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SHared automation Operating models for Worldwide adoption

SHOW

Grant Agreement Number: 875530

D2.4: Final validated business/ operating models

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Executive Summary

The current Deliverable, D2.4, presents the final results of the validation of SHOW business/ operating models. SHOW brings together all key stakeholder across 13 EU states, with the vision to support the deployment of shared connected and electrified automation in urban transport chains through testing of real-life CCAV scenarios to promote seamless and safe sustainable mobility. Therefore, the validation of the business models within D2.4 relies heavily on the feedback of consortium partners that are interested in operating tested services long term.

A comprehensive methodology is then constructed, based on six steps, and breaking down each business/ operating model into several assumptions and goals, which are then assessed one by one. The assumptions are defined starting from the business canvas described in previous *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites* and reviewed in the present document. They are then consolidated and analyzed based on feedback of consortium partners. The goals of SHOW business models include: (1) to improve accessibility and community vitality, (2) to reduce costs compared to existing solutions, (3) to reduce the externalities of private cars, in terms of pollution, CO_2 emissions, congestion, etc. and (4) to develop and validate a more advanced technology, that enables to provide in turn a better quality of service.

A scoring model is established to calculate the performances of business/ operating models. It relies on the analysis of acceptance surveys, vehicle's data collected, simulation results and/ or production costs. It is further enhanced by interviews with pilot sites in SHOW to provide comprehensive analysis of these performances.

D2.4 applies this methodology on all SHOW business/ operating models, previously identified in *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites*. The validation yielded high scores, indicating that certain business models are particularly effective in achieving specific goals. It is also found that all demonstrated, piloted envisioned services were attractive, namely for people with reduced mobility and contributed during the project to the creation and development of a business ecosystem. Nevertheless, their (current) low speeds may hinder daily adoption. The willingness to pay analysis showed consistent values across users from various sites and countries for autonomous shuttles and robotaxis. The conditions of viability are also investigated based on a PESTEL analysis. The findings indicate that the viability is sensitive to the costs of vehicles and supervision, to the maturity of automation technology, and also to the political support and policy making.

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Abbreviation List

Abbreviation	Definition
B2B	Business-to-Business
B2C	Business-to-Customers
BM	Business Model
CAPEX	Capital Expenditures
C-ITS	Cooperative Intelligent Transport Systems
GHG	Greenhouse Gas
IoT	Internet of Things
KPI	Key Performance Indicator
LaaS	Logistics-as-a-Service
MaaS	Mobility-as-a-Service
OPEX	Operating Expenditures
PDI	Physical and Digital Infrastructure
PT	Public Transport
PTA	Public Transport Authority
PTO	Public Transport Operator
SME	Small and Medium Enterprises
UC	Use-case
WTP	Willingness to Pay

Glossary

This chapter lists and describes certain terms which are used in the course of this document and need to be explained for a better understanding.

Testing business models

Business models are built by considering, implicitly or explicitly, several assumptions. These assumptions can be identified through analyzing the business model canvas. For instance, consider a first/last-mile service that aims to be provided during peak-hours. One assumption is that users are mainly transit passengers. That assumption should be verified through testing. Testing business models corresponds then to this process of testing (through questionnaires, observations, data collection, etc.) given assumptions.

Validating business models

Testing business models measures their performances regarding all of their components: existence of partners, value for customers, availability of key resources, generation of revenues or reduction of costs, etc. The validation of the business model is obtained through validating the main assumptions regarding all these components.

Robustness of business models

The analysis of business model robustness should be approached as part of a business model design process [1]. The business models' robustness is defined by as "the business model's ability to fend off external threats from interactions with competitors and partners, and to cope with changes in the business environment including user requirements, regulatory regimes, target groups and scale of operation [2],

1 Introduction

1.1. Purpose and structure of the document

The SHOW project aims to explore sustainable business schemes that are cost efficient and modular; in accordance with the existing/planned infrastructure and fleets and each city/region as well as the relevant operational and legal framework. The previous documents:

- **D2.2: Proposed business / operating models and mapping to UCs and Pilot sites** builds eight business models which are directly linked to the mega and satellite test sites and their use cases and proposes two additional models, covering then different types of services within SHOW (e.g. PT, MaaS, LaaS and DRT) at the different pilot sites of SHOW.
- **D2.3: First version of validated business/operating models** proposed an validation methodology of SHOW business/operating models in terms of sensitivity and robustness through validating the main assumptions regarding their main components (e.g. value for customers, availability of key resources, generation of revenues or reduction of costs, etc.). The validation methodology is applied to fully evaluate three selected business/ operating models.

