for AVs into the business and technical ecosystem of MaaS transport. As this is about a vision of a more sustainable mobility ecosystem, the methods of the relatively new Sustainability Business Canvas are used rather than the usual business analysis methods.

[1] TCM is a holistic approach that emphasises the integration of all costs associated with a door-to-door journey, including different modes of transport and mobility services. This perspective, which takes into account the needs and experiences of passengers and citizens, is in line with service-orientated mobility trends. It encompasses traditional modes of transport such as trains and buses as well as modern options such as car/bike sharing, ride sharing and AVs and aims to reflect real mobility needs and facilitate user- and citizen-centric business strategies. In addition, negative and positive external effects can be integrated that are not provided for in traditional forms of calculation.

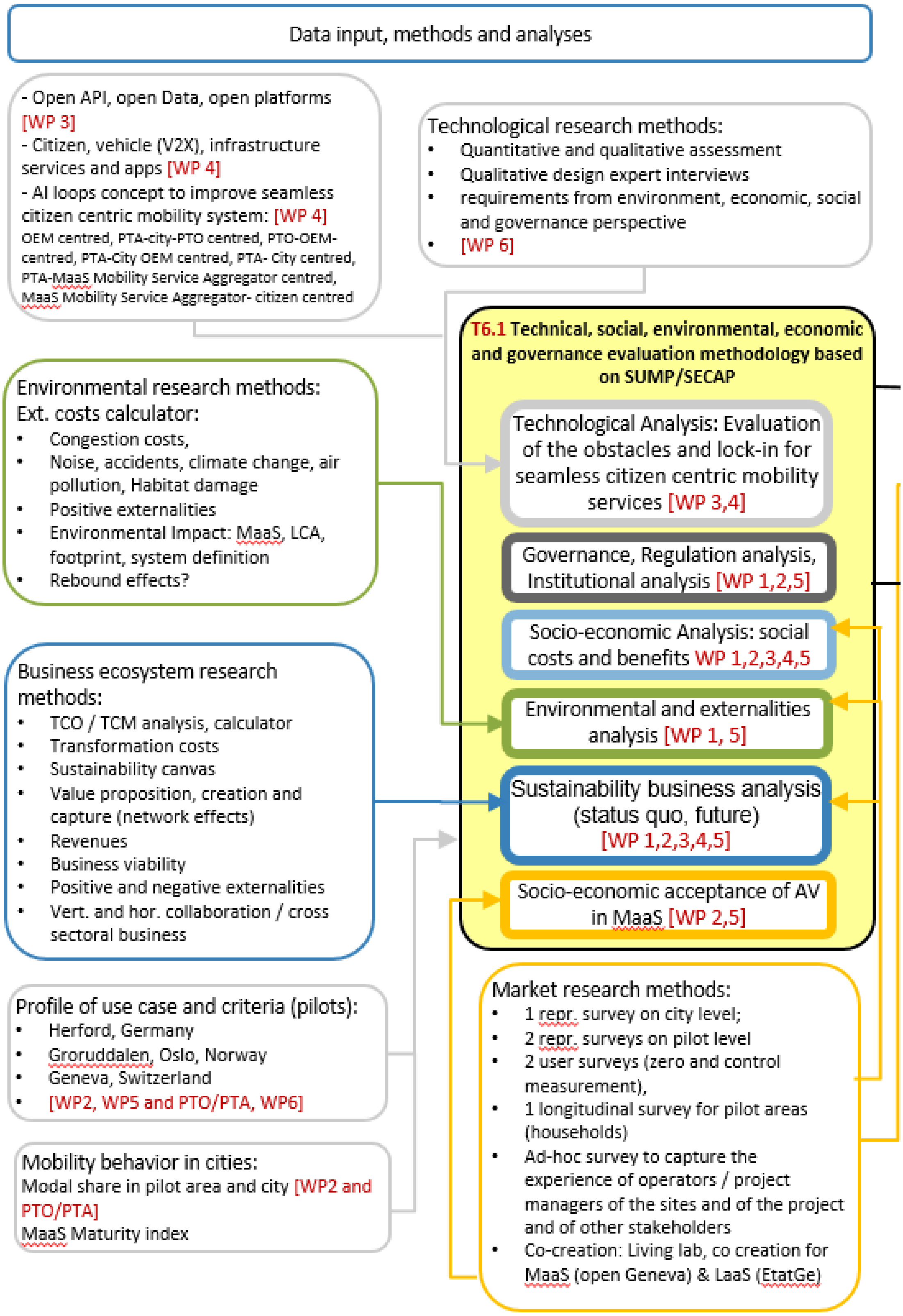


*Figure 4: Left part of the Big Picture*

It will also be analysed whether the integration of door-to-door and on-demand data from AVs into MaaS can provide more accurate mobility information and transform MaaS into an intelligent, self-learning (possibly AI-based) traffic system to improve the automated decisions of AVs, PTOs/PTAs, cities and, last but not least, the mobility services offered to users. Another focus is the avoidance of dominant market positions of stakeholders (e.g. vehicle fleet providers) and the creation of monopolies. Finally, public authorities play a central and crucial coordinating role in the integration of AVs into a MaaS or ITS ecosystem, which is the last dimension of analysis below.

**Governance, regulation, and institutional data input and governance, regulation, and institutional research method:**

The governance assessment focuses accordingly on evaluating appropriate governance approaches (such as laissez-faire, governing by enabling or doing, etc.) on the four dimensions mentioned above (technical, social, economic, environmental) to enable and objectify a balance between individual private and general interests as well as between the stakeholders of the ecosystem in general and to maximise the benefits for society to the integrated best for all stakeholders (common interest and the above mentioned purpose economy). A sustainable and inclusive planning process (SUMP/SECAP) is needed to address the complexity and dynamics of the mobility ecosystem. In particular, the analysis identifies the possibilities for a coopetition scenario (integrated and situational cooperation and/or competition) and presents applicable governance concepts, taking into account the applicable regulations within the EU and the European Economic Area and, where necessary, other applicable regulations at national and regional level. In this context, and given the role that regulation can play as both a facilitator and a challenge for innovation in transport systems, particular attention will be paid to regulations such as the General Data Protection Regulation (GDPR), the Network and Information Systems Security Directive (NIS 2) and the Data Management Act. Above all, of course, this analysis is carried out for the three participating cities, regions and nation states.

The final result will be a sustainability radar as presented for AVENUE in Nemoto at el. (2021; 2023) or Huber et al. (2022). In this radar, all five aforementioned dimensions are integrated to summarise the performance of AV in MaaS / ITS at the different locations, depending on the available data. These results will not only be described in detail by the participating scientists in the deliverables, but also in qualified scientific publications that will further develop research on AVs in ITS/MaaS.

### 2.3.2 Evaluation, transformation and stakeholder impact

As described above, the entire WP6 consists of the following three work tasks, each with two deliverables:

**T6.1: Technical, social, economic, environmental, business and governance evaluation of seamless transport of persons and goods**

D6.1 & D6.2 – Multivariate evaluation of ULTIMO CCAM ecosystem - First version & Final version

**T6.2: Concept and operating models and business development for a future intelligent citizen centric transport ITS/CCAM ecosystem for persons and goods**

D6.3 & D6.4 – Business plans, and partnerships for intelligent CCAM ecosystem – First version & Final version

**T6.3: Strategy for Transformation towards a future intelligent citizen centric transport ITS/CCAM ecosystem for persons and goods**

D6.5 & D6.6 – Transformation guidelines towards future transport ITS/CCAM ecosystem – First version & Final version

Based on the extensive research in the previously described section on the left hand side of the big picture, the results of the comprehensive investigation of the five dimensions merge seamlessly into the two deliverables D6.1 and D6.2, which fall under the task of T6.1. The content of these deliverables, as briefly mentioned above, presents the culmination of careful scientific enquiry and analytical processes that provide a nuanced understanding of the complicated ecosystem of automated mobility.

The first deliverable D6.1, and in particular the final D6.2, acts as a collection of findings, summarising the results of the multiple analyses conducted under the aforementioned dimensions. It serves as evidence of the empirical rigour with which the technical, social, environmental, (socio-)economic and governance dimensions related to automated vehicles in intelligent transport systems and Mobility-as-a-Service ecosystems were investigated. This, of course, goes beyond merely summarising results and provides a strategic narrative that places the findings in the broader context of the ULTIMO project's objectives and the overarching transformation goals for the mobility ecosystem.

The contents of D6.1 and D6.2 are a focused manifestation of the scientific rigour that underpins ULTIMO's efforts, summarising the complexity of automated mobility and its multi-layered implications. The careful integration of data, methods and analyses, as described in Section A, culminates in these findings, which make a significant contribution to the ongoing discourse and understanding of transformative change in the mobility paradigm.

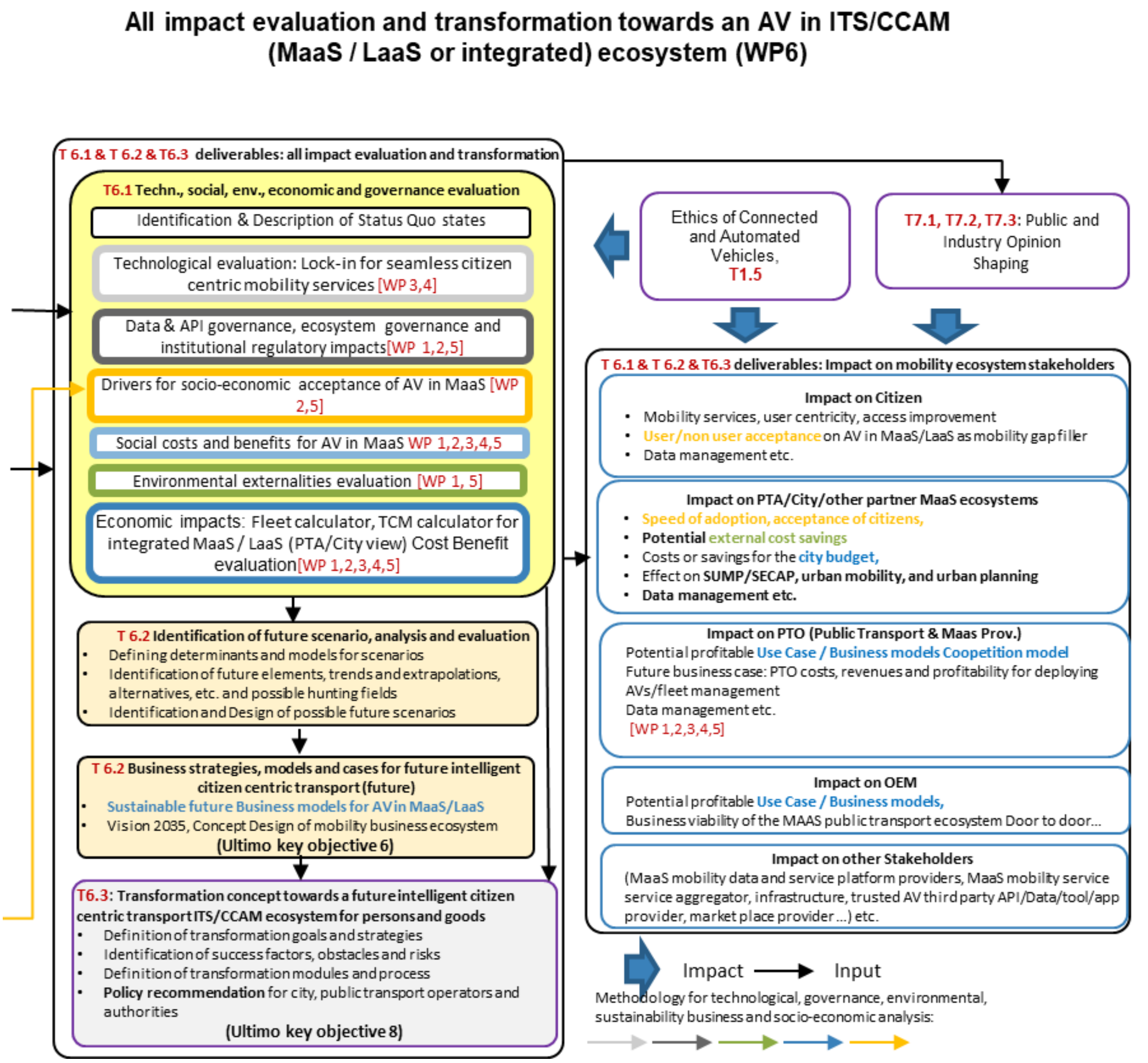


*Figure 5: Right part of the Big Picture*

The bottom line is that the final deliverable D6.2, as the project results report for T6.1, presents the detailed analyses of the status quo of the aforementioned five technical, social, ecological, (socio-)economic and governance dimensions.

And this status quo will of course not only be identified and described for the general mobility ecosystem at the European macro level, this analysis and its presentation will of course also be carried out for the meso level of the individual participating countries Germany, Norway and Switzerland and above all for the micro level of the three test areas in Herford, Oslo and Geneva. Ultimately, the various existing status quo states are presented, analysed and interpreted in order to build on them to transform the mobility ecosystem into an integrative, iterative, incremental, citizen-centric future vision of the European mobility ecosystem, just as envisaged in Figure 7. It is of course still possible to adjust the objectives and vision throughout the entire project process and this is done depending on the results of the analyses.

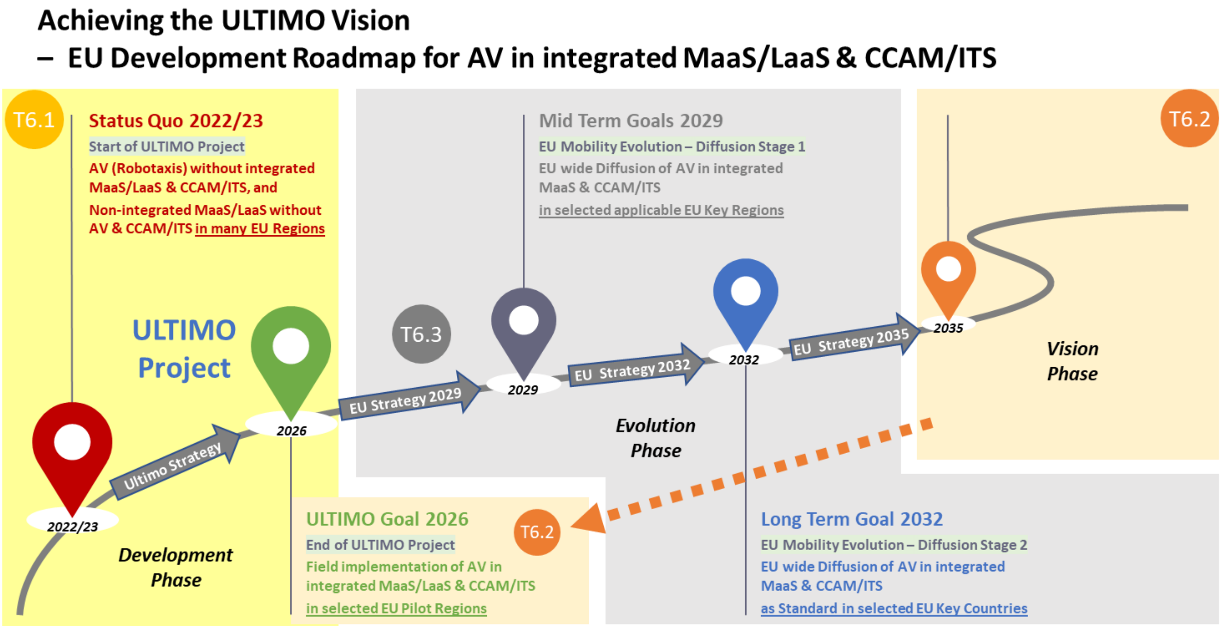


*Figure 6: Overview vision for EU mobility ecosystem*

In the domain of Task T6.2, and therefore simultaneously within the deliverables D6.3 and D6.4, a conceptual framework, an operational model, and a business development strategy are systematically presented. These components collectively contribute to the formulation of a prospective ITS/CCAM ecosystem that places citizens at its core. This developmental trajectory is complexly rooted in the foundational analyses conducted in T6.1, as shown in Figure 6. The vision for the future ITS/CCAM ecosystem unfolds through a series of discernible stages.

Within this schematic presentation, the project objectives of the ULTIMO strategy traverse from the present day, encompassing the status quo delineated in T6.1, through a development phase, culminating in the realization of the ULTIMO Goal 2026 through on-the-ground implementation. It is noteworthy that the ambit of T6.2 extends beyond the project's temporal confines, projecting its vision into the realm of the EU strategy for automated mobility and envisioning long-term goals leading up to a visionary environment for the mobility ecosystem in 2035.

This forward-looking perspective articulated in T6.2 not only aligns with the overarching project objectives but surpasses them by formulating a distinct vision for the year 2035, concurrent with the EU's strategic trajectory. The formulation of this vision, extending beyond the project's temporal bounds, underscores the proactive stance of ULTIMO in contributing to the broader discourse on the future of mobility. The visionary stance adopted in T6.2 not only complements the project's goals but sets the stage for a sustained and impactful influence on the trajectory of automated mobility beyond the culmination of the ULTIMO project.

Task T6.2 is divided into two different components, each serving a specific purpose: one is visionary, the other pragmatic. The visionary aspect of T6.2 aims to carefully identify, analyse and evaluate a future scenario in the field of mobility and transport. This visionary endeavour is based on analysing likely developments and seeks to provide a comprehensive understanding of the complex ecosystems that await us in the future. The pragmatic aspect of T6.2, on the other hand, is focussed on identifying business strategies, models and exemplary cases that can be used to shape a future intelligent, citizen-centric mobility and transport ecosystem. This pragmatic view takes into account the practical implications and business considerations associated with the envisioned future and aims to derive concrete strategies and models that can guide the realisation of the proposed vision.

As part of the visionary component, T6.2 conducts a multi-faceted analysis that focuses on identifying transformative elements, analysing their impact and evaluating the envisaged future scenario. This endeavour is in line with the overall objectives of ULTIMO and emphasises a future-oriented perspective that goes beyond the immediate project boundaries. At the same time, the pragmatic part of T6.2 includes a careful examination of business dynamics, strategies and practical cases that can be used to implement the proposed smart, citizen-centred mobility ecosystem. This pragmatic view ensures that visionary aspirations are not limited to theoretical constructs, but are underpinned with realisable strategies and models that meet the needs of real-world implementation. Essentially, through its dual focus, T6.2 seeks to bridge vision and practice, creating a comprehensive narrative that not only presents the future of mobility, but also lays the foundations for its strategic and practical realisation. This two-pronged approach adds depth and richness to the scientific enquiry and positions T6.2 as a central phase within the broader ULTIMO research framework. And this is presents the ULTIMO key objective 6.

Task 6.3 will build on the basic work of T6.1, which provides a detailed status quo analysis and future scenarios. It will utilise the future vision outlined in T6.2 to delve into the technical, social, economic, environmental, legal and political dimensions that will determine success or barriers in the mobility ecosystem. This task aims to conduct a thorough stakeholder analysis, define transition goals and develop comprehensive transition strategies along with viable business models. An important outcome will be an overarching implementation plan coupled with a detailed roadmap for EU market access and practical application measures. In addition, a transition plan will be outlined that aims to promote a sustainable, smart and citizen-centred ecosystem for personal and small goods transport. Particular attention will be paid to striking a balance between the different interests of stakeholders to maximise the common good while identifying and overcoming regulatory challenges. To ensure the involvement of all stakeholders in scenario planning, a novel approach is used that combines scenario thinking with the personas method and enables the creation of detailed, personalised narratives.

The comprehensive conceptual frameworks for all impact evaluation and transformation in T6.1, T6.2, and T6.3 aim to facilitate the generation of the deliverables which is also impacted by the results of T1.5: Ethics of Connected and Automated Vehicles. The significance of these initiatives lies in their collective potential to drive the transformation of the entire mobility ecosystem, encompassing all relevant stakeholders from an aggregated and strategic perspective:

- **Citizens**
- **PTA/City/other partner MaaS ecosystems)**
- **PTO (Public Transport & Maas Prov.)**

- **OEM**
- **Other Stakeholders**

(such as MaaS mobility data and service platform providers, MaaS mobility service aggregators, infrastructure, trusted AV third party API/Data/tool/app provider, market place provider, etc.)

However, the successful implementation of this strategic transformation concept requires more than just an integrated strategic framework. It requires a differentiated and individualised perspective as well as a strategic approach at stakeholder level within the complex mobility ecosystem. At its core, the concept of strategic transformation embodies a vision for the future of the mobility ecosystem, a plan for change that goes beyond conventional boundaries. However, for this vision to be translated into concrete and impactful outcomes, a dual focus is essential: one that not only includes the macro-level strategic considerations, but also examines the microcosm of individual stakeholder dynamics. The nuances of the mobility ecosystem are multifaceted and involve a multitude of stakeholders with different roles, interests, and responsibilities. To successfully manage this complexity, an individualised approach for each stakeholder group is essential. This includes a thorough understanding of the unique challenges, ambitions and operational intricacies specific to each stakeholder in the mobility ecosystem. In essence, the success of the strategic transformation concept hinges on the amalgamation of the broader strategic vision with the detailed, stakeholder-centric strategies. It is not a one-size-fits-all endeavour but a mosaic of tailored interventions that collectively contribute to the realization of the overarching transformational goals. This dual-tiered approach ensures that the impact of the strategic concept resonates effectively and sustainably throughout the diverse landscape of the mobility ecosystem, fostering a harmonious convergence of macro and micro perspectives. And these is analysed in WP6.

This approach not only provides pragmatic concepts but also serves as a valuable tool in addressing a fundamental question:

***'How does the transformation process, at the level of the entire ecosystem, influence the goals, tasks, and operational activities of the key stakeholders?'.***

In examining this question, the approach provides a comprehensive framework that goes beyond the theoretical and moves into the practical details of the transformation process. By analysing the impact at the level of the entire ecosystem, it offers insights into the dynamic interplay between the transformation processes and the day-to-day functions of key stakeholders. The holistic perspective afforded by this approach enables a nuanced understanding of how the goals and tasks of stakeholders are both influenced by and contribute to the broader ecosystem transformation.