The so developed methodology is based on (1) the generation assumptions for different use cases, mobility services and business / operating models, (2) the identification of relevant key performance indicators (KPI), and (3) the construction of a scoring model that measures KPIs of tested business / operating models.

The current document, the so-called ***Deliverable 2.4: Final version of validated business/operating models***, aims to evaluate all business/ operating models within the project SHOW. Based on the results of D2.3, improvements of the pre-defined methodology are proposed and integrated. In addition, a PESTEL and willingness to pay analysis are performed to enrich the quantitative evaluation of business KPIs.

This document is structured as follows. In the next section (Section 2), the methodology is presented in detail. It relies on a literature review of previous works to build a six-steps based framework that enables to conduct a cross-pilots evaluation. This methodology framework is then applied on all SHOW business / operating models (Section 3). This includes a review of business model canvases, generation of assumptions, definition of KPIs, and the scoring of these models (Sections 3.1 to 3.6). Furthermore, the willingness to pay is assessed for each business model and across different sites. Finally, a PESTEL analysis, based on interviews conducted in the framework of each pilot site, is included.

1.2. Intended Audience

The deliverable will address the relevant project partners within the SHOW consortium regarding business and operating models covering development, evaluation/pilots, deployment and exploitation aspects during the whole duration.

Regarding external audience, the deliverable is interesting for those that are active in the business modelling field of CCAV, either with regard to the research/study part or the deployment part.

1.3. Interrelations

The internal interrelations of A2.3 are presented in **Error! Reference source not found.** and detailed below:

- WP1 – A1.1: SHOW Ecosystem

Providing important information such as the definition of the different stakeholder groups and which consortium partners are falling under which stakeholder category as well as their gaps, needs, wants and priorities for automated vehicles and mobility services (person and freight). It also describes the procedures and mechanisms that will be developed to accommodate user opinion discovery regarding SHOW services.
Important deliverables:
    - *D1.1: Ecosystem actors needs, wants & priorities & user experience exploration tools*

- WP1 – A1.2: SHOW Use cases
  The use cases of the different test sites contain information that are needed for test site specific customization of the cost assessment calculation (e.g. stakeholders and the relevant UC(s) for them or the different test sites and which UC(s) apply to them).
  Important deliverables:
    - *D1.2: SHOW Use cases*

- WP2 –business / operating models'
  The SHOW business / operating models are defined and described based on the methodology defined by A2.1: using business models canvas, value proposition canvas, success / failures factors analysis, etc.
  The identified business / operating models are tested and validated after their instantiation in SHOW test sites (Mega and Satellite).
  Important deliverables:
    - *D2.1: Benchmarking of existing business / operating models & best practices*
    - *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites*

- WP6 – A6.1: SHOW marketplace
  Data, sub-data of mobility services
  Important deliverables:
    - *D6.1: SHOW Marketplace and services – first version*
    - *D6.2: SHOW Marketplace and services – second version*
    - *D6.3: SHOW Marketplace and services – final version*

- WP9 – A9.4: Impact assessment framework, tools & KPIs definition
  Provides the final version of the KPIs needed for the validation of business models performances and success metrics. It also provides relevant information regarding the test sites and which are the final services they are planned for operation (revisiting and elaborating in reality in the previously defined Use Cases), which stakeholders and targeted end users they have.
  Important deliverables:
    - *D9.2: Pilot experimental plans, KPIs definition & impact assessment framework for pre-demo evaluation*
    - *D9.3: Pilot experimental plans, KPIs definition & impact assessment framework for final pilots round*

- WP10 – A10.1: Simulation framework for extension of SHOW test sites
  A complete meta-/co-simulation framework is defined which has been implemented to enhance field tests and experimental results relevant for the validation.
  Important deliverables:
    - *D10.1 Simulation scenarios and tools*

- WP10 - A10.2: Vehicle and traffic simulations
  Micro- and macro simulations have been conducted for selected shared CCAV services at pilot sites and towards the impact assessment of safety, energy and environmental changes for several mixed scenarios.