The transformation of (key) stakeholders towards an AV in ITS/CCAM ecosystem, whether in the context of Mobility as a Service (MaaS), Logistics as a Service (LaaS) or integrated system, essentially follows the same general methodology as analysed in the previous chapters in the holistic strategic transformation process.  This methodology, carried out at the ecosystem level, involves a sequential order from the assessment of the status quo to the assessment of the future, resulting in the formulation of a transformation concept. However, when this methodology is applied at the stakeholder level, a more individualised and detailed approach is applied. At the stakeholder level, the transformation pathway is characterised by a detailed examination of how individual and key stakeholders within the ecosystem are adapting to the introduction of automated vehicles. While the general methodology remains consistent, its application becomes more targeted and focussed on the specific dynamics, needs and goals of individual stakeholder groups.

At this level, stakeholders can be broadly characterized using identical categories across each strategic planning phase—Status Quo, Future, and Transformation Concept. These generic characterizations encompass aspects such as roles, characteristics, strategic direction, collaboration, and value contribution, among others. These criteria serve as exemplars for understanding and categorizing stakeholders in the context of the transformative process. In the initial phase of Status Quo evaluation, these generic categories act as foundational elements for assessing the existing state of stakeholders. Roles played by each stakeholder, their inherent characteristics, the strategic directions they currently follow, collaborative efforts they engage in, and the value they contribute to the ecosystem are pivotal factors in comprehending the current landscape. Moving forward to the Future evaluation phase, these same categories become instrumental in envisioning the evolution of stakeholders. Delving into how roles might shift, characteristics adapt, strategic directions transform, collaborations expand or refine, and the evolving value contribution of each stakeholder provides a forward-looking perspective. This anticipatory analysis aids in aligning stakeholders with the envisioned future state of the ecosystem. Finally, in the Transformation Concept phase, these generic characterizations guide the formulation of strategies tailored to each stakeholder group. Understanding the dynamic interplay of roles, characteristics, strategic direction, collaboration, and value contribution is crucial for crafting interventions that seamlessly integrate with the overarching transformation goals. The Transformation Concept, therefore, becomes a bespoke roadmap that accounts for the unique considerations of each stakeholder, fostering a cohesive and effective transition:

### 1. Role

*- What are the stakes (interest profile) of a specific stakeholder towards mobility and the mobility ecosystem?*

This question seeks to understand the interests and preferences of a particular stakeholder concerning mobility and the broader ecosystem. It delves into the motivations, goals, and key concerns that drive their engagement and participation within the mobility landscape.

*- Which challenges and tasks is a specific stakeholder facing?*

This question focuses on identifying the specific obstacles and responsibilities confronting a particular stakeholder. It aims to outline the challenges they encounter in their role within the mobility ecosystem and the tasks they must undertake to navigate and contribute effectively.

*- Which tasks is a specific stakeholder responsible for (ownership)?*

Here, the emphasis is on delineating the tasks and activities for which a specific stakeholder holds ownership and responsibility. It seeks to define the areas where a stakeholder has a direct impact and control, outlining the scope of their influence and contributions to the mobility ecosystem.

## 2. Character

*- What is the Profile of Attitude and Behavior (Culture) of the specific stakeholder?*

This question explores the prevailing attitudes and behaviors, often encapsulated in the organizational culture, of a specific stakeholder. Understanding the cultural nuances helps in grasping the mindset, values, and approaches that influence their actions within the mobility ecosystem.

*- How is the Organization (Structure/Processes) designed or must be designed for fulfilling the tasks?*

This question delves into the organizational aspects, including structure and processes, to understand how a stakeholder's entity is configured to meet its responsibilities. It seeks to identify the organizational design necessary for effective task fulfilment within the dynamic context of the mobility ecosystem.

*- Which Competencies and Technologies does a specific stakeholder need or which competency profile is required?*

Here, the focus is on determining the essential competencies and technologies that a specific stakeholder must possess or develop. This includes identifying the skill sets, knowledge base, and technological capabilities required for the stakeholder to excel in their role within the mobility ecosystem.

*- Which Offerings does or shall a specific stakeholder provide?*

This question revolves around the products, services, or solutions that a stakeholder offers or intends to offer within the mobility ecosystem. It seeks to define the tangible contributions and value propositions that the stakeholder brings to the table, elucidating their role as a provider within the ecosystem.

*- How is the specific stakeholder characterized by SWOT categories?*

This question employs the SWOT analysis framework to assess the specific stakeholder's Strengths, Weaknesses, Opportunities, and Threats. It provides a holistic view of their internal capabilities and limitations, as well as the external factors and challenges they face. This analysis aids in strategic planning and decision-making for the stakeholder within the mobility context.

## 3. Strategic Direction

*- Strategic Goals of the Specific Stakeholder*

This section is about explaining the strategic objectives of a particular actor within the mobility ecosystem. It is about identifying and analysing the long-term goals and priorities that guide the actor's actions and decisions and shape its role and impact within the broader mobility landscape.

*- Designed or Required Strategies of the Specific Stakeholder*

The focus here is on presenting the strategies that a particular stakeholder has formulated or needs to develop in order to achieve its strategic goals. This includes examining approaches, plans and initiatives to overcome challenges, capitalise on opportunities and improve their own position in the mobility ecosystem.

*- Current or Targeted Value Proposition of the Specific Stakeholder*

This question addresses the unique value proposition that the stakeholder offers or intends to offer to the mobility ecosystem. It seeks to define the specific benefits, features and differentiators that make the stakeholder's offering attractive to customers, partners and other ecosystem participants.

*- Designed Business Models of the Specific Stakeholder*

This section analyses the business models that a particular stakeholder has developed or plans to implement. It includes an analysis of how the stakeholder creates, delivers and captures value, and describes the mechanisms by which it maintains its operations and contributes to the mobility ecosystem.

## 4. Collaboration

*- Ecosystem Partnerships a Specific Stakeholder is Part of*

This part examines the networks and partnerships a stakeholder is involved in within the mobility ecosystem. It aims to identify the ecosystems, alliances, and consortia the stakeholder is a member of, highlighting their role and contributions to collaborative initiatives.

*- Partners a Specific Stakeholder is Collaborating With*

Here, the emphasis is on identifying the key partners with whom a specific stakeholder collaborates. It explores the nature of these partnerships, focusing on strategic alignments, mutual goals, and the collaborative efforts undertaken to enhance the mobility ecosystem.

*- Details of Partner Collaboration*

This question provides an in-depth look at the specifics of collaborations between the stakeholder and their partners. It covers areas such as joint development projects, innovation initiatives, and sales collaborations, offering insights into how these partnerships function and contribute to the stakeholder's strategic objectives.

**5. Value Contribution**

*- Values or Value Proposition Contributed by the Specific Stakeholder*

This section aims to articulate the tangible and intangible values, concrete offerings, and unique selling propositions (USPs) that a specific stakeholder contributes to their partners, the mobility ecosystem, and the mobility topic at large. It seeks to highlight the stakeholder's impact, differentiators, and the benefits they bring to the table.

*- Values Provided by the Specific Stakeholder towards AV in ITS/CCAM*

Here, the focus is on detailing the specific values and contributions provided by the stakeholder towards Autonomous Vehicles (AV) in Intelligent Transportation Systems (ITS) and Cooperative, Connected, and Automated Mobility (CCAM). This includes exploring how the stakeholder supports innovation, safety, efficiency, and other key aspects within these specialized domains of the mobility ecosystem.

## 2.4 Input from the predecessor project AVENUE and from Tasks T6.1 & T6.3

### 2.4.1 Input from AVENUE (WP8 & WP9)

The AVENUE project, which was funded under the European Union's Horizon 2020 programme from May 2018 to September 2022 (grant agreement No. 769033), focused on the integration of automated minibuses (AMs) into a MaaS/ITS ecosystem to improve cost-attractiveness, efficiency and sustainability in public transport. The project's vision provides a transformative approach for future mobility ecosystems focusing on connected, cooperative and automated mobility (CCAM) and outlines a strategic roadmap from the status quo during the project lifetime (somewhat 2020) to a vision for 2030 that emphasises the integration of AMs into MaaS/ITS ecosystems to achieve economic efficiency, sustainability and improved public transport services.

The roadmap is based on the results of work package WP8, which analysed potential future scenarios and business models for CCAM and identified the integration of AMs into MaaS/ITS as the most viable approach. This integration was analysed using various analytical tools, including the Business Canvas and SWOT analysis. However, there are significant challenges to realising this vision, such as technological barriers, regulatory frameworks and the need for economies of scale and scope. AVENUE finally acknowledged that these obstacles need to be overcome to achieve cost attractiveness, in particular the reduction in the number of safety drivers and their eventual replacement by supervisory functions, a transition that is currently hindered by technological and regulatory constraints.

The recommendations for realising Vision 2030 involve a wide range of stakeholders, including vehicle manufacturers, service providers, public transport operators (PTOs), public transport agencies (PTAs) and the EU itself. Key strategies include standardising vehicle designs, using data and artificial intelligence to improve the capabilities of AVs, clarifying business models, fostering alliances between European manufacturers, integrating AMs into mobility planning and initiating public awareness campaigns to increase the uptake of AM-based mobility solutions. The results of AVENUE emphasise the need for a holistic approach that takes into account social, environmental and economic factors. This includes integrating AM into strategic planning to realise its potential to improve public transport systems, reduce the environmental footprint and provide cost-effective, inclusive mobility solutions. Public and private stakeholders are encouraged to work together to ensure interoperability, regulatory compliance and the creation of a favourable environment for the introduction of innovative mobility services.

To summarise, the AVENUE vision roadmap provides a comprehensive guide for the transition to a sustainable, efficient and citizen-centric mobility ecosystem. By addressing technical, legal and market challenges, it lays the foundation for the widespread deployment of AVs as part of MaaS/ITS and aims to revolutionise urban transport by 2030.

### 2.4.2 Input from T6.1

The deliverable "D6.1 Multivariate Evaluation of ULTIMO CCAM Ecosystem" provides a first baseline analysis of efforts to integrate AVs into MaaS/LaaS with the aim of a sustainable, commercially viable future for both public and freight transport. Despite previous projects in the EU focussing on AVs, challenges such as non-viable business models, lack of scalability and insufficient user-centric services have hindered the transition from testing to large-scale commercial deployment, or, for example, the AVENUE project described above has identified the need for more detailed analysis.

The deliverable is divided into a number of key dimensions of an impact assessment, all of which are important for the vision process in Task T6.2:

#### 2.4.2.1 Governance Impact Assessment:

**Data governance:** Emphasises the need for a robust data governance framework to manage the vast data generated by AVs and advocates for open APIs and data to ensure interoperability and maximise benefits for all stakeholders, especially users and the population at large. The alignment of the ULTIMO project with the European data strategy aims to create a single data market to enable safer and cleaner transport systems through standardised data access and exchange.

**Regulatory Analysis:** Concentrates on navigating the complex regulatory landscape for the integration of AVs into MaaS. It highlights the challenge of reconciling technological advances with regulatory frameworks and proposes a collaborative governance model to address specific regulatory barriers at national and local levels, emphasising the potential of public transport authorities and operators in fostering innovation within regulatory boundaries.

#### 2.4.2.2 Economic Impact Assessment:

Consists of a cost-benefit analysis and dynamic price modelling. The analysis identifies gaps in empirical data for the design of sustainable business models and the need for comprehensive economic assessments. It explores innovative models for value creation and the implementation of seamless transport services using the Total Cost of Mobility (TCM) approach. Dynamic pricing strategies are explored to support cross-sector business models, with a focus on integrating AI-based algorithms for pricing and improving decision making in the AV in MaaS ecosystem.

#### 2.4.2.3 Social Acceptance:

The aim is to understand and improve user acceptance of AV in MaaS. This includes developing surveys to explore the behaviour and acceptance of potential users, assessing how AV services could change mobility behaviour and focusing on reducing private car use.

#### 2.4.2.4 Environmental Impact Assessment:

Analyses the external costs and environmental impacts of integrating AVs into MaaS. This includes the assessment of potential externalities and the application of a life cycle perspective to provide insights into the hidden mobility/transport costs for society and to promote sustainable mobility solutions.

Overall, the ULTIMO project applies the SUMP methodology to tackle the complexity of integrating AVs into mobility ecosystems. This approach is designed to fulfil people's mobility needs, improve quality of life and foster cooperation between different stakeholders, including public authorities, businesses and citizens. By engaging stakeholders, assessing impact scenarios and developing long-term visions and strategies, the ULTIMO project seeks to create a sustainable, smart and citizen-centred mobility ecosystem that is in line with the European concept of urban transport planning.

In the following, we present the transformation concept from the status quo of the current mobility ecosystem to the ULTIMO Vision 2035.

### 2.4.3 Input from T6.3: Status Quo of the three test sites

#### 2.4.3.1 STATUS QUO 1: Summary of interview results

In the following a concise summary regarding the status quo findings of the ULTIMO project from the Deliverable D6.3 is presented. It serves as an input from Deliverable D6.3, highlighting the current progress and challenges of deploying autonomous vehicles in Geneva, Herford, and Oslo

## Geneva

In Geneva, the Transport Publique Genevois (TPG) has initiated a deployment plan for AVs, with a systematic approach that includes vehicle identification, authorization for site exploitation, testing phases, and eventual passenger accommodation. Social aspects in Geneva highlight a demand for on-demand services, particularly in rural areas, which AVs could potentially address. Environmental considerations prioritize resolving technical issues to ensure the viability of AV operations, with an observed increase in the use of Demand-Responsive Transport (DRT) services over time.

## Herford

Herford's deployment plan involves a phased introduction of AVs, starting with initial test operations and gradually expanding to larger service areas. The modal split data in Herford reveals a high reliance on private cars, indicating a need for improved public transport options. Social insights from Herford highlight gender disparities in travel behavior and underscore the importance of enhancing public transport services to meet diverse travel needs.

## Oslo

In Oslo, a comprehensive deployment plan has been developed, with a vision to introduce AVs across the city gradually. Social aspects in Oslo emphasize various mobility needs and trip types, with a focus on understanding travel patterns to optimize AV deployment. Governance dynamics across all three cities involve stakeholder engagement and efforts to refine data governance structures to support AV integration.

## Overall

The preliminary findings from the ULTIMO project underscore the progress made in AV deployment planning across Geneva, Herford, and Oslo. While each city faces unique challenges, including social, environmental, and governance considerations, there is a shared commitment to advancing sustainable mobility solutions through AV technology. Further research and collaboration will be essential to overcome these challenges and realize the full potential of AVs in urban transportation systems. The methodology employed in this study involved developing a series of targeted questions to conduct status quo surveys and interviews with experts from various sites, including Public Transport Authorities (PTA) and Public Transport Operators (PTO). By engaging with experts intimately involved in transportation planning and operations, the study aimed to capture a nuanced understanding of the challenges, opportunities, and progress related to AV integration within each city.

### 2.4.3.2 STATUS QUO 2: Summary current mobility offers at the test sides

This subchapter is a compressed version of the chapter of the same name in Deliverable D6.3. We compiled a detailed map of all available mobility offers on Google Maps, including train and metro lines, various bus routes with their corresponding stops, and even highways and bike-sharing systems. However, these have not yet been fully finalised for all three test tracks and may need to be reported in full in the final deliverable.

## Oslo: Grorud Valley test site

Figure 7 demonstrates the mobility choices in the Grorud Valley test site and the public transportation connecting Grorud Valley residents with Oslo. The pilot site, marked in black, is where automated vehicles will be tested. Three metro lines originating from Oslo and ending in Grorud Valley, with stops at marked locations, are indicated by the "M" symbol. A train (green symbol) and a ring bus (blue symbol) also traverse the area, with the latter expected to be replaced by an automated vehicle during the project. Finally, the three highways in orange are depicted.

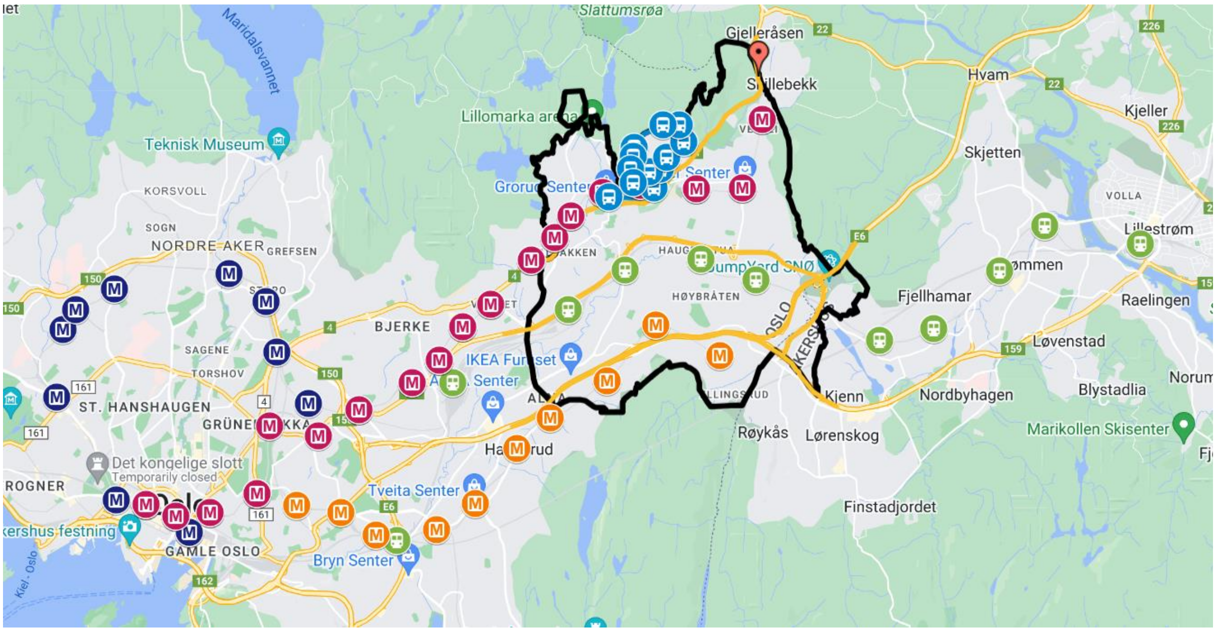


Figure 7: Complete overview of mobility offer in Grorud Valley with connection to Oslo

Figure 7 illustrates the transportation links between Oslo centre and the Grorud Valley, while Figure 8 is dedicated to displaying the transportation options available within the pilot area at the test site. Detailed descriptions of each mobility option are provided below.


Figure 8: Pilot Site overview

**Train**

There is a single railway line that runs through the Oslo centre and the Grorud Valley pilot site, extending up to Lillestrøm, starting from either Asker or Spikkestad. This line is referred to as the local train L1 and is represented by a green train symbol. The most important stations to consider for the ULTIMO project are Oslo centre, Alna stasjon, Nyland, Grorud stasjon, Haugenstua stasjon and Høybråten stasjon. Oslo S Trelastgata, the main train station in Oslo, is included because of the connection of this train between Oslo and the pilot site.

**Metro**

The Grorud Valley test site is influenced by three metro lines. Metro 2 (orange symbols) has 14 stops, starting in Stortinget (Oslo) and ending in Ellingsrudåsen (Grorud Valley pilot site). Metro 4 (dark blue symbols) and Metro 5 (pink symbols) run together towards Grorud Valley, starting from Økern. While Metro 4 starts at Bergkrystallen, Metro 5 begins at Sognsvann, both going through Oslo's main train station, Oslo S Trelastgata, and terminating in Vestli.

**Ring bus line 63**

The Grorud Valley test site is accessible via multiple bus routes, with one, the ring bus line 63, being a promising candidate for automation. This line runs between the Grorud Metro Station, which connects to Metro lines 4 and 5, and covers a distance of approximately 5 kilometers, making 12 stops. It is located on the outskirts of the pilot site.

**Highways**

Apart from public transport, highways traversing Grorud Valley must be considered, including National Road 4, National Road 163, and European Highway E6 (which splits into E6 above and National Road 153). These highways demand faster speeds for automated vehicles to operate on them, while also posing challenges for slower AVs, pedestrians, and cyclists in crossing them, thus fragmenting the pilot site into distinct sections.

## Herford test site

The PTA (Deutsche Bahn) is currently selecting a pilot area for the automated vehicle to operate later in the project at this test site. They have designed various test tracks, as shown in Figure 9, and are considering two areas with different route suggestions (Figure 10). We are working on incorporating all existing bus routes into the map to provide a similar overview to Grorud Valley. However, this extension may not be introduced until the next deliverable.

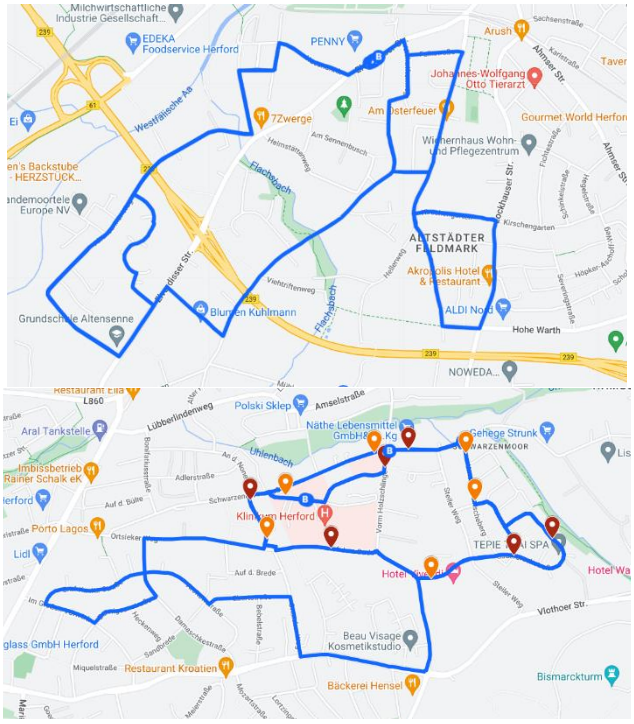


Figure 9: Herford suggested test areas

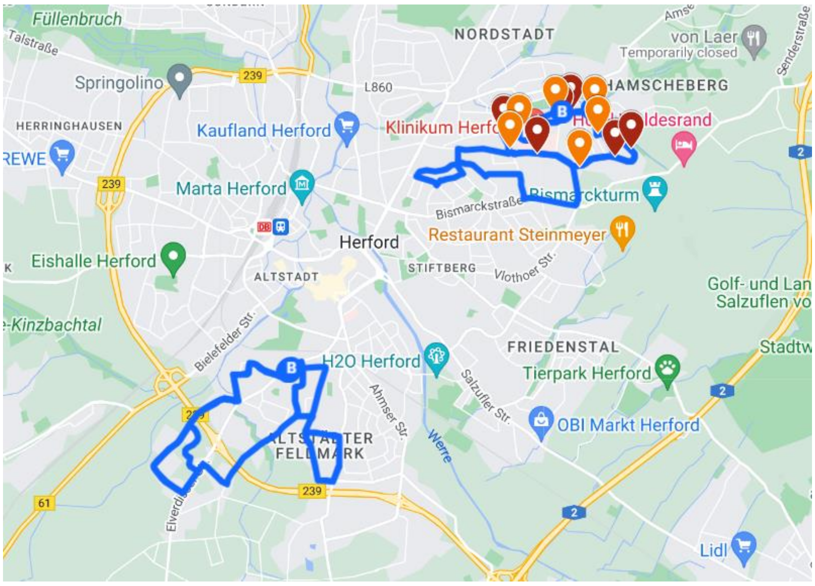


Figure 10: Herford Overview

## Geneva: Test Sites

Two test sites have been selected in Geneva, namely Belle-Idée and Champagne. Belle-Idée is an ideal location for testing various autonomous vehicles, particularly the current Gama models.

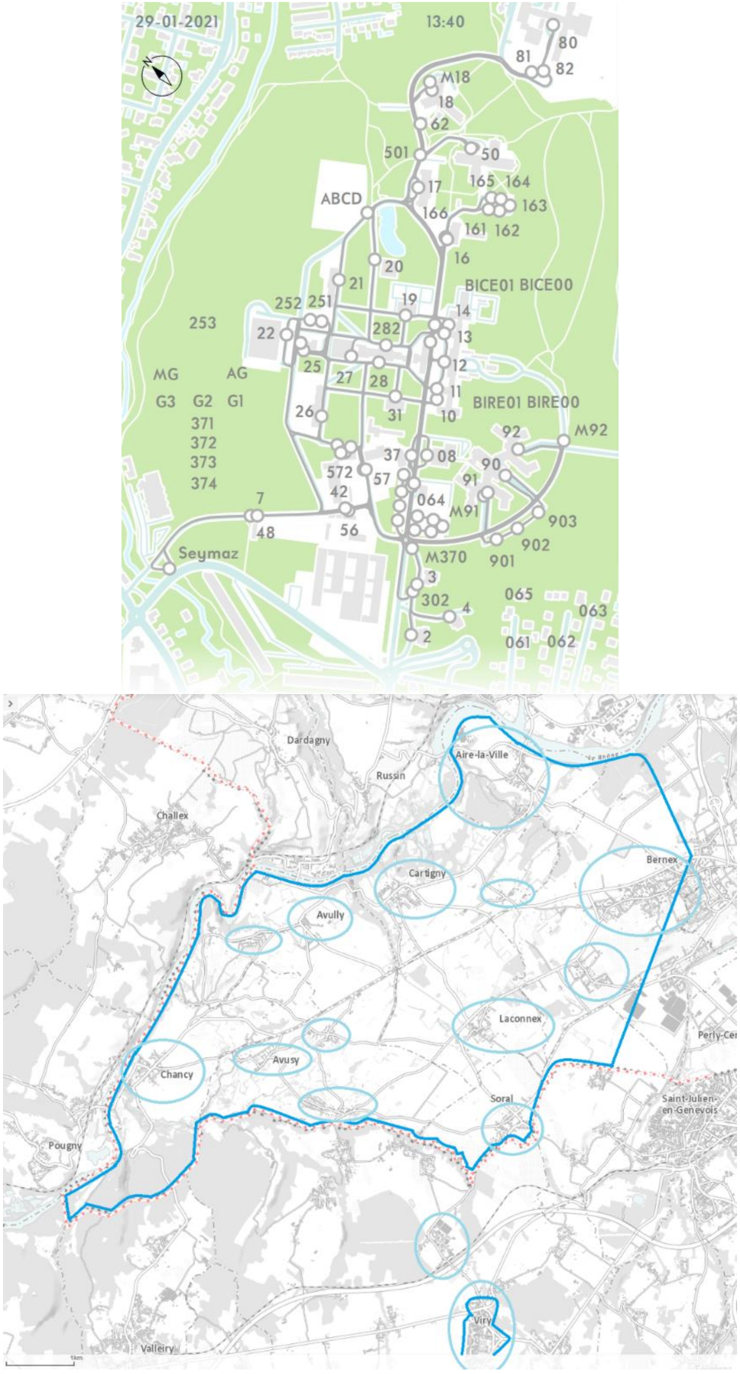


*Figure 11: Geneva Overview*

On the other hand, the Champagne area is more demanding, necessitating higher speeds and superior vehicle performance.

## 2.5 Methodology: Scientific input from T6.1 and AVENUE for the conception of the scenarios

At the outset of AVENUE, a detailed scenario matrix was crafted to outline four distinct paths for implementing AVs. Drawing from this foundational work, the following paragraphs summarize the methodology and key findings, laying the groundwork for the ULTIMO project. These insights stem from the initial economic impact deliverable by (Antonialli et al. 2019), providing a solid basis for further analysis.

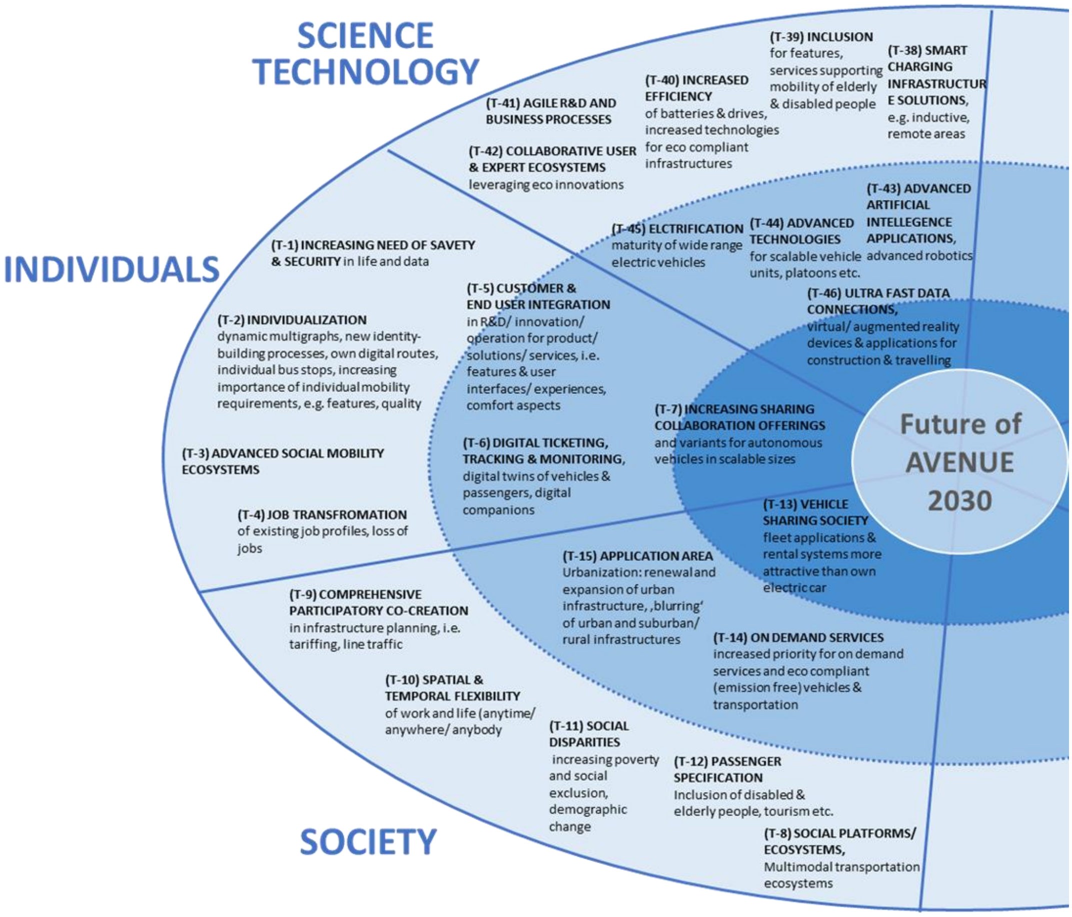


*Figure 12: AVENUE Trend Radar (1)*

In AVENUE, future trends were categorized into four main areas: people mass transportation, urban and suburban/rural transportation, autonomous electric transport, and overarching future developments. Key trends within each category were then translated into a trend radar, resembling a PESTLE framework, with segments like politics, economics, society, technology, legislation, and ecology/environment. This visualization depicted the impact and relevance of trends on the future of automated mobility. Through this structured approach, trends from diverse categories were seamlessly integrated into the trend radar. Figure 12 and Figure 13 illustrate this representation. Such visuals aid in understanding the multifaceted forces shaping AV implementation's future and provide a foundation for scenario development in the ULTIMO project. By leveraging this framework, ULTIMO can build upon insights garnered from AVENUE, advancing our understanding of AV deployment's economic implications in urban settings.

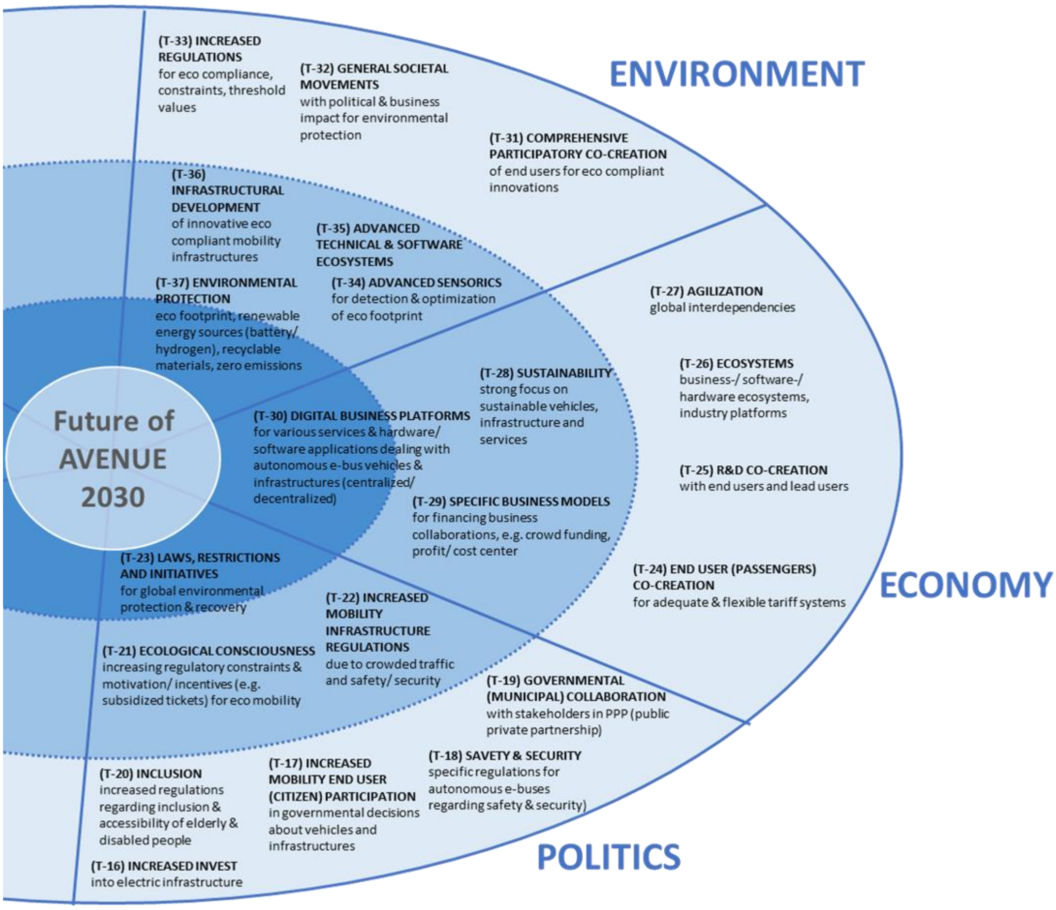


*Figure 13: AVENUE Trend Radar (2)*

The trends identified within each segment of the trend radar, as well as across segments, were grouped into broader macro-trends. These macro-trends formed the foundation for shaping the vision of AVENUE 2030, as depicted in Figure 14. Subsequently, a mobility trend matrix was created to delineate the specific impact of each macro mobility trend on the various segments of the PESTLE-like trend radar.

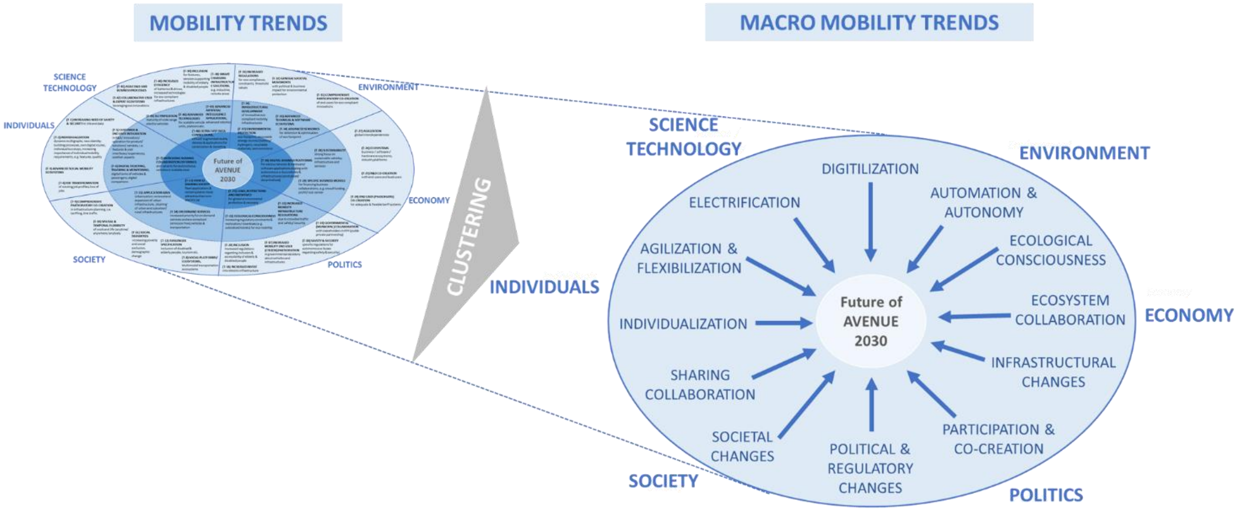


*Figure 14: Clustering of mobility trends*

Future scenarios serve as virtual depictions of forthcoming ecosystems, encompassing pertinent actors, activities, constraints, and impact factors. These scenarios play a pivotal role in pinpointing plausible passenger use cases and business prospects. Crafting these future scenarios entailed defining them along bi- or multipolar dimensions, positioned within the "Wilson matrix" according to their level of uncertainty and significance. Specifically, trends exhibiting high uncertainty and importance were marked as potential dimensions within the scenario matrix. Figure 15 illustrates the contradictory dimensions identified within AVENUE and subsequently tested for scenario matrix development.

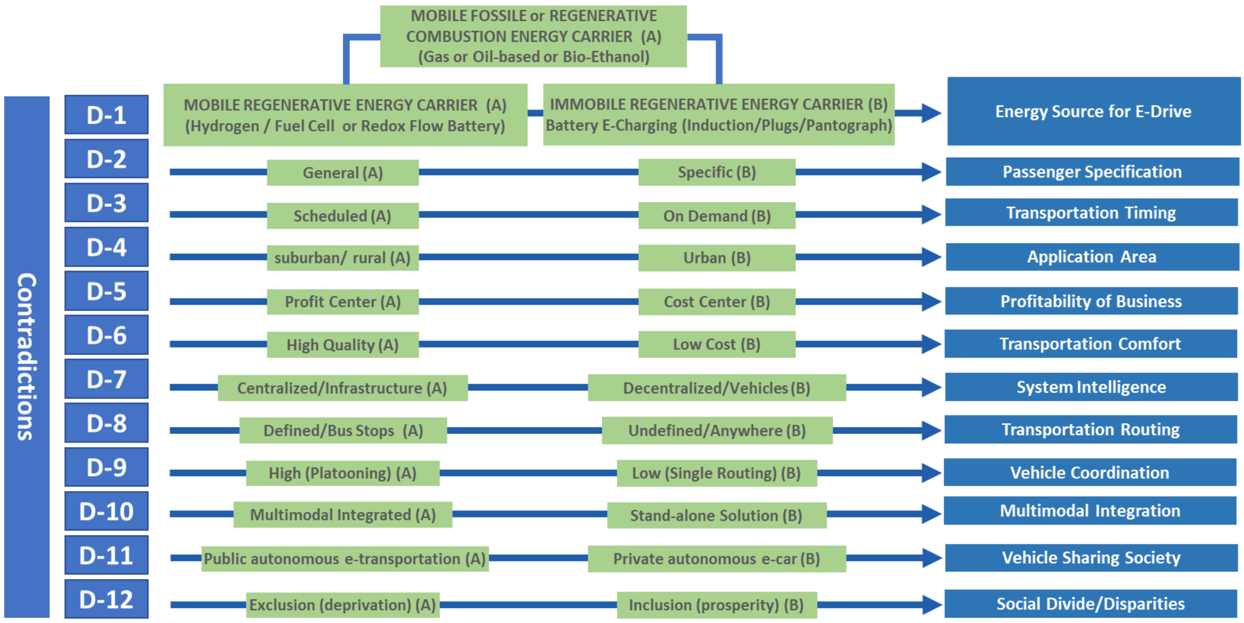


*Figure 15: Contradictory dimensions for scenario definition*

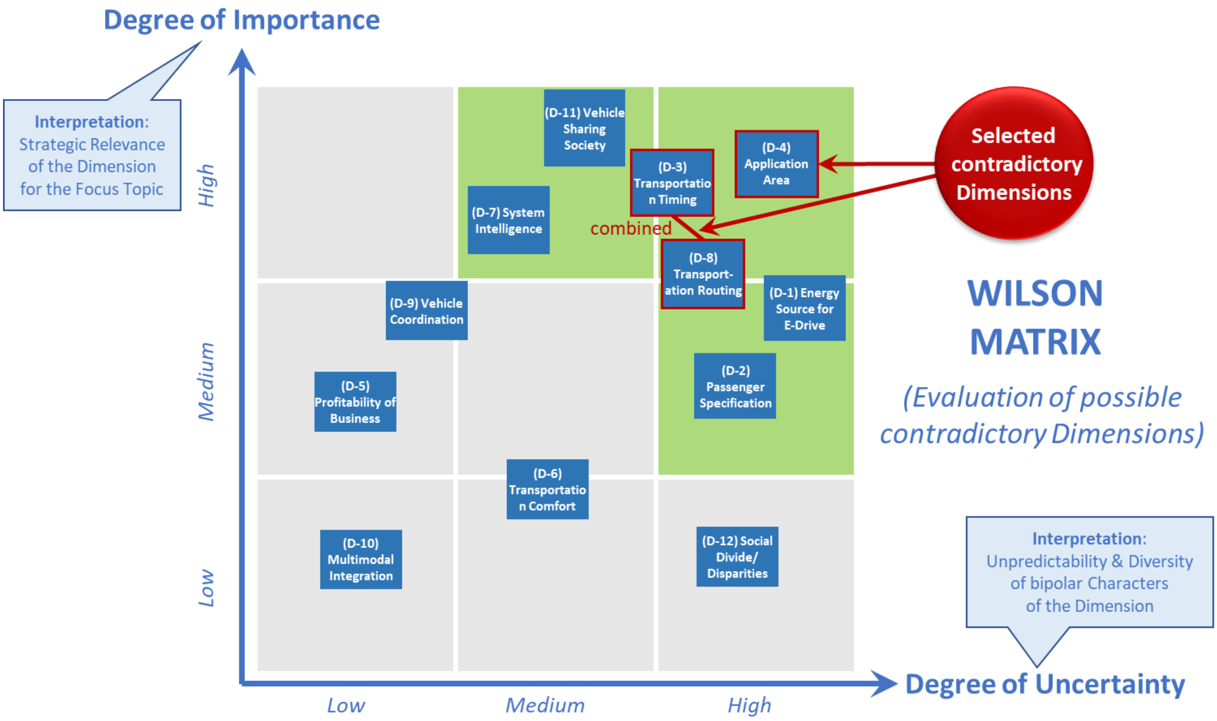


*Figure 16: Selection of contradictory dimensions for scenario definition (see Pillkahn 2008, p. 202 and Wilson and Morrison 2003)*

The chosen dimensions comprised the application area (D-4), transportation routing (D-8), and transportation timing (D-3). Following extensive deliberations, it was determined to integrate transportation routing and transportation timing into a single integrated dimension termed "traffic mode," delineated by attributes such as "line traffic" (scheduled/defined bus stop) and "on-demand traffic" (on-demand/anywhere).

Building upon these dimensions, four distinct future scenarios were delineated: AVENUE Country-Callbus, AVENUE City-Callbus, AVENUE Country-Line, and AVENUE City-Line (refer to Figure 17). These scenarios were subsequently elaborated upon and deliberated further through what are termed as scenario charters.