Important deliverables:

- *D10.1 Simulation scenarios and tools*
- *D10.2: Pilot guiding simulation results*
- *D10.3: Requirements for AV fleets operation simulation suite and first evidence on pilot results based simulations for impact assessment*
- *D10.4: Pilot results based simulations for impact assessment*

- WP10 - A10.3: Person, mobility, freight and environment related simulations
  This focuses on conducting simulations related to people, mobility, energy and environment. It also studies the user' behavior when automated features are present and shows the behavioral differences for vehicles of different automation level and conventional vehicles.
  Important deliverables:
  - *D10.1 Simulation scenarios and tools*
  - *D10.2: Pilot guiding simulation results*
  - *D10.3: Requirements for AV fleets operation simulation suite and first evidence on pilot results based simulations for impact assessment*
  - *D10.4: Pilot results based simulations for impact assessment*

- WP10 – A10.4: Combination of simulations
  Combines several types and scales of simulations with the focus on micro/macro level traffic and driving simulations and highlighting the safety level and the economic benefits of highly automated vehicle fleets.
  Important deliverables:
  - *D10.3: Requirements for AV fleets operation simulation suite and first evidence on pilot results based simulations for impact assessment*
  - *D10.5: AV fleets operation simulation suite*

- WP16 – A16.1: SHOW market analysis
  In this task the positioning of SHOW in the CCAV market is conducted. It provides important information for the business impact calculations, such as new cost structures.
  Important deliverables:
  - *D16.1: Market Study*

- WP16 – A16.2: Economic and business impact assessment
  Total-Cost-of-Ownership (TCO) and Cost Benefit Assessment (CBA) and Cost Effectiveness Assessment methodologies (CEA) have/will be applied for business models that are tested in *A2.3 - Business / operating Models application in Pilot sites and their validation*. Economic indicators will be used to (in)validate business models.
  Important deliverables:
  - *D16.2: First version of business and exploitation plans*
  - *D16.3: Final business and economic assessment and exploitation plans*

- WP16 – A16.3: Exploitation plans per partner and stakeholder groups
  The results from *A2.3 - Business / operating Models application in Pilot sites and their validation* will feed A16.3, which generates business exploitation models and strategies per cluster as well as roadmaps for large-scale deployment.
  Important deliverables:
  - *D16.3: Final business and economic assessment and exploitation plans*

- WP17 – A17.1: Best practices and application guidelines for different stakeholder groups
  This task has the aim to create application guidelines in form of an instruction manual for industries, PT authorities, PT operators, cities and regions. These guidelines will be built on the inputs from different SHOW WPs, among them the results coming from A2.3.
  Important deliverables:

- *D17.1: First issue of best practices and decision making mechanisms for different stakeholder groups*
- *D17.2: Best practices for implementation and application guidelines for Industry, Operators and Cities*