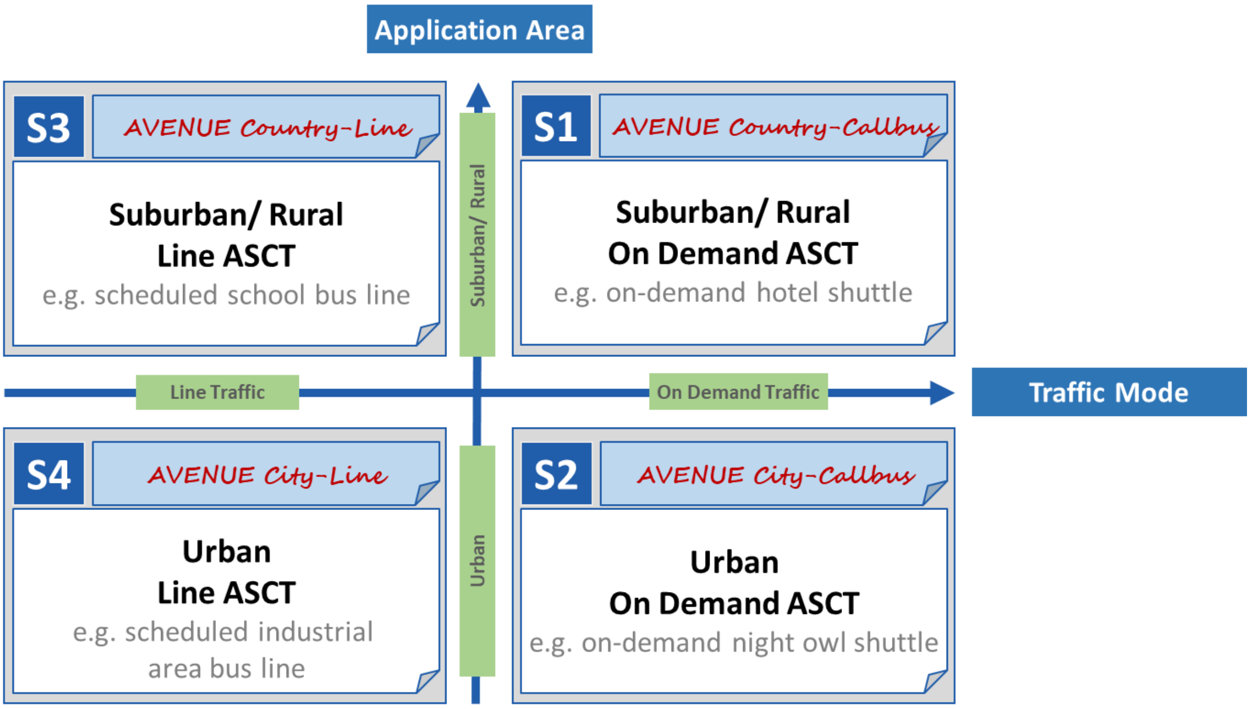


*Figure 17: Scenario matrix AVENUE*

The archetypical scenarios represented alternative application situations for AVENUE, either applied singularly or in combination in real-world settings. They served as the foundation for identifying passenger use cases and developing attractive business hunting fields and opportunities. The systematic top-down approach, from general trends to archetypical scenarios to business opportunities, provided the basis for practical applications in the AVENUE pilot use cases.

# 3 Identification of future scenarios, analysis and evaluation

Scenarios, integral to strategic planning and decision-making, serve as indispensable tools for crafting plausible narratives about future events. The landscape of scenario construction boasts several diverse methods, each characterized by its unique strengths and weaknesses. The methodological underpinning of scenario planning is a subject of profound scholarly exploration and continuous refinement, as evidenced by the substantial body of literature devoted to its investigation. Such is the depth of inquiry in this domain that meta-analyses, exemplified by Cordova-Pozo and Rouwette (2023), have been conducted to synthesize and evaluate existing research comprehensively.

## 3.1 Theoretical Framework of Scenario Planning

This chapter, while aspiring to provide a nuanced overview of scenario planning, is cognizant of the vastness of the topic and acknowledges that a comprehensive exploration is beyond its scope. The sheer volume of research and development underscores scenario planning's significance as a subject meriting rigorous scholarly attention. The seminal moment that thrust scenario planning into public consciousness occurred in 1972 with the contentious publication of 'The Limits to Growth' by Meadows and Meadows (1972), a break point event highlighted by Mietzner and Reger (2005). This seminal work not only catalysed public interest but also initiated a trajectory of scholarly engagement with scenario planning that continues to evolve.

In the subsequent chapters, our exploration will pivot towards a meticulous dissection of the very phrase 'Scenario Planning,' aiming to provide clarity and depth to this conceptual cornerstone. The ensuing discussion will transcend mere definition, delving into the intricacies of its theoretical underpinnings and practical applications. Moving beyond the theoretical realm, the narrative will navigate through the diverse methods employed in scenario planning, shedding light on their respective merits and limitations. As we traverse this intellectual terrain, our journey will culminate in a comprehensive review of noteworthy studies that have applied scenario planning methodologies to the domain of Automated Vehicles (AVs). By embarking on this structured journey through the realms of definition, methodology, and application, we endeavour to contribute to the broader discourse surrounding scenario planning, adding layers of understanding to its multifaceted nature. Through the inclusion of pertinent studies on AVs, we seek to bridge the gap between theoretical considerations and real-world applications, acknowledging the dynamic interplay between scholarly inquiry and practical implications. The forthcoming chapters promise a thorough exploration, offering readers a more profound appreciation for the intricate world of scenario planning in strategic foresight and decision-making.

### 3.1.1 Scenario Planning

The discourse surrounding scenario planning is characterized by a shared acknowledgment of its fundamental principles, yet it remains marked by a lack of a singular, universally accepted definition. A myriad of perspectives, shaped by varying contexts and objectives, underscores the dynamism inherent in the conceptualization of scenario planning by different authors and practitioners. Despite this diversity, there is a discernible consensus that scenario planning stands as a strategic management tool with the overarching objective of developing and analysing a set of plausible future scenarios. Schoemaker (1995) underscores this consensus, positioning scenario planning as a proactive approach to assist organizations in anticipating and preparing for potential future developments.

According to Schwartz (1991), scenario planning embodies a methodological emphasis on a systematic and imaginative approach to contemplate alternative futures. This method unfolds through an iterative process, involving the construction, testing, and refinement of multiple scenarios. The aim is not to predict the future with unwavering certainty but, rather, to discern plausible and relevant scenarios that empower decision-makers to prepare for uncertainties and undertake proactive measures to navigate potential challenges and opportunities (van der Heijden 2005).

Amer et al. (2013) contribute to this multifaceted understanding by accentuating the creation of diverse and confronting stories about the future within the ambit of scenario planning. This narrative diversity serves the purpose of challenging an organisation's assumptions and fostering the development of adaptive strategies in the face of transformative change. Chermack et al. (2001) delve into the processual aspect of scenario planning, elucidating its role in facilitating organisational learning and strategic decision-making. This process involves the identification of driving forces, the construction of plausible scenarios, and the critical assessment of each scenario's potential impact on the organization.

Scenario planning, as expounded by Bradfield et al. (2005), emerges as particularly germane in environments characterised by high uncertainty and complexity. Positioned as a method for comprehensively exploring and understanding the future, it involves the development of a spectrum of plausible futures and the identification of strategic options for the organization. Oliveira et al. (2018) extend this narrative by highlighting the instrumental role of scenario planning in aiding organisations to identify novel opportunities, effectively manage risk, and foster innovation. They portray it as a dynamic process of crafting narratives about potential future developments, serving as a cornerstone to inform decision-making and equip organisations for a spectrum of potential futures.

Stakeholder engagement and collaboration, emphasized by Spaniol and Rowland (2019), add a relational dimension to the scenario planning process. Recognizing the importance of diverse perspectives, these scholars underscore the collaborative nature of scenario planning, wherein engaging stakeholders becomes pivotal. Bishop et al. (2007) contribute to the discourse by arguing that scenario planning, when adeptly employed, can serve as a catalyst for the development of strategic resilience within organisations. This resilience, characterised by the capacity to adapt and respond to changing circumstances, positions scenario planning as a proactive and strategic tool in navigating an ever-evolving landscape.

In synthesis, while the nuances of specific definitions may exhibit slight variations, there exists a prevailing consensus among scholars and practitioners regarding scenario planning's overarching role as a strategic tool. This consensus extends beyond mere theoretical appreciation, finding resonance in practical applications, including innovative projects such as those exploring the use of AVs. By engaging in the systematic exploration of a spectrum of plausible scenarios, scenario planning emerges as a robust and versatile strategy for preparing organisations to thrive amidst the uncertainties of an ever-evolving future.

### 3.1.2 Different Methods

Herman Kahn, a trailblazer in the realm of scenario planning, catapulted the discipline into prominence with his seminal work 'The Year 2000.' In this groundbreaking endeavour, Kahn and his team meticulously developed future scenarios, leveraging identified trends, and subjected them to rigorous evaluation based on historical trend developments and diverse sequences of events. The objective was to craft "surprise-free projections" of the future, as elucidated by Kahn and Wiener (1977). This early exploration laid the foundation for scenario planning, marking a pivotal moment in the historical trajectory of strategic foresight.

As scenario planning has evolved, garnering heightened attention in recent years, the contributions of Kees van der Heijden have emerged as paramount. Regarded as a leading practitioner and scholar in the field, van der Heijden's extensive writings traverse the theoretical and practical dimensions of scenario planning. His work, exemplified by influential pieces such as those in 2000 and 2005, is marked by a distinctive focus on the refinement and development of scenario planning methods across diverse applications (van der Heijden 2000, 2005).

The classification and categorization of scenario planning methods represent a concerted effort to distil the multifaceted landscape of strategic foresight. Huss and Honton (1987a) delineated three scenario planning styles: the Intuitive Logics Method (ILM), Trend-Impact Analysis (TIA), and Cross-Impact Analysis (CIA). Building upon this foundation, Bradfield et al. (2005) grouped these styles into three distinct scenario planning schools. The Intuitive Logics School, emphasizing plausibility, contrasts with the Probabilistic Modified Trends (PMT) School, wherein TIA and CIA find common ground, focusing on probability (Weimert and Römer 2021). The contextual origins of these schools are elucidated by Bradfield et al. (2005), with the acknowledgment that the PMT School, including TIA and CIA, emanated from developments in the United States. Notably, a unique school for long-term planning emerged in France, credited to Gaston Berger, a French philosopher, under the nomenclature "Prospective Thinking" or the French School (la prospective). This diversification of schools was further explored and compared by Durance and Godet (2010) and Amer et al. (2013). Amer et al. (2013) contributed to the discourse by classifying ILM as a qualitative method, TIA and CIA as quantitative methods, and the French School as an intermediate amalgamation of the two.

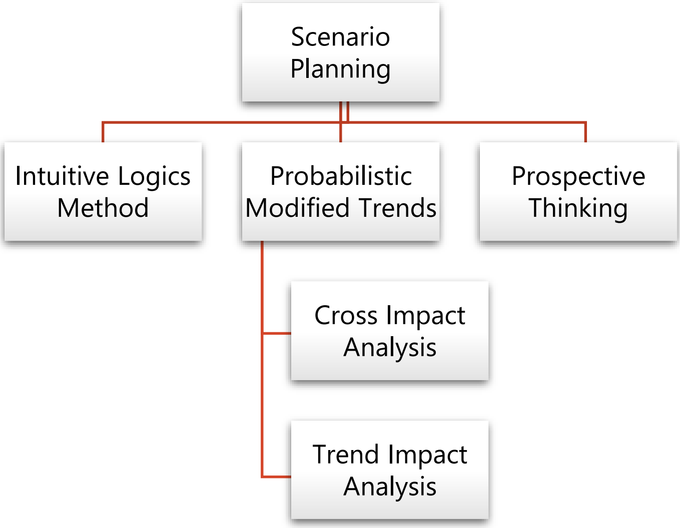


*Figure 18: Scenario Planning Schools and Methods*

Despite these classifications, the taxonomy of scenario planning remains a subject of ongoing debate and divergence among researchers. Numerous scholars have proposed diverse categorisations, such as those by Bishop et al. (2007), Börjeson et al. (2006), and Dean (2019), leading to an intricate landscape with numerous categories contingent on the variables utilised for grouping methods. This lack of consensus, as noted by Börjeson et al. (2006), underscores the complexity inherent in classifying scenario planning methods, mirroring the dynamic nature of the field.

In conclusion, the journey of scenario planning from its inception by Kahn to the contemporary discourse shaped by van der Heijden exemplifies an evolving field with diverse schools and categorisations. The intricate interplay of qualitative and quantitative methodologies underscores the richness of scenario planning, while the absence of a unified taxonomy accentuates the ongoing intellectual exploration within the discipline. The following subchapters dive into more detail of the three beforementioned scenario planning schools.

**Intuitive Logics Method**

The ILM, emanating from the research institute SRI International, has garnered unparalleled attention within the extensive literature on scenario planning. Renowned for its application in constructing scenarios, ILM relies on a logical structure that harmoniously integrates expert judgment with a systematic approach, offering a nuanced lens for exploring plausible future trajectories. Its inaugural use in a business context by the Royal Dutch/Shell company, as documented by Pierre Wack in two seminal articles published in the Harvard Business Review (Wack 1985a, 1985b), catapulted ILM to the forefront of strategic foresight methodologies.

Huss and Honton (1987b) elucidated the foundational principles of the ILM, emphasising its reliance on the intricate relationships among social, environmental, political, economic, technological, and resource factors. This method leans heavily on the experiential insights of expert teams, avoiding the use of mathematical algorithms and adopting a more qualitative orientation over a quantitative one. The absence of a strict algorithm contributes to the flexibility and adaptability of ILM, allowing for dynamic exploration of diverse scenarios tailored to the contextual intricacies of the subject matter.

Over time, the ILM has undergone significant evolution, manifesting in various methodological adaptations and diverse approaches, as documented by Bradfield et al. (2005). Noteworthy figures and seminal works in the field, including Ozbekhan (1969), Schoemaker (1995), and Schwartz (1991), have enriched the discourse surrounding ILM, contributing to its theoretical underpinnings and practical applications.

Recent efforts have been directed towards enhancing the scientific rigor of ILM for research purposes. Wright et al. (2013a), Wright et al. (2013b) and Derbyshire and Wright (2017) exemplify this endeavour, emphasising the need to augment ILM's applicability in scientific research contexts. These studies signify a concerted effort to elevate ILM from its qualitative roots to a methodologically robust framework suitable for rigorous scientific inquiry.

The implementation of ILM involves a systematic process of defining key factors and driving forces, often elucidated through a PEST analysis conducted by expert teams. These factors are subsequently classified based on their impact and uncertainty, forming the foundation for the construction of a scenario matrix. The two factors deemed to possess the most significant impact and uncertainty are instrumental in generating a scenario matrix, typically yielding four scenarios for each combination of positive and negative developments. Additional factors contribute to the narrative fabric of the scenarios, enriching the qualitative dimension of the methodology (Derbyshire and Wright 2014; Postma and Liebl 2005).

In essence, the Intuitive Logics Method, marked by its reliance on expert judgment, qualitative orientation, and adaptability, stands as a cornerstone in the panorama of scenario planning methodologies. Its evolution and ongoing efforts to enhance its scientific rigor underscore its resilience and adaptability as a strategic tool for exploring and preparing for a spectrum of plausible futures.

**Probabilistic modified trends (TIA and CIA)**

The Trend-Impact Analysis (TIA) method, distinguished by its quantitative orientation, emerged in the 1970s, drawing inspiration from traditional forecasting methodologies. This method represents a systematic approach that harnesses historical events, extrapolates pertinent data, and seamlessly integrates expectations regarding future events, their probabilities, and anticipated impacts (Cordova-Pozo and Rouwette 2023). The TIA method unfolds through a series of meticulously structured steps and processes, aiming to foster the development of robust scenarios. Two critical components delineate its application: firstly, the calculation of surprise-free future trends utilising historical data, and secondly, the incorporation of expert judgments to predict potential events deviating from the historical data extrapolation. This dual approach, as expounded by Gordon (1994), embodies a holistic strategy that combines empirical data with expert insights, augmenting the method's predictive precision.

In contrast, Cross-Impact Analysis (CIA) represents a more intricate methodological approach in the realm of scenario planning. This method, as outlined by Cordova-Pozo and Rouwette (2023), calculates the likelihood of future events by scrutinising the probability of specific past events occurring. Unlike relying solely on experts for direct probability estimates, CIA introduces a nuanced dimension by considering the historical likelihood of events. Noteworthy is its capacity to calculate the likelihood of two events occurring simultaneously, leading to a diverse array of possibilities that may not have been initially contemplated during the data collection phase. This feature, as highlighted by Muskat et al. (2012), endows CIA with the potential to yield novel and surprising scenarios, enriching both the researcher's perspective and the engagement of experts.

The inherent value of CIA extends beyond its capacity for generating novel scenarios. This method serves as a powerful analytical tool due to its ability to dissect and analyse interactions among various factors within social, technological, and environmental developments. Helmer (1977) underscores the utility of CIA in exploring complex systems, revealing potential areas of risk or opportunity. This analytical depth positions CIA as an invaluable instrument for scenario planning in dynamic and intricate contexts.

In summary, the TIA method, with its quantitative foundations and integration of expert judgments, provides a systematic approach to scenario planning, enhancing predictive capabilities. In contrast, CIA's intricate methodology, drawing on historical event likelihoods, introduces a richness of possibilities and serves as a potent tool for unravelling the complexities inherent in diverse and dynamic systems. Both methodologies, with their distinct strengths, contribute significantly to the arsenal of scenario planning, facilitating nuanced exploration and anticipation of future developments.

### 3.1.3 Prospective thinking

The French School of scenario planning, recognised as La Prospective, emerged in the 1950s under the visionary guidance of Gaston Berger and underwent further refinement by Bertrand de Jouvenel and Michel Godet. La Prospective stands as a methodological framework designed to foster informed decision-making by creating a shared vision of the future. Distinguished by its comprehensive approach, this school employs a harmonious blend of qualitative and quantitative methods, encompassing systems thinking, trend analysis, and scenario construction (Jouvenel 1967). The intricacies of La Prospective unfold through a structured process involving key steps: (I) identification of pivotal driving forces and trends, (II) creation of a typology of uncertainties rooted in these driving forces, (III) construction of multiple plausible scenarios, (IV) rigorous analysis and evaluation of the scenarios through predefined criteria, and (V) the subsequent development of strategic options grounded in the scenario outcomes (Godet 2000).

Berger (1959) underscores the significance of adopting a long-term perspective in La Prospective, emphasizing the need to engage a diverse group of stakeholders. This participatory aspect, a cornerstone of the method, extends beyond mere consultation, striving to build consensus among stakeholders and ensuring a more inclusive decision-making process. Jouvenel (1967) adds another layer by highlighting the imperative of imagination and creativity in scenario construction. This emphasis on the creative process contributes to the richness of the scenarios, ensuring that they transcend mere extrapolations of current conditions. Meanwhile, Godet (2000) introduces the utilisation of tools like morphological analysis, providing structure to the scenario construction process and enhancing the method's efficacy.

La Prospective's widespread application in France and other European countries, particularly in sectors such as the public domain, transportation, and energy, underscores its versatility and adaptability (Godet 2000). The method's strength lies in its participatory nature, fostering consensus-building and aligning diverse perspectives towards a common vision of the future. Additionally, La Prospective places a distinct emphasis on the evaluation of strategic options, elevating its practical utility in strategic decision-making.

However, despite its strengths, La Prospective has not been immune to criticism. Scholars like Ramírez and Wilkinson (2016) have voiced concerns over the method's reliance on expert judgment and its perceived determinism in approaching the future. Such criticisms underscore the ongoing debates within the scenario planning community regarding the balance between structured methodologies and the inherent uncertainties of the future. As La Prospective continues to evolve, addressing these critiques while preserving its participatory strengths will be pivotal for its sustained relevance in the ever-evolving landscape of strategic foresight.

### 3.1.4 Scenario Planning in the context of Automated Vehicles

Scenario planning within the domain of AVs presents a crucial opportunity for navigating the uncertainties inherent in their deployment and assessing their potential impacts. Numerous studies have leveraged scenario planning methodologies to explain the multifaceted dynamics surrounding AV adoption in sustainable transportation systems.

For instance, Fidanoglu et al. (2023) delved into the integration of AVs within the PT network, particularly focusing on their role in last-mile connectivity, in Bursa, Turkey. Their findings underscored the potential of AVs to enhance service quality and energy efficiency, thereby offering a promising opportunity for sustainable urban mobility. Similarly, Miskolczi et al. (2021) undertook a comprehensive literature review to develop four distinct scenarios outlining potential futures for urban mobility. Their scenarios, informed by factors such as automation levels, sharing mobility, and environmental considerations, offer valuable insights into the diverse trajectories that urban mobility may follow.

In the Netherlands, Milakis et al. (2017) crafted four scenarios envisioning the deployment of AVs, grounded in technological advancements and policy frameworks. Through detailed evaluation, they projected the implications of AV penetration on traffic dynamics, transport planning, and travel behaviour up to 2030 and 2050. Moreover, Gruel and Stanford (2016) explored the societal effects of AV availability, describing scenarios that define shifts in travel behaviour and modal choices. Beiker (2015) contributed by devising three distinct scenarios ranging from evolutionary to transformative, summarising potential paths for AV-driven mobility paradigms. Stead and Vaddadi (2019) conducted a comprehensive review of scenario studies, shedding light on the nuanced impacts of AVs on urban landscapes and emphasising the importance of contextual factors and policy frameworks.

Nogués et al. (2020) employed a backcasting approach to develop scenarios centred on access to mobility and shared versus individual mobility preferences. Their study concluded in the identification of a preferred scenario integrating AVs into PT networks, supported by a robust policy framework. Galich and Stark (2021) conducted focus group discussions to explore the impact of AV introduction on private car ownership, highlighting the varied outcomes depending upon implementation specifics.

Furthermore, Gandomani et al. (2022) conducted a comparative study of shared mobility options, offering insights into the potential cost savings and environmental benefits associated with AV deployment. Filippi et al. (2023) provided a comprehensive review of optimisation trends in urban passenger transport, illuminating opportunities for enhancing flexibility and integration in service delivery.

Notably, the Association of German Transport Companies (VDV) in Germany has advocated for proactive measures to steer AV deployment towards sustainable mobility outcomes, emphasising the importance of supporting public transportation initiatives (Röhrleef et al.). This underlines the importance of proactive policy interventions and stakeholder collaboration in shaping the future trajectory of AV deployment.

In summary, scenario planning serves as a potent tool for unpacking the complexities of AV deployment, offering valuable insights for policymakers, urban planners, and transportation stakeholders alike. As AV technologies continue to evolve, scenario planning will remain indispensable for anticipating and navigating the transformative impacts of this disruptive innovation on urban mobility landscapes.

## 3.2 Identification of future elements: Trends (extrapolations) and e.g. alternatives

Building upon the theoretical framework outlined in the preceding chapter's literature review, the process of scenario development commences. ULTIMO adopts the scenario-building approach previously employed with success in AVENUE, aligning with the methodologies associated with the Intuitive Logics Method (ILM) school.

Future trends emerge from diverse knowledge sources and shifts. It's crucial to acknowledge that trends, in a narrower sense, represent projections from the current state to forthcoming developments. Additional future components encompass constants, innovations, inconsistencies, uncertainties, and outliers. For the purpose of this analysis, the term "trends" will be used broadly to encompass all prospective elements. Figure 19 precisely delineates the areas of focus. The "what" delineates the objectives to be attained, the "how" outlines potential solutions, and the "where" identifies the specific domains under examination. In the context of ULTIMO, the "where" pertains to suburban and rural transportation zones and associated mobility frameworks. The desired outcome, or "what," is an efficient and sustainable transportation system encompassing both passenger and freight transportation. The proposed approach, or "how," entails the integration of electric, automated transportation within Mobility-as-a-Service (MaaS) and Intelligent Transportation Systems (ITS), while logistics and freight transportation may be facilitated through a Logistics-as-a-Service (LaaS) model.

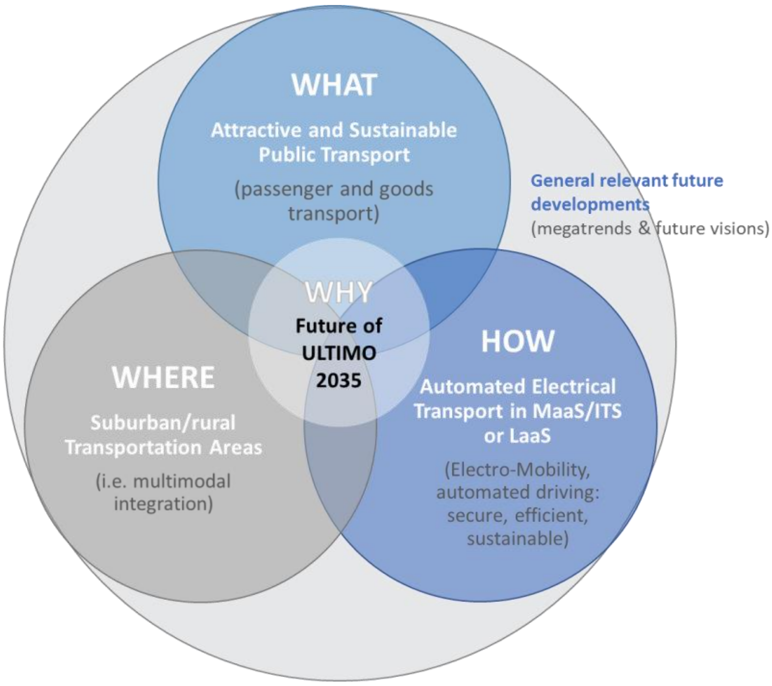


*Figure 19: Future of ULTIMO 2035*

Following the establishment of the scenario-building foundation, a comprehensive analysis ensues. The subsequent sections expand upon the details of the four sequential scenario development stages. Our methodology integrates elements from the AVENUE ILM with the initial three steps delineated in the five-step framework proposed by of Milakis et al. (2017), supplemented by an additional refinement step, as illustrated in Figure 20.

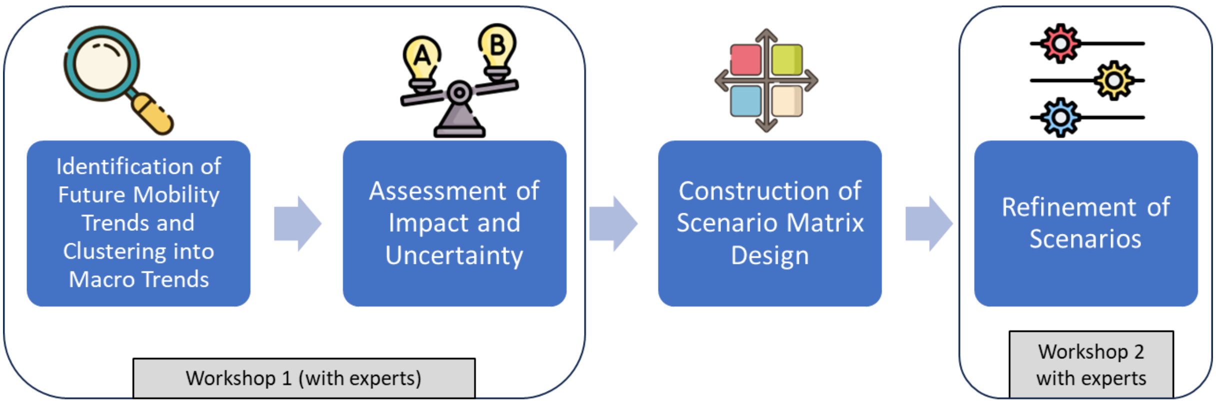


*Figure 20: Steps for construction of scenario*

The four progressive steps employed in scenario development encompass: (i) identification of forthcoming mobility trends associated with automated vehicle deployment and their aggregation into macro trends, (ii) evaluation of the impact and uncertainty inherent in the identified macro trends, (iii) formulation of the scenario matrix, and (iv) meticulous refinement and elaboration of the scenarios. Although the preliminary three stages have been initiated, the process of refining the scenarios is still pending completion, awaiting the finalization of the scenarios.

For the examination of future trends, we employ a framework that echoes the methodology utilised in the preceding AVENUE project. This framework, depicted in Figure 21, serves as the organisational structure for categorising and analysing identified trends based on their respective sectors. These sectors encompass environmental, economic, political, societal, individual, and science and technology trends. Notably, within this framework, the traditional "legal" dimension has been replaced by the "individual" dimension, underscoring ULTIMO's pronounced emphasis on citizen-centric considerations.

Each trend identified undergoes a rigorous assessment to determine its potential impact on shaping the future landscape of ULTIMO 2035. Subsequently, these trends are strategically positioned within the trend radar visualisation, with their placement reflecting their assessed level of impact. Trends situated nearer to the centre within the deep blue circle denote a higher anticipated impact on the future trajectory of ULTIMO 2035. Conversely, trends positioned towards the outer periphery of the radar signify a comparatively lower projected impact on the future development of ULTIMO 2035.

By adopting this comprehensive framework, ULTIMO aims to meticulously analyse and understand the multifaceted dynamics of future trends across various sectors. This proactive approach not only facilitates a deeper comprehension of potential future scenarios but also enables ULTIMO to strategically position itself to capitalize on emerging opportunities and navigate potential challenges effectively.

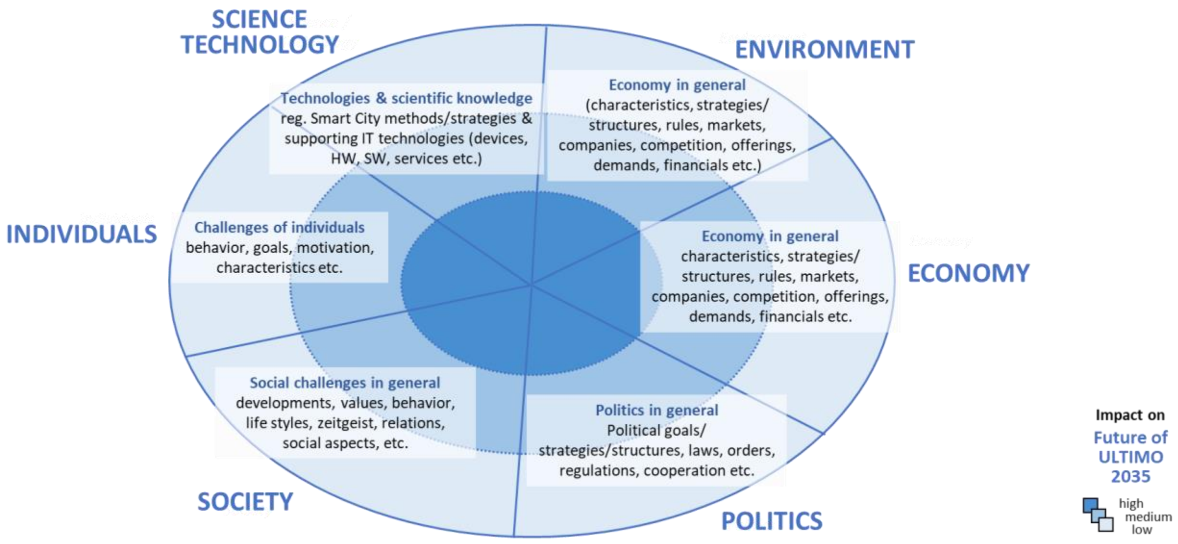


*Figure 21: Trend Radar Segments*

The ULTIMO trend analysis represents an evolutionary step forward, building upon the robust foundation established by the trend analysis conducted during the AVENUE project. Currently, a dedicated team comprising researchers and domain experts in the realm of mobility is engaged in the meticulous refinement and updating of the trend radar framework, as illustrated in Figure 22.

This work encompasses a multifaceted approach, blending insights gathered from the literature, including articles by Miskolczi et al. (2021), Hwang and Hong (2023), Tori et al. (2023), Smith et al. (2018), Xenou et al. (2022), with invaluable input garnered through collaborative workshops with esteemed experts immersed in the mobility and transportation domain. By leveraging these diverse sources of knowledge and expertise, the ULTIMO team intents to enrich the trend radar with the latest advancements, emerging paradigms, and critical insights pertinent to the evolving landscape of automated mobility.

Furthermore, a pivotal focus of the ongoing efforts pertains to the expansion of the trend radar framework to encompass the realm of logistics and goods transport. This strategic initiative is driven by the recognition of the integral role played by logistics in shaping the future trajectory of automated mobility systems. By integrating logistics considerations into the trend analysis, ULTIMO seeks to gain a comprehensive understanding of the interconnected dynamics between passenger mobility and goods transport, thereby enabling a holistic assessment of future scenarios.

Central to this effort is the emphasis placed on optimising the viability and feasibility of implementing identified trends, with a keen eye on their proximity to market readiness. By refining the trend radar to account for logistical dimensions and enhancing its alignment with market realities, ULTIMO wants to fortify its strategic positioning and readiness to navigate the evolving landscape of automated mobility with foresight and agility.

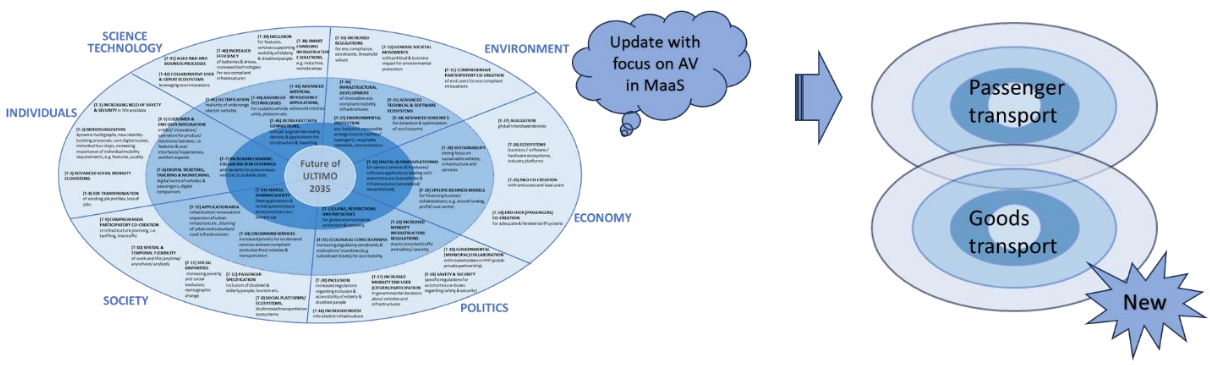


*Figure 22: Trend Radar update*

Upon the completion of this comprehensive analysis, the numerous mobility trends identified will undergo a meticulous clustering process, culminating in the definition of overarching macro trends. These macro trends will then undergo rigorous evaluation, with particular emphasis on their implications across each of the PESTLE-like categories, namely politics, economics, society, technology, individual, and environment.

Crucially, throughout this analytical process, it remains imperative to maintain a steadfast alignment with ULTIMO's overarching objectives. This necessitates a continuous and rigorous cross-referencing of identified trends against ULTIMO's strategic imperatives, ensuring that the assessed trends resonate cohesively with ULTIMO's mission and vision. Moreover, it is upon the research team to consistently reassess and recalibrate their analyses, continually scrutinising the relevance and applicability of identified trends from the perspective of ULTIMO's strategic priorities.

Amidst this evaluative process, it is paramount to remain aware of the most significant and compelling criteria that underpin ULTIMO's strategic objectives. By anchoring the analysis within the context of ULTIMO's overarching goals, the research team can effectively prioritise trends that hold the greatest potential for driving transformative impact and advancing ULTIMO's mission in the realm of automated mobility.

## 3.3 Definition of determinants (dimensions) and design of an appropriate model for scenarios

In this pivotal phase of the analysis, the identified macro trends will undergo a rigorous process of further refinement and evaluation. Initially, these trends will be elaborated into bi- or multipolar dimensions, thereby enabling a nuanced exploration of future trajectories within each trend domain. It is imperative that these dimensions capture contrasting factors, thereby facilitating the description of opposing future scenarios. Notably, the aim is to reveal potential future possibilities rather than predetermined outcomes or fixed futures dictated by specific legislative or regulatory frameworks.

For instance, consider a trend such as the integration of AVs into a MaaS ecosystem. The associated dimensions could span the spectrum from minimal integration to full integration, thereby capturing the extremes of this range. Subsequently, these dimensions will be subjected to rigorous evaluation within a framework known as the "Wilson-Matrix," wherein their relative importance and uncertainty will be systematically assessed.

Importantly, the concept of "uncertainty" within this context should be understood as a spectrum of potentialities, encompassing a range of plausible future outcomes rather than deterministic prognostications of likelihood. This evaluative process will be facilitated through collaborative workshops involving a diverse array of domain experts, including researchers, Public Transport Authorities (PTAs), Public Transport Operators (PTOs), and other stakeholders with specialised expertise in the field.

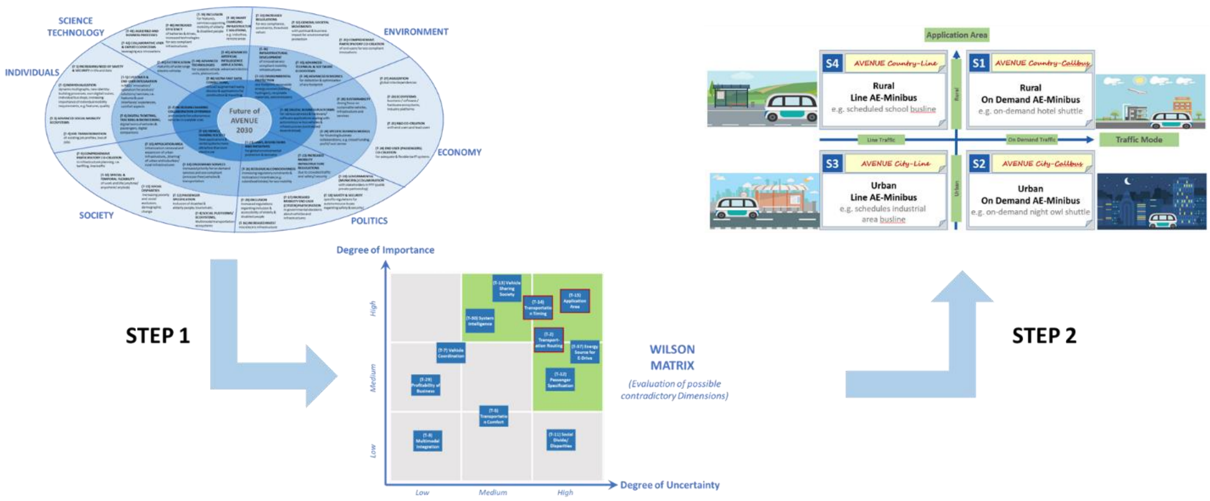


Figure 23: From Future Trend Radar to Future Scenario (Antonialli et al. 2019)

Ultimately, the two dimensions identified as exhibiting the highest levels of uncertainty and importance will serve as the defining axes of a 2x2 scenario matrix. This matrix will serve as a foundational framework for the generation of diverse and comprehensive future scenarios, thereby facilitating strategic decision-making and policy formulation within the realm of automated mobility. Figure 23 provides a visual representation of this iterative process, drawing upon insights gleaned from the AVENUE project to inform the methodology adopted in the current analysis.

At present, our strategy entails the utilisation of a 2x2 scenario matrix, primarily due to constraints related to resource availability. However, given the potential complexities introduced by the incorporation of goods transport into the analysis, alternative approaches may be warranted to effectively visualise and develop the scenarios. One such alternative is the utilisation of a spider diagram, renowned for its intricate yet comprehensive nature (see Figure 24).

While the 2x2 scenario matrix offers simplicity and clarity in depicting divergent future trajectories along two primary axes, the spider diagram provides a more nuanced and multifaceted representation. By employing a spider diagram, we can accommodate a broader array of variables and dimensions, thereby enabling a more holistic exploration of potential scenarios. This approach is particularly advantageous in scenarios where the interplay of numerous factors necessitates a more intricate analytical framework.

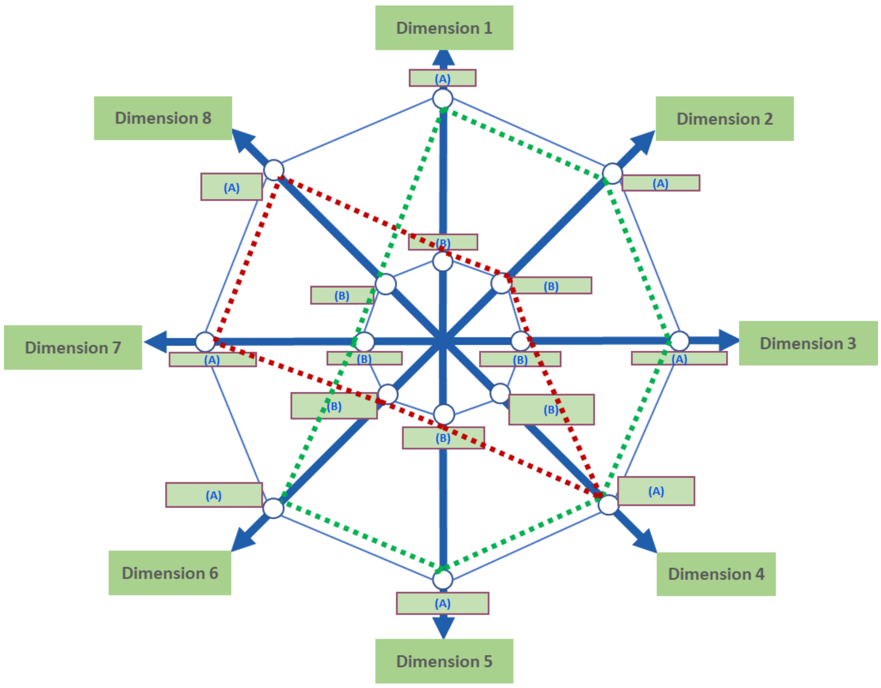


*Figure 24: Example of Spider Diagram for Scenario Development*

However, it is essential to acknowledge that the adoption of a spider diagram entails a trade-off between complexity and comprehensibility. While it offers greater depth and granularity in scenario development, it may also pose challenges in terms of interpretation and communication. Therefore, careful consideration will be given to selecting the most appropriate visualization method, balancing the need for complexity with the imperative of clarity and accessibility.

In essence, the choice between a 2x2 scenario matrix and a spider diagram hinges on the specific requirements of the analysis, as well as the intended audience and objectives of the scenario-building exercise. Both approaches offer distinct advantages and trade-offs, and the selection of the optimal methodology will be guided by pragmatic considerations and the overarching goals of the ULTIMO project.

## 3.4 Characterisation analysis and evaluation of future scenarios

As the trend analysis remains ongoing and has yet to reach completion, only a preliminary 2x2 scenario matrix has been formulated thus far. Further analysis of trends, encompassing both passenger and goods transport, is imperative before proceeding with the subsequent steps outlined for generating final scenarios.

Displayed in Figure 25 are the preliminary scenarios developed thus far. This matrix describes the dimensions of the selected governance strategy (centralized vs. decentralized) and the level of integration into Mobility as a Service (MaaS) systems (integrated vs. not integrated), resulting in the definition of four distinct future scenarios.