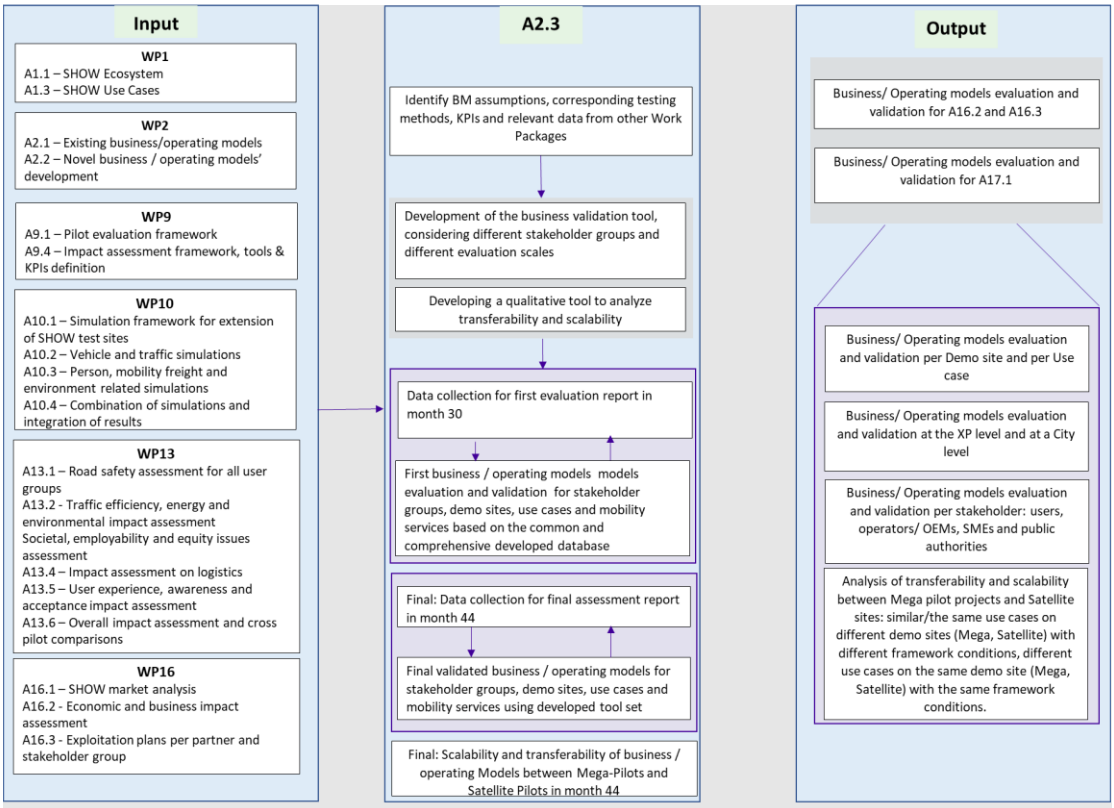

Figure 1 Description of interaction with SHOW WPs and Activity A2.3

2 Methodological approach

In previous deliverables *D1.2: SHOW Use cases* and *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites*, we have identified ten (10) business and operating models, eight of which planned in SHOW and two of them being novel. In D2.3, we then proposed a methodology to (in)validate these business models and applied it to three selected models. This validation is being achieved through the instantiation of business/ operating models in SHOW test sites.

In this section, we present the final version of the methodological approach, based on results of D2.3 and feedback from stakeholders of SHOW.

2.1. Related works

Business model validation domain has not been investigated sufficiently. Although there have been several research studies on business models, e.g., defining business model, taxonomy of business models, decomposing business models into its constituents, ontology, design tools [2]–[8]; the evaluation of business models, especially before they are introduced to the market, is still an area that has not been sufficiently investigated.

2.1.1. Evaluation and validation concepts

Three main contexts for the validation of business models could be discerned:

(a) The validation of a business model that has already been running for many years, with the goal to optimize its performance. This validation is mainly based on a data-driven analysis [9] but could also rely on a strategic management approach.
(b) The validation of a future business model, by considering long-term scenarios in order to analyse trends and uncertainties. This validation is performed through simulation-based approaches, in particular system dynamics models [10].
(c) The validation of emerging business models, that are under-experimentation in order to identify their strengths/ weaknesses and to facilitate their implementation in the market. This validation is based on a combination of the two previous approaches; analyzing data generated from pilot projects and exploring the impacts of deployment through simulation-based methods.

Within the SHOW project, we focus on the last case where business/ operating models are tested throughout large-scale field pilots.

2.1.1.1. Strategic management approach

Osterwalder and Pigneur [6] proposed to assess business models by considering two perspectives: firstly, providing a big picture assessment using the Business Model Canvas, and secondly breaking down the business model into “building blocks” and assessing each one of them through performing a SWOT analysis (i.e., analyzing Strengths, Weaknesses, Opportunities, and Threats).

A similar approach had been proposed by Haaker et al. [11] within the H2020 European Project ENviSION[1], where the components of the Business Model Canvas are analyzed regarding different assumptions that are reflecting the trends and uncertainties. These assumptions are derived from existing scenarios and evaluated through specific sessions with involved stakeholders. A heat map enables to visualize the impact of outcomes of uncertainties on the business model’s components and suggests ways to increase the robustness of the business model. This approach has, however, two main limitations. Firstly, it considers all assumptions without any prioritization. The heat map could then guide to improve or to ignore some

[1] https://cordis.europa.eu/project/id/645791

components of the business model that are not important or critical. Secondly, the validation is based only on internal sessions, without real testing, which is far from being reliable.