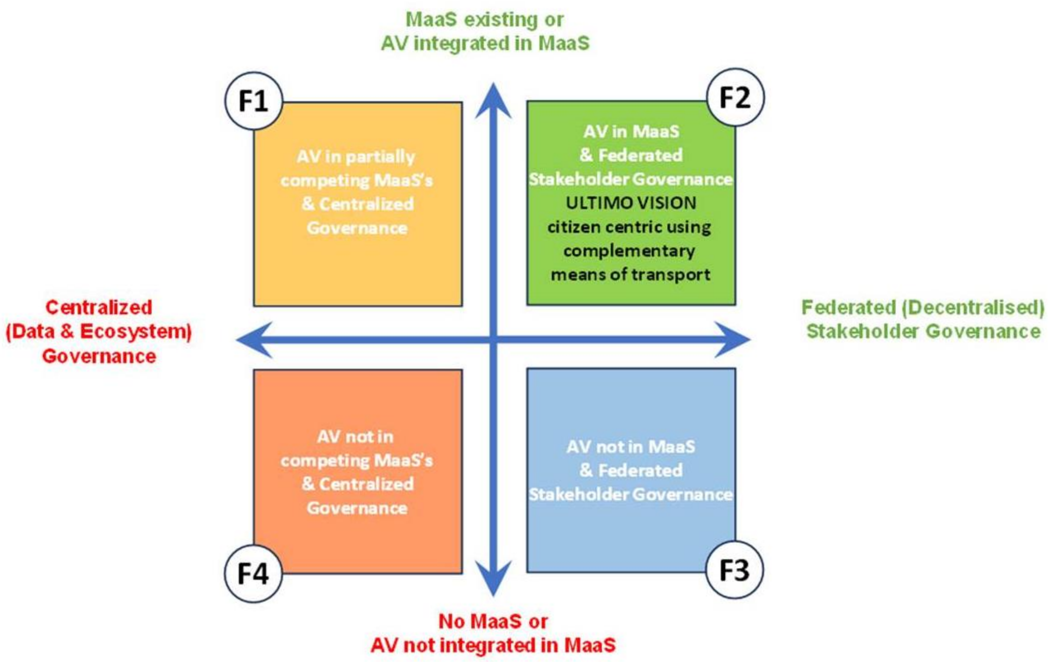


*Figure 25: Possible Future Scenarios*

Future 1 (F1) depicts a scenario characterised by a centralised governance framework wherein AVs are integrated into partially competitive MaaS networks. Future 2 (F2) envisages an AV in MaaS solution under a federated stakeholder governance model, entailing full integration into either an existing or newly established MaaS ecosystem. This aligns with the overarching vision of ULTIMO, which advocates for a citizen-centric approach promoting the complementary utilisation of diverse public transport modes, thereby augmenting rather than undermining the existing public transport infrastructure. This vision is scheduled for further refinement and elaboration in subsequent deliverables.

Future 3 (F3) portrays a scenario featuring AVs within a federated stakeholder governance framework, although without integration into a MaaS system. Conversely, Future 4 (F4) outlines a pessimistic scenario characterised by AVs operating within a centralised governance structure that encompasses ecosystem and data management responsibilities. This scenario, lacking of MaaS integration, fosters competition with other modes of transport, consequently hindering rather than strengthening public transport initiatives.

While these scenarios are preliminary, they remain aligned with the ULTIMO research question and constitute plausible alternative futures, despite the ongoing nature of the future trends analysis and the absence of LaaS and goods transport considerations. These scenarios are envisioned as potential trajectories that are deemed feasible, if not imminent, given the current understanding of the landscape.

Upon completion, each scenario will undergo a comprehensive refinement and detailing process. To facilitate this, we have devised a structured framework (depicted in Figure 26) that will be systematically applied to each potential future. This framework encompasses various dimensions, including overarching characteristics, key messages, anticipated impacts, and the envisioned alignment with ULTIMO's overarching vision. Additionally, a SWOT analysis will be conducted, dissecting the Strengths, Weaknesses, Opportunities, and Threats inherent in each scenario. To bolster the credibility of each scenario, supporting arguments advocating for their plausibility will be articulated. Moreover, an exploration of the primary triggers and drivers capable of catalysing the transition from speculative possibility to tangible reality will be undertaken. Subsequently, a thorough examination of success factors and potential risks pertaining to ULTIMO within the context of each scenario will be documented and incorporated into the framework.

Furthermore, given the importance of stakeholder engagement and dynamics, a dedicated segment of the framework will be dedicated to analysing stakeholder strategies and behaviours. This will particularly focus on key stakeholders such as passengers, transportation system authorities (PTAs/PTOs), and ULTIMO solution providers. Finally, to ensure a balanced assessment, counterarguments against the probability of each scenario's occurrence will be meticulously weighed against the earlier compiled supporting arguments. This comprehensive framework aims to provide a robust foundation for refining and evaluating each scenario within the broader context of ULTIMO's objectives and aspirations.

The central objective of this initiative is to construct a compelling and resonant vision derived from our envisaged future scenarios. Our aim is to distil the essence of our envisioned future state into a vivid and inspiring narrative that encapsulates our collective aspirations and ambitions. Through meticulous deliberation and strategic foresight, we seek to translate this vision into tangible strategies and actionable initiatives that propel us toward our desired destination.

This comprehensive process entails not only the imaginative exploration of future possibilities but also the strategic delineation of pathways and milestones essential for realising this vision. By fostering a shared understanding and commitment to this articulated future state, we lay the groundwork for collaborative action and transformative change. Through this concerted effort, we aim to galvanise stakeholders and mobilise resources toward the realisation of our shared vision for the future.

| Scenario/Future F1: [Name] |
| --- |
| **General Characteristics & Key Message** |
| |
| **General Impact & Vision for ULTIMO** |
| Impact:<br>Vision: |
| **SWOT Analysis** |
| Strengths:<br>Weaknesses:<br>Threats:<br>Chances: |
| **PROs for the probability for scenario occurrence** |
| |

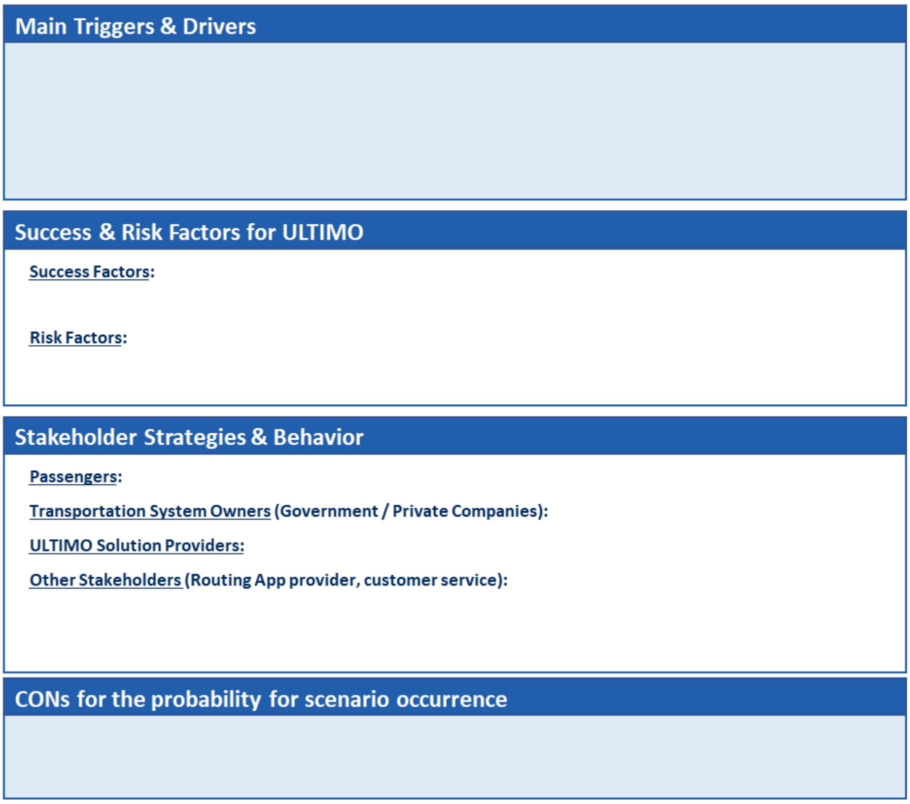


*Figure 26: Scenario Refinement*

# 4 ULTIMO vision: 'Mobility for All'

## 4.1 Introduction and previews

Automated mobility is no longer the newest kid on the block but is only slowly outgrowing infancy. Level 4, the status of automated driving without any human operator on board, isn't yet realized in Europe on a larger scale.

Within the ULTIMO project, 23 partners from eight countries work together to push the boundaries of automated driving to Level 4 and to realize commercially viable services. In the project, automated transport services will be deployed in three European cities, each with fleets of at least 15 vehicles covering all mobility needs in a Mobility as a Service (MaaS) setup. Our vision? To provide Mobility for All, also for those with reduced mobility, all without the need to own a car.

This vision is not uncontroversial, as a recent exchange in Norway has shown. The debate was sparked by the launch of ULTIMO's first deployment site in Oslo by public transport authority Ruter. In the discussion, the self-driving car project was criticized by a political party as:

- **a waste of time and funds**
- **as a service that does not address people's real transportation needs**

They called automated transport:

- **in no way accessible to everyone**
- **the cause of job losses for bus drivers.**

They recommended that Ruter should focus on improving the existing public transportation system and should invest in more capacity instead of investments in self-driving vehicles. These arguments can be valid. Not only ULTIMO is addressing them.

At ULTIMO we don't shy away from discussion, and the situation provided a good opportunity to explain our vision to skeptical politicians and important stakeholders – first by an employee of Ruter, after even by the Oslo City Council. Their arguments illustrate what drives us at ULTIMO.

We are working towards a world in which people no longer need cars. Instead, a good public transport system takes us wherever we want. For that goal, strengthening traditional scheduled public transport services might not be sufficient. Here efficiency also plays a role: for suburban or rural areas large mass transit might not be the best option. Instead, we need to create new services that complement public transport and that are on-demand, serve as mobility-gap fillers, and are easily accessible. Instead of replacing public transport, Public Transport Operators (PTOs) and Public Transport Authorities (PTAs) like Ruter are strengthening the public transport system, covering areas that could otherwise only be reached by car. Within ULTIMO, we believe that self-driving vehicles can be a perfect tool to reach these objectives.

There are strong reasons for our belief:

1. **AVs can complement and improve existing means of transport**, offering a true alternative to the private car at an affordable price. They can provide door-to-door service when other transport services are not running anymore, or in rural areas. In our vision, AVs don't compete with public transport.

2. **Automated driving makes travelling more comfortable and safer** (over 90% of road traffic accidents are due to human error1, see Winkle 2016)

3. **The vehicles can be customized to the needs of different target groups**, including the elderly and people with disabilities (for instance, wheelchair accessible vehicles are sent to those who need them)

4. **The option of booking on-demand journeys can provide the same liberty as initiating a drive with a private car.** Citizens are free to choose, and a change in mobility patterns will be achieved by providing a better offer (not by coercion)

5. **Automated driving is also a solution to the shortage of drivers** that is already hindering the development of public transport in many cities around Europe (UITP 2024).

6. **AVs are simply good news for the planet.** When integrated into the public transport system, they could take every citizen to their destination with fewer cars, drastically reducing carbon emissions and congestion in cities.

Furthermore, a substantive part of funds for innovative projects such as ULTIMO come from the European Commission, who is a strong believer in automated mobility and whose support is pivotal for making our green vision a reality.

In fact, cost-efficiency is another compelling argument pro-AVs: at the forefront of shared mobility services are the PTOs with a clear mandate: ensuring a high quality of service and the best safety of passengers and other road users, while optimizing their operational costs. Automation offers opportunities in these three areas by alleviating the strain on bus driver wages, which is often correlated with personnel shortages in many countries. This is particularly beneficial for costly social services such as Demand Responsive Transport (DRT), also known as paratransit. The resulting cost savings can then be redirected to areas underserved by public transport, enhancing service frequency and safety.

In short, when used as shared vehicles that are integrated into an effective public transport network or MaaS, automated vehicles can be a key solution to create healthier and more competitive and sustainable cities. They can make public transport more flexible, providing affordable services at places where it wasn't possible before. Thus, AVs can drastically reduce car ownership and regain essential urban space.

Within ULTIMO, we dare to see automated driving as a new opportunity and a fitting solution to create better mobility for all. For a future where roads and car parks are freed up and given back to the people.

## 4.2 Scenarios and Use Cases as Basis for the Development of an ULTIMO vision

The ULTIMO vision plays a key role in the paradigmatic, strategic and operational transformation of mobility systems. Wiek and Iwaniec (2014) state that "Envisioning how a desirable future might look is a long-standing effort in human evolution and social change. Utopian thought and visions provide direction for actions and behaviour; more so, they create identity and community. Accordingly, the discourse on sustainability and sustainable development has recognized that positive visions about our societies' future are an influential, if not indispensable, stimulus for change. Visioning is, thus, considered a key method in sustainability research and problem solving, for instance, in transformational sustainability science or in planning for urban sustainability."

The ULTIMO project develops a conceptual design for the integration of automated vehicles (AVs) - in this case automated minibuses (AM) - into a citizen-centric Mobility-as-a-Service (MaaS) system. AMs work as a mobility gap filler as they complement and extend the public transport system by a flexible and universally applicable modality and complement spatial and temporal gaps. Further, AMs can also be integrated into an Intelligent Transport System (ITS) using data based and AI technologies to improve the transport system as-a-whole.

As ULTIMO will operate in 3 international pilot sites with 23 partners involved from 8 countries and the project has a budget of with 55 million € financed by the European Union, Switzerland, and the partners, ULTIMO aims to set an **EU wide standard for AM in MaaS/ITS**.

### 4.2.1 Scenarios as Basis for a Future Ultimo Vision 2025

After the identification of future elements (Pillkahn 2008) (trends, constants, contradictions, uncertainties, new aspects, etc.), their positioning within a 'future radar', clustering, and evaluation, the most critical and contradictory future elements have been identified for the building of an 'appropriate' or beneficial future scenario model (here: MaaS integration vs. Governance model) for ULTIMO. Among all generated 'possible' future scenarios the most 'desirable' (not necessarily the most 'probable'!) one has been identified that is to be aimed for. For many good reasons discussed in previous chapters this 'desired future scenario - F2': 'AV in MaaS & Federated Stakeholder Governance' is the one that ULTIMO is aiming and where the ULTIMO concept wants to evolve and be successful. This desired future scenario could provide the most benefits and advantages for the citizens and all other stakeholders regarding all factettes of SUMP, PESTLE, and other categories, and thus this is the one where ULTIMO must develop its 'profile' and identifies a promising position for its AV in MaaS businesses, technologies, offerings, services etc. This is shown in Figure 27.

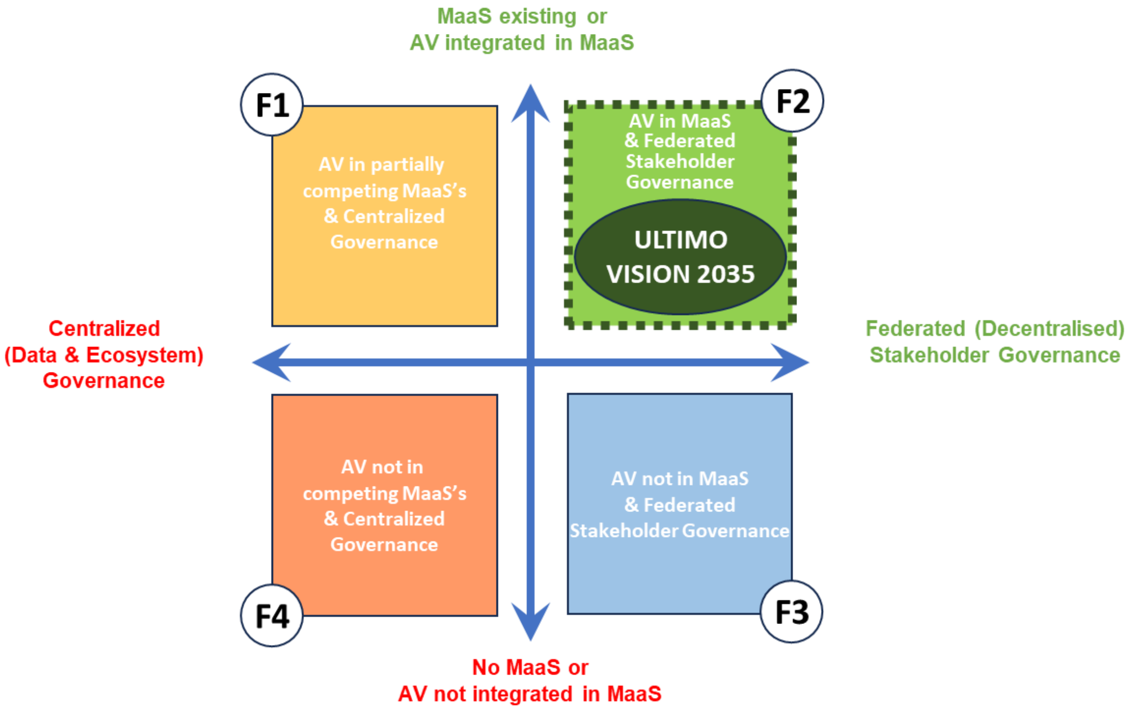


*Figure 27: ULTIMO Vision 2035 as a Future Positioning within the Desired Future Scenario*

Another point of view focuses the type and related usage (citizen behaviour) of 'Automated Vehicles' (AV), regarding multifaceted advantages and disadvantages and especially with respect to their integration into MaaS as 'AV in MaaS' which represents the 'desired future scenario F2'.

With this view we can identify the following three alternative use cases of AMs, which are existing in each of the four future scenarios, but with different character:

#### 4.2.1.1 Use Case 1: Privately owned AVs

Privately owned automated cars, deployed reflecting the traditional demand as a **continuum of the current paradigm** of individual mobility behaviour.

Advantages:

- Very convenient due to exclusive usage, highest degree of individuality & freedom

Disadvantages:

- Cost of individual mobility would be very high for the users and not affordable for most of the citizens.
- More vehicles on the road lead to higher traffic volume and congestion costs (externalities)
- Weakening public transport

#### 4.2.1.2 Use Case 2: AVs as robotaxis

Designed for **on-demand, door-to-door service**, these Avs vary in size, speed, and occupancy factors, tailored for both single rides and potential ridesharing. Generally **owned by private companies** with primary commercial and private interest, they could **compete with public transport when not integrated in a MaaS**.

Advantages:

- Robotaxis may achieve high user acceptance due to end-to-end transport comfort.
- Better individual mobility for affordable prices due to vehicle sharing for individual rides.

Disadvantages:

- Avoiding synergetic complementarity with other means of transport within a MaaS
- Competing with and weakening public transport
- Transport system as whole will be less efficient and sustainable due to high externalities (e.g. congestion costs, lower occupancy per ride)

#### 4.2.1.3 Use Case 3: Automated Minibuses in MaaS (1) / ITS (2)

Automated minibuses operate within a **smart public transport system** and can transport **up to 15 people with nearly door-to-door service**, **on-demand** offers and ride pooling. They are **connected to other private and public transportation modes to offer an individual seamless**

**journey.** The transport offers can be customized by factors such as price, time, comfort, $CO_2$ footprint, user preferences and profile, weather etc.

Advantages:

- An offer nearly as comfortable as a private car due to spatial and temporal flexibility
- Increase citizens' acceptance by improved offer (spatial and temporal flexibility to an affordable price, better availability, and reliability)
- Reducing external costs (air pollution, climate change, traffic congestion, etc.) through better use of resources and energy (efficiency), improving environmental footprint including space saving
- Improving the resilience in case of incidents or accidents of the transport systems, through AI and safety & security Technologies (e.g. blockchain)
- AM can enlarge accessibility including PRM and attractivity of mobility services.

Disadvantages:

- Reduced comfort through change of means of transport of a seamless individual journey.
- Reduced privacy, security and comfort for passengers when sharing a ride with other people without safety operator.
- Reduced privacy & security for user when sharing data with other stakeholders to serve the general interest.

## 4.3 Identification of Hypotheses and Vision Statements

The additional perspective of these three AV based Use Cases to the four future scenarios of the ULTIMO future scenario model in Figure 27 underlines that Automated Minibuses have the potential to enable, leverage, and accelerate a successful MaaS concept. These can be regarded as 'Hypotheses' for the derivation of 'ULTIMO future vision statements':

### 4.3.1 Hypotheses 1 - AV in MaaS is a Game Changer

<u>**Future Vision Statement – F2-1:**</u>

**The citizen is in the centre of the concept.**

The citizen can choose between different means of transport depending on costs, time, comfort, and environmental footprint of the seamless journey offer (see Figure 28)!

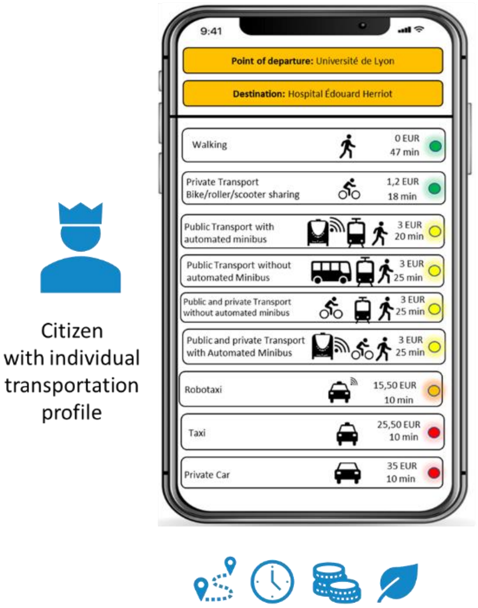


*Figure 28: The citizen is in the centre of the concept*

A typical Citizen use case for a journey can be describe using a journey planning software app as shown in Figure 28:

1. Enter ‘real’ Start and Destination (door-to-door) of your journey.
2. Choose between various transportation modes (public transportation, bikes, scooters etc.) and include presets according to your preferences (weather, time, PRM, etc.)
3. Combine your desired transportation modes.
4. Simulate time, distance, cost, and CO2 emissions of your ride.
5. Evaluate your seamless journey alternatives and choose the most convenient option (see app on the left)
6. Quick ride booking and digital payment of the seamless intermodal journey via one single ticketing app.
7. Learnings from the individual MaaS journey towards future individual AI based continuous mobility service improvements for better citizen satisfaction.

## 4.3.2 Why is AV in MaaS a Game Changer?

AV in MaaS is a game changer because AVs are complementing and fostering other means of transport, in particular mass transport. It provides temporal flexibility and spatial flexibility and does not compete with public transport Figure 29.

*Figure 29: The citizen is in the centre of the concept*

The benefits of the Citizen centric Transportation cycle (see Figure 29) are:

- The seamless and reliable combination of all means of transport of a MaaS with AVs enables **citizen-centric** approach, safer and a service which is **nearly as convenient and flexible as a private vehicle**.
- **AVs can be customized to the needs of different target groups**, including the elderly and people with disabilities.
- The combination of AVs with MaaS could lead to individual transport **(mobility service)** which is much **more affordable than private cars.**
- The use of AVs in MaaS can make public transportation nearly as **attractive** than in cities connecting citizen from **suburban and rural areas** with transport system of the city.
- AV in MaaS increases the **flexibility** as it fills two types of mobility gaps: **Temporal gaps** e.g. at 2am in the morning and **spatial gaps** when there are no trains.
- AVs in MaaS are simply **good news for the planet**. Citizens could travel with fewer privately owned cars, reducing carbon emissions, congestion, and space in cities.
- AVs in MaaS lead to a larger variety of transport offers incl. privately owned cars. This **benefit** changes the behavior of the citizens **without a coercive policy.**
- **Incidents and accidents of means of transport** can be managed easier when AVs bridge gaps in the transport system.
- PTOs could **optimize their operational costs** and at the same time ensure high quality of service (e.g. in underserved areas, Demand Responsive Transport (DRT)) and best safety of passengers and road users by **addressing personnel bus driver shortages**.

### 4.3.3 Hypotheses 2 - AV in ITS as a driver for system innovation of the transport system

**Future Vision Statement – F2-2:**

**AM integrated in ITS: AI as a driver for better performance and flexibility.**

Thanks to the Integration of **AM in MaaS**, a major optimization of the system is made. Additionally, the application of **AI** technologies and the continuous processing of data enables the development of the mobility system into a **self-optimizing intelligent transport system (ITS).**

- Continuous improvement of **efficiency and performance of vehicle and the transport system**
- Continuous improvement of flexibility **of the transport system**
- Continuous increase of **transport services and their availability, safety, and comfort**
- Continuous decrease of negative externalities on **environment**

**Future Vision Statement – F2-3:**

**(Data-) Acceptance is ensured by appropriate technologies and regulations.**

- Recorded data is only visible to those parties, who are **directly involved** within the programme to provide value for the stakeholders (citizen, TPO, OEM, City) of the mobility transport system to serve the general interest.
- Your **private data** are **secured** and will not be forwarded or sold to unauthorised third parties. (GDPR)
- We emphasize the importance of data collection as this allows a **beneficial implementation** of **continuous improvement** digital mobility service as precondition for the application of AI.
- **AI based technologies** behind AV in MaaS are strictly monitored and subject to conditions. The according data exchange is always **safe and secure** and is only provided to stakeholders with relevant interest to ensure maximum of privacy.

**Future Vision Statement – F2-4:**

**Data serve the general interest by federated governance and open data sharing**

The Data & Information Input of main Stakeholders of AV in MaaS and their Benefits are:

| | **Stakeholder** | **Data & Information Input** | **Resulting benefits** (through fast, medium, and slow closed loops) |
|---|---|---|---|
|  | **Citizens** | Mobility **preferences, needs** | Comprehensive mobility offers a best of citizen **satisfaction** |
|  | **MaaS service aggregator** | Mobility **preferences, needs, demand, and offerings Ticketing, journey data** | **Improvements** and adjustments of the Minibuses and services (e.g. Software and AI optimization) |
|  | **OEM's and third parties** | Data & Information from environment, **vehicle** and **incidents and accidents** of AVs | **Optimization of vehicles (safe and performant Automated Minibuses), vehicles services** |
|  | **Transport Operators** | Mobility demand, **incidents & accidents** of the transport system and Mobility needs **Vehicle capacity utilisation data** | Transport and infrastructure capacity and performance optimization (resource and energy), Development of safe, resilient (flexible) and citizen centric **mobility system** |
|  | **Public Transport Authorities & Cities** | Data about **Mobility needs,** Transport system **utilisation and performance & services and capacities; Traffic, infrastructure, environment** | **Optimization** of **transport ecosystem governance,** traffic regulations & **City and mobility infrastructure planning, positive for the planet** |

*Figure 30: Data & Information Input of main Stakeholders of AV in MaaS and their Benefits*

As displayed in Figure 30 all stakeholders **receive and share** data & information to improve the whole mobility system (efficiency, performance and flexibility, data security & privacy) to serve the general interest. **Added value** is provided by making a **win-win** situation by federated governance and open data sharing for all the stakeholders of the mobility ecosystem and avoid the "winner takes it all effect".

## 4.4 Formulation of an ULTIMO Vision 2023 and Conclusion

Summarizing the previous elaborations of the central Future Vision Statements and aggregating all their advantageous detailed implications identified in the previous chapter the ULTIMO Future Vision 2035 within the desired scenario F2: AV in MaaS and Federated Stakeholder Governance can be formulated in the following way:

**ULTIMO Vision 2035**

**With the successful implementation of the ULTIMO concept as an EU wide standard in 2035:**

**FV-1: The citizen is in the centre of the concept.**

**FV-2: AM is integrated in ITS with AI as a driver for better performance and flexibility.**

**FV-3: (Data-) Acceptance is ensured by appropriate technologies and regulations.**

**FV-4: Data serve the general interest by federated governance and open data sharing.**

This so designed ULTIMO Vision 2035 meets the general criteria of a future vision as:

- … a precise picture of a future reality, which is …
- … close enough to see ways of feasibility and to be …
- … far enough to create enthusiasm among the people.

As an extension of this vision the transportation and related services of (small) goods can also be integrated. In this sense the Scenario F2 can be extended to AV in MaaS and LaaS (Logistics-as-a-Service). All related aspects of the discussed concept have to be extended in a corresponding way to the topic of LaaS and its specific concepts, technologies, businesses, goals, strategies, etc. The extension of MaaS by LaaS requires furthermore a significant and challenging integration effort but provides attractive benefits for citizens and the entire mobility ecosystem.

As a conclusion of this promising vision design we are looking forward that a successful transformation towards sustainable and resilient mobility could be enabled by AV as game changer combined with an Intelligent Transport System avoiding coercive policy.

# 5 Development of promising future business strategies, models and cases for future intelligent citizen centric transport ecosystems

Intelligent and citizen-centric transport ecosystems are shaping the future of transportation. AS we move towards a more interconnected, sustainable and efficient transportation system, it is crucial to develop innovative business strategies and models that align with these goals. In this constantly evolving field, the need for forward-thinking transportation solution is of high significance. The development of future business strategies, models and cases for intelligent and citizen-centric transport ecosystems requires a comprehensive understanding of the evolving landscape of transportation. It is essential to delve into various such as technological advancements, changing consumer behaviours, regulatory frameworks and sustainability initiatives. In addition, the development of business within ITS involves considering various scenarios and potential challenges. This includes for example exploring different funding models, public-private partnerships, and innovative revenue streams that can support the sustainable growth of these ecosystems (see Chapter 4) while delivering tangible benefits to citizens. Furthermore, a multidisciplinary approach is required that encompasses technology, citizen-centric design, economic viability and environmental sustainability. By delving into these aspects, new opportunities can be unlocked that contribute to the advancement of future transportation systems.

## 5.1 Methodology for the definition of sustainable future business models for AV in MaaS/LaaS in ITS/CCAM

In the scope of ITS/CCAM the integration of Autonomous Vehicles (AVs) into Mobility as a Service (MaaS) and Logistics as a Service (LaaS) represents a pivotal intersection of technological innovation and sustainable urban development. However, defining sustainable future business models within this dynamic ecosystem demands a methodological approach that considers multifaceted factors, including economic viability, environmental impact, societal acceptance, and technological advancement.

The concept of Mobility as a Service (MaaS) represents a transformative approach aimed at fostering sustainable, intermodal, and flexible urban mobility systems. Highlighted in (Caballini et al. 2023) MaaS emerges as a crucial solution to address the challenges posed by urbanisation, societal shifts, congestion caused by private vehicles, and growing environmental concerns. By placing the needs of customers and users at the forefront, MaaS aims to integrate various transportation options seamlessly, offering not just transport but holistic mobility offers. (Sochor et al. 2018) underscore the multifaceted nature of MaaS, emphasizing its focus on customer-centric transport solutions, multimodal mobility offerings, and the integration of services, information, payment, and ticketing systems. However, the practical implementation of MaaS presents great challenges, particularly in balancing the differences between public and commercial services to create customisable mobility service packages. Balancing the need for flexible, commercially driven services with the integrity of publicly subsidised transport systems requires good navigation and coopetition among stakeholders to safeguard customer bases.

Innovating new business models within the MaaS paradigm requires a differentiated understanding of the dynamics within MaaS ecosystems, as articulated by (Hoveskog et al. 2022). MaaS integrators, operators, users, and facilitators each play distinct yet interrelated roles in shaping the functionality and viability of MaaS platforms. By tailoring solutions to individual preferences and behaviours, MaaS embodies a user-centric approach that seeks to optimise mobility experiences while addressing the complexities of data management, infrastructure, and stakeholder collaboration. Thus, unlocking the full potential of MaaS necessitates a collaborative effort among diverse actors, including transport service providers, IT companies and insurers, to provide sustainable and inclusive mobility. Within this scope the concept of Sustainable Business Model Innovation (SBMI) / Business Model Innovation (BMI) plays an important role. Sustainable Business Model Innovation (SBMI), as explained by (Geissdoerfer et al. 2018) focus on analysing and planning shifts to more sustainable business practices. This includes creating entirely new models or updating existing ones to reduce negative environmental and social impacts while ensuring long-term viability. SBMI aims to make positive environmental and social impacts by making strategic operational changes within a company. Built on a triple bottom line approach—considering economic, social, and environmental factors—SBMI aims to create value that extends beyond mere financial gains (Ferlito and Faraci 2022).

(Shakeel et al. 2020) contribute further to the discourse by highlighting the nature of BMI and sustainable business models (SBM), where SBMI is presented as a synthesis of both concepts. Drawing parallels between BMI's logic of value creation and sustainable value and innovation, SBMI represents a strategic alignment of environmental, social, and economic considerations within business models. This alignment necessitates not only changes on the triple bottom line (Ferlito and Faraci 2022) but also adaptations to address evolving stakeholder needs and environmental considerations, reflecting a holistic approach to business transformation.

The shortage of applicable business models is a significant obstacle to the realisation of 'real' Mobility as a Service (MaaS) commercial offerings. To address this challenge, (Krauss et al. 2022) propose a new conceptual framework integrating the Business Model Canvas with a morphological approach. This framework combines relevant factors into a single comprehensive tool, facilitating the development of MaaS business models. By generating morphological boxes for each of the nine building blocks of the Business Model Canvas (Osterwalder and Pigneur 2010) this framework assists operators in understanding MaaS features and provisioning from an operational perspective. Furthermore, digitalisation plays a pivotal role in supporting Sustainable Business Model (SBM) implementation, yielding positive effects for society and the planet. According to (Broccardo et al. 2023) digitalisation not only fosters operational optimisation but also aligns with the principles of SBM. This conclusion underscores the economic benefits of digitalisation, which tend to favour or enable operation optimisation, contributing to the advancement of sustainable practices.

However, one of the most anticipated benefits are competitive pricing and higher service quality. Through detailed data from user travel profiles and preferences that the PTO can use, a broader service offering and prices tailored to individual needs can be achieved (Arias-Molinares and García-Palomares 2020). This undertaking requires substantial development and provision of interoperable and integrated services, applying adjustments in business models to adapt to evolving regulatory frameworks and user preferences (Dahlen Silva 2021). Moreover, similar to AVs in MaaS is complementary to AVs in LaaS necessitating collaboration among stakeholders to address challenges related to regulatory compliance, infrastructure development, and customer acceptance. By leveraging data-driven insights and advanced analytics, stakeholders can derive innovative strategies to ensure the safe, efficient, and environmentally responsible deployment of AVs in logistics operations, ultimately contributing to the advancement of sustainable mobility solutions in the domain of ITS/CCAM.

## 5.2 Development process and framework for future business models for AV in MaaS/LaaS in ITS/CCAM for ULTIMO

In the pursuit of sustainable business models for Automated Vehicle (AV) services within Mobility as a Service (MaaS) or even broader, as in the context of Logistics as a Service (LaaS), a structured approach is essential. Such an approach integrates various dimensions ranging from socio-economic acceptance to operational feasibility, and environmental impact assessment. This subsection outlines the development process and framework tailored to address the multifaceted challenges and opportunities within the domain. The framework (Figure 31) comprises three distinct levels, each serving a specific purpose in the development of sustainable business models for AV services in MaaS/LaaS. Level 1, Foundational Analysis, establishes the contextual groundwork, while Level 2, Operational Viability Assessment, delves into the practical considerations of implementation. Finally, Level 3, Sustainable Business Model Synthesis, integrates insights from the preceding levels to conceptualize comprehensive business models.

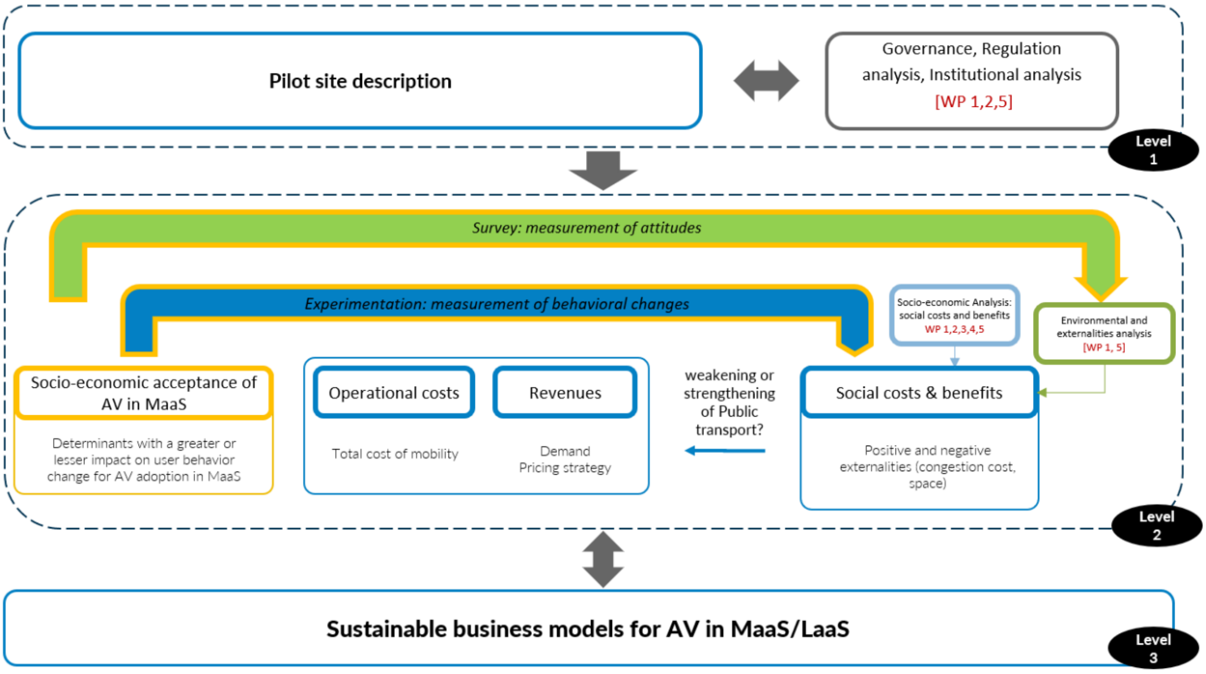


*Figure 31: Development process and framework for future business models for AV in MaaS/LaaS in ITS/CCAM for ULTIMO*

## 5.2.1 Level 1: Foundational Analysis

**Pilot Site Description and Governance, Regulation Analysis, Institutional Analysis**

At the apex of the illustration lies the foundational elements of pilot site description and governance, regulation, and institutional analysis. These aspects serve as the basis for the subsequent stages of model development, ensuring alignment with local context, regulatory frameworks, and institutional capacities.

## 5.2.2 Level 2: Operational Viability Assessment

**Socio-economic Acceptance of AV in MaaS**

The first level of the framework pertains to the socio-economic acceptance of AV in MaaS. This encompasses factors influencing user behaviour change and adoption patterns. Understanding determinants such as trust in technology, perceived benefits, and cultural norms is paramount. To assess these, both qualitative methods such as surveys for measuring attitudes and experimental studies for behavioural changes (of users) are imperative.

**Operational Costs and Revenues**

Moving to the middle level, operational costs and revenues emerge as pivotal considerations. The total cost of mobility, comprising infrastructure, maintenance, and operational expenses, must be evaluated. Simultaneously, revenue streams, driven by demand dynamics and pricing strategies, are subject to further investigation. Achieving a balance between cost-effectiveness and revenue generation is instrumental in fostering the financial sustainability of AV-MaaS/LaaS services.

Hereby, on-demand fleet size calculation, particularly in the context of AVs, plays a crucial role in optimizing various aspects of transportation systems. By analysing inputs such as demand patterns, waiting times, detour times, vehicle parameters (e.g., capacity, charging duration), ridesharing levels, and traffic conditions, on-demand modelling allows operators to make informed decisions that directly impact operational costs, external costs, social costs, and benefits (Figure 32).

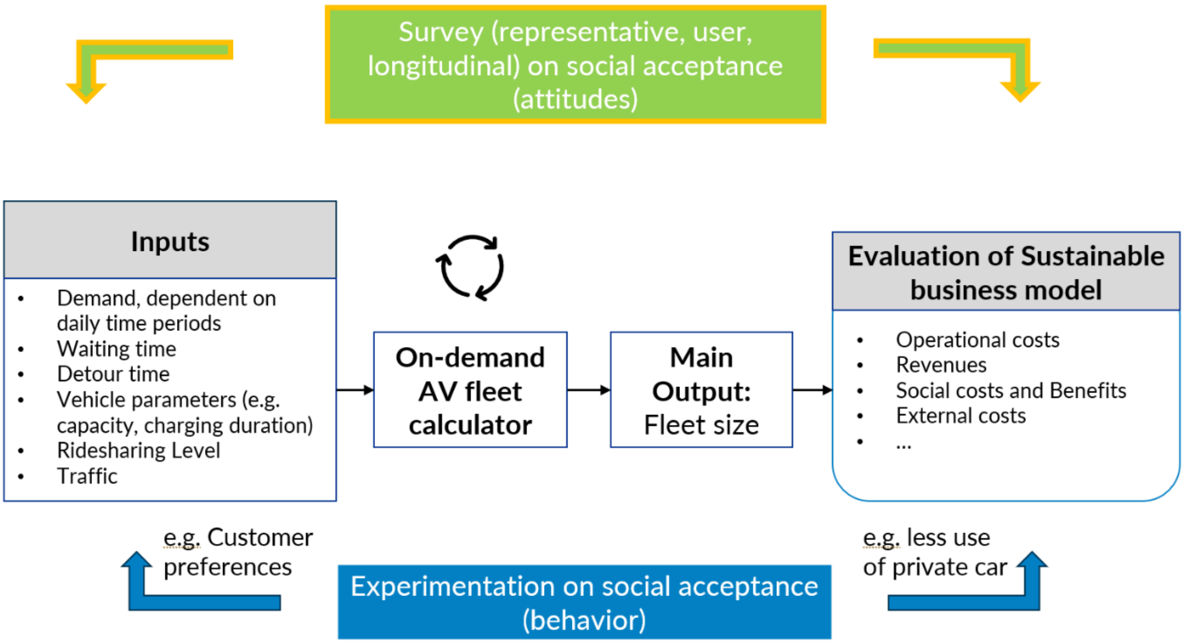


*Figure 32: General Framework for On-demand AV fleet size calculation and evaluation of sustainable business models*

Calculating the fleet size for autonomous vehicles plays a pivotal role in the planning and implementation of urban sharing systems utilizing this mode of transportation. It involves evaluating factors such as demand patterns, service coverage, and operational efficiency to determine the ideal number of vehicles needed to effectively meet user needs while minimizing operational costs and maximizing overall system performance. Researchers have put forth several methodologies and models to estimate fleet size for autonomous vehicles, with some approaches distinguishing between fixed line and door-to-door AV services for specific areas (Badia and Jenelius 2021), while others consider fleet sizing within a dynamic ridesharing framework (Fagnant and Kockelman 2018). Additionally, literature explores the integration of AV services, including feeder services designed to transfer customers between various points, such as mobility hubs or train stations (Sipetas et al. 2023; Badia and Jenelius 2021).

Furthermore, studies have examined the impacts of fleet size on various aspects, with research in Sioux Falls and Pittsburgh identifying critical penetration levels at which optimized fleets can improve system traffic flow and reduce costs (Battifarano and Qian 2023). Another simulative study in the greater Zurich region revealed a nonlinear relationship between served demand and required fleet size, indicating potential reductions in fleet size of up to 90% with acceptance of slightly longer waiting times (Boesch et al. 2016). However, operations of dynamic AV fleets may require strategies to optimise vehicle assignment based on demand, aiming to minimise travel distances and waiting times for customers (Hyland and Mahmassani 2018). Determining fleet size for autonomous vehicles in sharing systems is essential for ensuring efficient and cost-effective operations. Various methodologies and models have been proposed to estimate the optimal fleet size, considering factors such as demand patterns, with the aim of strategically reducing system costs, travel distances, and waiting times.