More recently, Bland and Osterwalder [12] proposed a new framework in order to reduce the risk and increase the likelihood of success for business projects. This framework builds on the popular Business Model Canvas and Value Proposition Canvas and integrates assumptions mapping and other lean startup-style experiments. In particular, three types of assumptions are generated based on Business Model Canvas and Value Proposition Canvas: desirability assumptions, feasibility assumptions and viability assumptions. Testing and experimenting are focusing then only on important and highest risks assumptions, for which the business will fail if they are false. Several testing approaches are proposed by Bland and Osterwalder [12] depending on the business typology (B2B vs B2C vs B2B2C, software vs hardware vs service). These include for instance customer interview, paper prototype, online ad, storyboard, learning cards, etc. The main advantage of this framework is its simplicity. Also, since it is based on popular methods (e.g., Business Model Canvas), it is then intuitive and applicable for different types of business models. It had been applied within the H2020 European Project R2PI[2] [13] and TRUSTS[3] [14]. Nevertheless, its very openness guides to a conceptual evaluation [15]. In addition, it is not clarified how the outcomes of this approach could be used to validate or invalidate the business model.

Lüdeke-Freund et al. [16] proposed another conceptual framework for sustainability-oriented business model assessment by combining the Business Model Canvas with the Sustainability Balanced Scorecard as a controlling tool [17]. In order to integrate sustainability indicators, their framework considered in addition to the model of [17] a non-market perspective and defined indicators based on the Global Reporting Initiative (GRI) standard [18].

2.1.1.2. Engineering approach

Other studies have focused on the measurement of business models success factors. Horsti [19] presented a validation tool for e-business models. He adopted the categorization of Hedman & Kalling's [20] framework as a basis, considering seven components that are causally related: customers, competitors, offering, activities and organization, resources, supply of factor and production input, and management scope. In a second step, he identified through a literature review 42 prerequisites of success and 15 measures of success. Each success factor gets a quantitative value, after having been prioritized and put in an order according to its importance. If a success factor is bigger than a pre-determined threshold value, then this business model is good regarding that specific success factor. The most important feature of this method is that the success factors are analyzed very deeply. However, he does not give weights to the values of success factors. The interrelations between success factors are ignored. Another weak point is that the validation is based on only one business model.

The framework of Wohltorf [21] "Scoring-Model for Success Evaluation of Ubiquitous Services" uses the same logic as Horsti's tool. Three domains are considered, to which the success factors can be allocated: user, competition, and technology. As for Horsti's tool, Wohltorf gives quantitative values to success factors, but also proposed weighting them according to their importance. If the overall value is bigger than a threshold, then the business model is successful. The main limitation of this framework is related to the domains considered for the evaluation (users, competition, and technology). Many components are ignored such as value proposition, profitability, and so on, which may be critical to some services. Wohltorf's Scoring Model seems to be appropriate to evaluating new services, rather than evaluating business models [15]. The classification of success factors according to the business models' goals is recommended especially for transportation projects [22].

[2] https://cordis.europa.eu/project/id/730378
[3] https://cordis.europa.eu/project/id/871481

Gordijn and Akkermans [23] base their validation of business models on e3-value ontology [24]: “a value model which shows actors who are exchanging things of economic value with each other”. The model focuses on the analysis of the allocation of costs, benefits and risks across actors in the ecosystem. The elements and relationships encompass the actor, value object, value port, value interface, value activity and value exchange of a business model [25]. Their criterion is financial feasibility of an e-business model, which means that all actors involved can make a profit or increase their economic utility. Sensitivity and financial risk analysis could be also performed through considering different scenarios with different market assumptions about occurrences of consumer needs, price of value objects, and investments per actor, to estimate revenues and expenses for the actors in the model. Unlike previous validation tools, Gordijn & Akkermans [23] focus on the profitability aspect and do not use success factors. Furthermore, since it is relying on what-if scenarios, it is difficult to find a generic scenario for all business models, which could be considered as a limit of this method.