On-demand ridesharing modelling serves as analytical basis for determining the operational costs, revenues, social costs and benefits, and external costs associated with AV services. Through the analysis of various inputs such as demand patterns, waiting times, detour times, vehicle parameters, ridesharing levels, and traffic conditions, operators can derive insights into the economic and societal impacts of AV adoption. By accurately assessing these factors, stakeholders can make informed decisions regarding fleet size optimisation, revenue generation (and maximisation) strategies, and environmental considerations, ultimately contributing to the development of more efficient, sustainable, and socially beneficial AV transportation systems.

**Social Costs & Benefits**

Parallel to operational aspects, the social costs and benefits associated with AV deployment demand attention. These encompass both positive and negative externalities, including congestion costs and spatial implications. Undertaking socio-economic analysis to quantify these impacts facilitates informed decision-making. Additionally, environmental and externalities analysis, focusing on sustainability metrics and, aids in mitigating adverse effects and enhancing the overall societal advantages in urban mobility.

### 5.2.3 Level 3: Sustainable Business Model Synthesis

At the lowest level of the framework resides the culmination of efforts—the sustainable business model. Drawing insights from the preceding stages, this model embodies a holistic approach that balances economic viability with social and environmental considerations. It leverages innovative pricing mechanisms, technological advancements, and regulatory support to create value for stakeholders while minimizing negative repercussions. Notably, the framework underscores the iterative nature of model development, wherein feedback loops and continuous improvement are integral. As new data emerges and contexts evolve, the framework should enable adaptability, fostering the evolution of sustainable business models that are responsive to changing needs and requirements.

In conclusion, the proposed development process and framework offer a structured pathway for conceptualizing, refining, and operationalizing sustainable business models for AV services in MaaS/LaaS. By embracing a multi-dimensional approach encompassing socio-economic, operational, and environmental dimensions, stakeholders can navigate the complexities of the evolving area of urban mobility while advancing towards a more sustainable and inclusive public transport.

#### 5.2.3.1 Identification of business strategies as the basis for sustainable business models for ecosystems

As part of the overarching goal to develop promising future business strategies, models, and cases for intelligent citizen-centric transport ecosystems, the identification of specific strategies within Automated Vehicles (AVs) in Mobility-as-a-Service (MaaS) or Logistics-as-a-Service (LaaS) is crucial. These strategies form the cornerstone for crafting sustainable business models that not only optimize efficiency but also prioritize societal well-being and environmental sustainability within interconnected transportation networks. To effectively identify these business strategies, it is imperative to conduct a comprehensive analysis of the MaaS or LaaS ecosystem. This involves examining the network of stakeholders, including AV manufacturers, transportation service providers, technology firms, regulatory bodies, and end-users, to understand their roles, needs, and expectations. By gaining insights into the dynamics of these ecosystems, businesses can pinpoint opportunities for collaboration, innovation, and value creation. To further this endeavour, stakeholders must prioritise sustainability principles, which are paramount in shaping the future of AVs within MaaS or LaaS ecosystems. This entails integrating more eco-friendly practices and technologies into operational frameworks, such as investing in AV fleets and promoting ride-sharing initiatives to reduce congestion and emissions. Additionally, stakeholders can champion the adoption of smart charging infrastructure to minimise environmental impact and enhance operational efficiency.

Moreover, leveraging data and technology stands as a pivotal strategy in driving innovation within AV ecosystems. The vast array of real-time data generated by AVs presents unprecedented opportunities for optimisation, ranging from route planning to predictive maintenance. By harnessing advanced analytics and machine learning algorithms, stakeholders can unlock insights that enhance service reliability, reduce costs, and improve overall user experience. Collaboration emerges as another critical strategy for success in AV-enabled MaaS or LaaS ecosystems. Through strategic partnerships with government agencies, urban planners, infrastructure providers, and other industry stakeholders, stakeholders can co-create innovative solutions that address complex transportation challenges. By fostering collaborative efforts, stakeholders can contribute to the development of integrated transportation systems, seamless intermodal connectivity, and shared mobility platforms that benefit all stakeholders involved.

Furthermore, to maximise the societal benefits of AV-enabled MaaS or LaaS ecosystems, equitable access and affordability must be prioritised. This involves designing inclusive services that cater to diverse user needs, including those in underserved communities and vulnerable populations. Implementing transparent pricing models and subsidy programmes can help ensure that AV services remain accessible to all socio-economic groups. In addition to fostering equitable access, it is essential to address the integration of AV technology within existing urban infrastructures. This includes considerations such as vehicle-to-infrastructure communication systems and smart traffic management. By investing in infrastructure upgrades and incorporating AV technology seamlessly into urban planning, stakeholders could maximise the efficiency and effectiveness of AV-enabled transportation systems.

In conclusion, the development of sustainable business models for AV ecosystems requires a multifaceted approach that encompasses regulatory compliance, equitable access, resilience, and continuous innovation. By prioritising these key areas and adopting a collaborative approach with in MaaS and LaaS ecosystems, stakeholders can contribute to the creation of transportation ecosystems that are not only efficient and environmentally sustainable but also inclusive, resilient, and responsive to evolving societal needs.

### 5.2.3.2 Characterisation of operational costs, revenues and social costs and benefits for PTOs

In response to the evolving landscape of transportation, Public Transportation Operators (PTOs) are actively integrating Automated Vehicle (AV) services into their operations. This strategic shift necessitates a thorough examination of operational cost structures to ensure financial sustainability and maximize societal benefits. Our current focus lies in refining these cost structures, particularly in the context of AV services within PTOs, through a comprehensive and iterative approach (Figure 33).

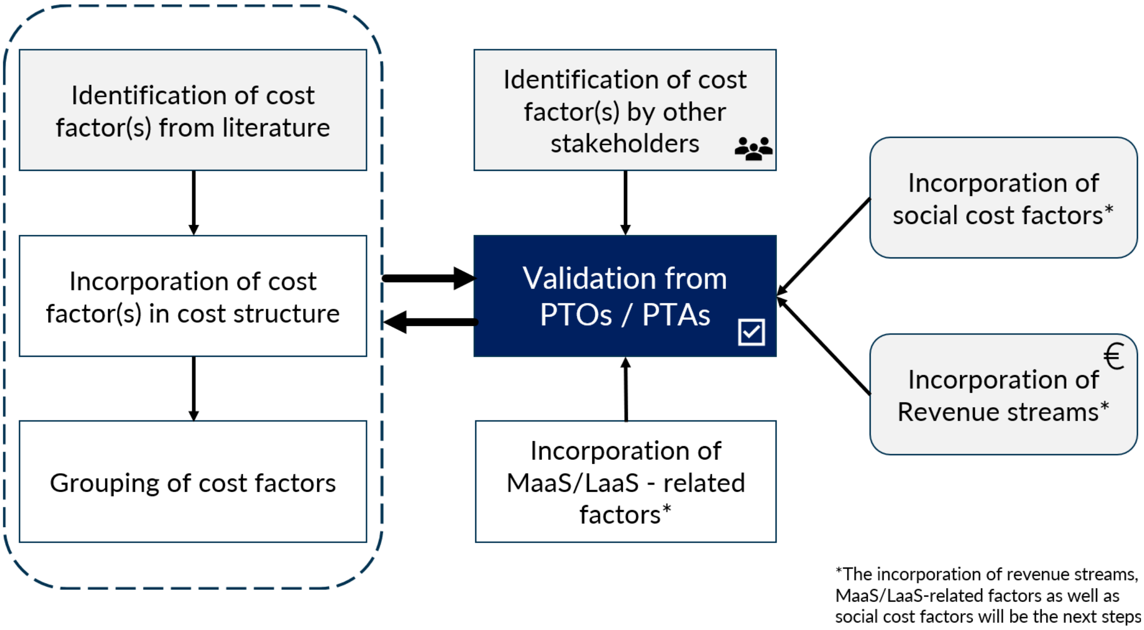


*Figure 33: Approach for characterisation of operational costs, revenues and social costs*

#### 5.2.3.2.1 Analysing Operational Costs

Our efforts begin with a detailed analysis of operational costs specific to AV services. While traditional transportation modes incur expenses related to maintenance, fuel, and labour, the introduction of AVs introduces new cost elements such as software components and data management. Through rigorous examination and collaboration with PTOs/PTAs, we aim to accurately capture and quantify these emerging costs, ensuring a comprehensive understanding of the financial implications associated with AV deployment. Table 2 presents the current cost structure for AV services.

*Table 2: Current AV Cost structure*

| | Cost Factor | Unit | Base |
|---|---|---|---|
| **1** | **General Operational Costs** | | |

| | | | |
|---|---|---|---|
| **1.1** | Telecom Fees | *No. of sim cards* | Vehicle |
| **1.2** | Insurance costs | € | Vehicle |
| **1.3** | Map Updates | *Estimated road changes per year and km (in ODD)* | No. of road changes per 100 km of road |
| **2** | **Personnel Costs** | | |
| **2.1** | Work Stations | € | No. Service Personnel |
| **2.2** | Customer Service | *No. Customer service interactions* | Vehicle |
| **2.3** | Vehicle Rescue | € | No. of Vehicle rescues |
| **2.4** | Organisational / Overhead costs | € | No. of people in the organisation |
| **3** | **Infrastructure Costs** | | |
| **3.1** | Service Centres | *No. of Service Centres* | Vehicle |
| **3.2** | Overnight Parking | € | Vehicle |
| **3.3** | Intermediate (Idle) Parking | € | Vehicle |
| **3.4** | Orchestration in ITS Platform | € | Vehicle |
| **3.5** | Power Consumption | *kWh* | Vehicle |
| **4** | **On-site Operations** | | |
| **4.1** | On-site Teams | € | No. of On-Site Teams |
| **4.2** | Off-board Supervisor (OBS) | € | No. of OBS |
| **4.3** | On-board Service Personnel (OSP) | € | No. of OSP |
| **5** | **Licenses and Maintenance** | | |
| **5.1** | SDS License Fee (Self-Driving System) | € | Vehicle |
| **5.2** | Refurbishment of SDS System | € | Vehicle |
| **5.3** | Interior Cleaning Facilities | € | Vehicle |
| **5.4** | Interior Cleaning | € | Vehicle |
| **5.5** | Exterior Cleaning Facilities | € | Vehicle |
| **5.6** | Exterior Cleaning | € | Vehicle |
| **5.7** | Service (Manual, Mechanic Repairs) | € | Vehicle Kilometres Travelled (VKT) |
| **6** | **Charging Facilities / Infrastructure** | | |
| **6.1** | High-capacity Pudo | € | No. of High Capacity Pudos |
| **6.2** | Special Needs Pudos | € | No. of Special needs Pudos |
| **6.3** | Road/Vehicle Fees | € | Vehicle |
| **6.4** | Charging facility costs | € | Vehicle |
| **6.5** | City ITS Integration Costs | € | Vehicle |
| **6.6** | City/County Integration Costs | € | Vehicle |
| **6.7** | Fleet Management System | € | Vehicle |

In addition to the current cost structure presented in Table 2, our analysis identifies further factors crucial for a comprehensive understanding of the operational costs associated with Autonomous Vehicle (AV) services. These additional factors extend beyond the traditional expenses encountered in conventional transportation modes, reflecting the complexities introduced by AV technology. By undertaking a thorough investigation of these supplementary elements and engaging in extensive consultations with Public Transportation Operators (PTOs) and Authorities (PTAs), our aim is to provide a comprehensive insight into the financial landscape surrounding the deployment of Autonomous Vehicles (AVs). Table 3 breaks down these extra cost factors, highlighting their importance and how they impact operational expenses.

*Table 3: Further cost factors (to be clarified)*

| **7** | **Further cost factors (to be clarified)** | **Remark** |
|---|---|---|
| **7.1** | In Vehicle Services | Costs associated with in-vehicle services tailored for Automated Vehicles. |
| **7.2** | Infotainment | Expenses related to providing entertainment and informational services within AVs. |
| **7.3** | Additional costs for AI | Additional expenditures for implementing and maintaining artificial intelligence in AV systems. |
| **7.4** | Data Platform Provider (Cost) | Costs incurred for utilising a data platform provider for managing AV data. |
| **7.5** | MaaS/LaaS Network Provider (Cost) | Expenses associated with utilising Mobility as a Service (MaaS) or Logistics as a Service (LaaS) network providers for AV operations. |
| **7.6** | Identity Provider (Authentication Service) | Costs for utilising an identity provider service for authentication purposes within AV systems. |
| **7.7** | API Provider (Interface Management) | Expenses related to utilising an API provider for managing interfaces and data exchange within AV systems. |
| **7.8** | Accessibility Services (Personnel-related) | Costs associated with providing personnel-related accessibility services within AV operations. |
| **7.9** | Marginal costs for Application Services | Additional costs incurred for specific application services integrated into AV operations. |

Alongside the analysis of operational costs, consideration of general service parameters is integral to understanding the dynamics of Autonomous Vehicle (AV) services (Table 4). These parameters encompass various aspects such as the size of the Operational Design Domain (ODD), demand levels, vehicle lifespan, and other key factors that shape the operational framework of AV services.  outlines the general service parameters essential for understanding the operational dynamics and service provision of Autonomous Vehicle (AV) services, providing insights into factors that influence AV deployment and operation.

Table 4: Particular general services parameters

| 8 | General Service Parameters | Unit | Remark |
|---|---|---|---|
| **8.1** | Size of ODD | $km^2$ | Area covered in the Operational Design Domain (ODD). |
| **8.2** | Demand | *No. of Passengers or Trips* | Number of passengers or trips requested in a given time period. |
| **8.3** | Lifetime of the Vehicle | *Years* | Operational lifespan of the Autonomous Vehicle (AV). |
| **8.4** | Vehicle Capacity | *No. of Passengers* | Maximum number of passengers that the AV can accommodate. |
| **8.5** | Vehicle Speed (Average) | *km/h* | Average speed at which the AV operates. |
| **8.6** | Occupancy rate | *%* | Percentage of time the AV is occupied by passengers. |
| **8.7** | Fleet Size (Free Float System) | *No. of Vehicles* | Number of vehicles available in a free float system. |
| **8.8** | Operation hours | *Hours* | Total hours of operation for the AV service. |
| **8.9** | Max. Waiting Time | *Minutes* | Maximum waiting time for passengers before an AV arrives. This parameter is expected to significantly influence the required fleet size to meet service level requirements. |

**Process of Grouping Cost Factors for Autonomous Vehicle (AV) Service Cost Simulation**

Before conducting the grouping process, we presented the detailed cost structure and general service parameters associated with Autonomous Vehicle (AV) services. Now, as a logical continuation of our analysis, we embark on the crucial step of grouping cost factors. This iterative process is undertaken to prepare for a subsequent cost simulation, which is intended to be conducted alongside the AV Service Cost Calculator. The process of grouping cost factors is an essential step in preparing for a comprehensive cost simulation aimed at enhancing the analysis and understanding of AV service costs. This iterative process serves as a precursor to conducting a cost simulation, which is intended to be carried out in conjunction with the AV Service Cost Calculator.

The primary objective of grouping cost factors is to establish a structured framework that facilitates the development of programming logic. By categorising and organising cost factors into logical groups, we create a foundation upon which programming objects can be defined. This structured approach enables us to analyse the relationships between different AV service costs in a more systematic and comprehensive manner. Furthermore, the grouping of cost factors allows for a more efficient and streamlined cost simulation process. By clustering related cost elements together, we can identify commonalities, dependencies, and interactions that may exist between various components of AV service costs. This, in turn, enables us to design and implement programming logic that accurately captures the complexities of cost dynamics within AV service operations (Figure 34).

In summary, the process of grouping cost factors serves as a crucial preparatory step towards conducting a robust cost simulation for AV services. By establishing a structured framework and defining programming objects based on grouped cost factors, we aim enhance our ability to analyse and understand the interdependencies of AV service costs in a systematic and comprehensive manner.


*Figure 34: Grouping of AV cost factors*

#### 5.2.3.2.2 Revenues

Innovative pricing strategies are critical to maximizing the revenue potential of AV services at public transit operators (PTOs). As the integration of AV technology changes traditional revenue models, our focus shifts to developing strategies that balance financial sustainability with accessibility and affordability for users. At the heart of our approach is the exploration of dynamic pricing mechanisms specifically tailored to AV services. By leveraging real-time data analytics, predictive modelling and demand forecasting, we aim to refine tariff structures and pricing tiers to adapt to fluctuating demand patterns, time-of-day variations and user preferences. This dynamic pricing should not only increase revenue potential, but also optimize resource allocation and service efficiency. In addition, we want to explore diversification strategies to expand revenue streams beyond traditional fare collection. Value-added services, subscription-based models and strategic alliances offer the opportunity to increase revenue while improving passenger convenience. By leveraging dynamic pricing mechanisms, diversifying revenue streams, and cultivating collaborative partnerships, it is aimed to explore revenue potentials while delivering value-centric mobility solutions tailored to meet the evolving needs of passengers and communities.

#### 5.2.3.2.3 Integrating Social Costs and Benefits

In parallel, it will be of importance to integrate social costs and benefits into our decision-making framework. The deployment of AV services brings about both positive and negative externalities, ranging from improved mobility and environmental sustainability to potential job displacement and equity concerns. Through rigorous analysis and stakeholder engagement, it is the objective to quantify and monetise these social impacts, enabling a more holistic assessment of the societal implications of AV deployment and informing strategic decision-making. It is therefore necessary to consider the implications for various stakeholders, including commuters, residents, businesses, and vulnerable populations. Assessing the positive externalities, such as increased accessibility, allows us to highlight the potential benefits of AV integration. Conversely, examining the negative externalities, such as potential job displacement and unequal access to AV services, can enable us to identify areas requiring mitigation strategies and policy interventions. By engaging with diverse stakeholders and conducting thorough analyses, strategies can be developed that maximise the benefits of AV deployment while addressing potential challenges and ensuring equitable outcomes for all members of society.

## 5.3 Next steps in ULTIMO

As the ULTIMO research project progresses, specific next steps are outlined to further refine our understanding and application of Automated Vehicle (AV) services within Mobility as a Service (MaaS) and Logistics as a Service (LaaS) frameworks.

- **Validation of Operational Cost Factors:** Engage in collaborative efforts with Public Transportation Operators (PTOs) and Public Transportation Authorities (PTAs) to validate and refine operational cost factors specific to AV services. Through rigorous data analysis and stakeholder consultation, ensure the accuracy and reliability of our cost estimation models. This iterative process will involve collecting data from multiple sources, including pilot projects and real-world AV deployments, to validate the assumptions underlying our cost calculations.

- **Selection of On-demand Modelling Software:** Evaluate and select On-demand Modelling software tailored to the unique requirements of AV services in Herford and Geneva. This selection process will involve thorough assessment of software capabilities, compatibility with existing infrastructure, and adaptability to local regulatory frameworks. Moreover, an extensive evaluation process will be undertaken to assess the compatibility of the selected software with the unique operational requirements and research goals of our project. This evaluation will involve close collaboration with software vendors and industry experts to ensure that the chosen solution aligns seamlessly with our objectives and enhances the accuracy and efficiency of our modelling efforts.

- **Further Development of AV Service Cost Calculator:** Continuously enhance and refine the AV service cost calculator to incorporate feedback from stakeholders and accommodate evolving operational dynamics. Ensure the tool remains a reliable resource for PTOs, PTAs, and other stakeholders to assess the financial feasibility of AV deployment. This may involve integrating new cost factors, refining cost estimation algorithms, and improving user interface and accessibility to facilitate widespread adoption and usability.

- **Finalisation of Sustainable Business Model Framework:** Synthesise insights from literature review and stakeholder input to finalise the sustainable business model framework for AV in MaaS/LaaS. This framework will provide actionable guidelines for stakeholders to navigate the economic, social, and environmental dimensions of AV deployment, fostering long-term sustainability and resilience in the mobility ecosystem. Key components of the framework will include revenue generation strategies, cost-sharing mechanisms, and considerations for equitable access and environmental impact mitigation.

# 6 Summary & Conclusion – Key Objectives 6 & 8

This deliverable is a comprehensive exploration of business plan development and partnership building within a smart CCAM ecosystem. ULTIMO aims to revolutionise sustainable, user- and citizen-centric mobility by integrating AVs into MaaS/LaaS for public transport and logistics. The deliverable details a journey from the current state of mobility systems to a futuristic, automated transport ecosystem and emphasises the critical role of collaboration, innovation and strategic planning in this transformation.

The main highlights are:

**Project overview:** The ULTIMO project focuses on creating scalable, economically viable models for large-scale deployment of AVs in public transport and logistics.

**On-demand mobility and fully automated vehicles:** The document emphasises the shift towards on-demand transport services and describes the benefits of fully automated vehicles in improving public transport systems, addressing challenges such as economic viability, scalability and user- and citizen-centricity.

**The ULTIMO dream for public transport:** The vision of a transformed mobility ecosystem with a robust fleet of automated minibuses that enable on-demand, door-to-door public transport services and seamlessly integrate with existing transport modes to provide a comprehensive, efficient urban mobility solution.

**Methodology and strategic approach:** Describes the multidimensional strategy (WP6) for the transition to an intelligent transport system, including the technical, socio-economic, environmental and governance dimensions. The methodology uses data from previous projects (such as AVENUE) and incorporates new analyses to design a future-oriented mobility ecosystem.

**Stakeholder impact and transformation approach:** Details the transformation plan for realising the vision, focusing on practical implementation strategies, stakeholder engagement and business model development for an integrated CCAM ecosystem. This section emphasises the importance of interoperability, security and citizen-centric services to achieve sustainable impact.

**Future Scenarios and Vision 2035:** Presents a long-term vision for automated transport and outlines scenarios for the integration of AVs into urban and rural mobility ecosystems. It emphasises the role of technology, governance and public-private partnerships in overcoming barriers to implementation.

Future scenarios and Vision 2035 will be further developed, analysed and described in detail until the end of the project and in the final deliverable. The transformation process towards this vision is presented in the associated deliverable D6.5 of task T6.3.

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