2.1.2. Indicators for the evaluation and validation of BM

Due to the business model concept’s historical background, which is partly in the domain of strategic management, the validation of business models is closely related to economic oriented performances. Wirtz [8], for instance, proposed a financial business model framework, which considers as main assessment criteria the achievement of a promised value proposition, the degree of customer satisfaction, and profitability. The model of Osterwalder [6], [12] considered that the performance of a business model has to be expressed in terms of financial costs and revenues. The e3 model of Gordijn and Akkermans [23] is also centered on the profitability.

A few studies proposed to consider also non-monetary aspects, especially social and/ or ecological performances for the evaluation of business models [16], [26], [27]. The social and / or ecological performances should be adapted so they are relevant for the organization’s strategy and the definition of corresponding strategic objectives and performance drivers.

Other indicators to evaluate business models’ success are linked to concepts of viability and robustness [28].

A viable business model is essential for the success and the long-term survival of any project or service [31]. A business model becomes viable when all stakeholders can derive value from it, fostering their engagement and commitment [32]. The easiest way to do this is to assess the profitability of each stakeholder. Furthermore, for non-profit-driven stakeholders, their value capture is assessed qualitatively in terms of benefits generated [33, 23]. For a business model to be viable it also must be technologically viable [34]. A business model is technologically viable when an acceptable technological solution enables the provision of the envisioned service. In conclusion, a business model is viable when it is viable in terms of value and technology.

Robustness is defined by Bouwman et al. [1] as “the ability to cope with changes in the business environment”, by Casadesus-Masanell and Ricart [2] as “the business model’s ability to fend off external threats from interactions with competitors and partners”, by Snihur and Zott [29] as “the business model’s ability to provide a high familiarity to users and partners, while being sufficiently novel as a protection against imitation” and by [11] as ‘the long-term viability and feasibility of a BM in a given future environment”. Overall, the scarce literature on business model robustness has not converged towards a common understanding and has not yet yielded a comprehensive perspective for designing robust business models.

2.1.3. Summary and proposed approach

As a summary, two types of approaches are proposed in the existing literature for the validation of business models:

1) **A strategic management approach**: relying on breaking down the business model into its components and performing a validation of assumptions according to each component. This approach is holistic, conceptual and does not propose a clear and deterministic method to validate or invalidate business models.
2) **An engineering approach**: aiming at proposing a scoring model to measure performance indicators and using success factors to validate or invalidate business models. These indicators are mainly considered as economic in previous studies. This approach is more adapted to analyze a specific business model, and less transferable and generalizable.

In the SHOW project, we propose to combine these two approaches. Our objective is to assess ten distinct business / operating models. Thus, a generic approach should be developed, which is replicable from business model to another, and which enables in addition a cross-pilots and cross-business models' validation. On the other hand, each SHOW business/ operating model has specific strategies and goals (e.g. economic viability, reducing congestion, supporting business ecosystem development, etc.). Our methodology proposes then to formulate the success factors through performance indicators while considering the specific goals of each business model.

This methodology, developed exclusively within the SHOW project, combines management and engineering approaches. It is applied in report D2.4 to all SHOW business and operating models, providing well-informed recommendations to support the successful development and deployment of these models.

2.2. Framework for SHOW business models' validation methodology

The SHOW business models' validation methodology is combining existing approaches based on management methods (Business Model Canvas, Assumptions prioritization, etc.) and engineering methods (Scoring models, KPIs measurement).

It is structured into six steps, which are the following:

- **Step 1:** Describe business / operating models and mapping with test sites/ use cases
- **Step 2:** Identify goals and critical assumption of each business/ operating model
- **Step 3:** Identify KPIs in order to assess defined assumptions, by considering corresponding goals
- **Step 4:** Design of testing and data collection, and formulate the KPIs
- **Step 5:** Measure the KPIs
- **Step 6:** Analyze results and formulate the recommendations and improvement actions.

In parallel to these steps:

- A *scoring model* is developed to measure KPIs by using data coming from different sources (vehicles, surveys, etc.).
- A series of *interviews* with stakeholders is conducted to support and complement the validation procedure.

These steps are visualized in **Error! Reference source not found.**.

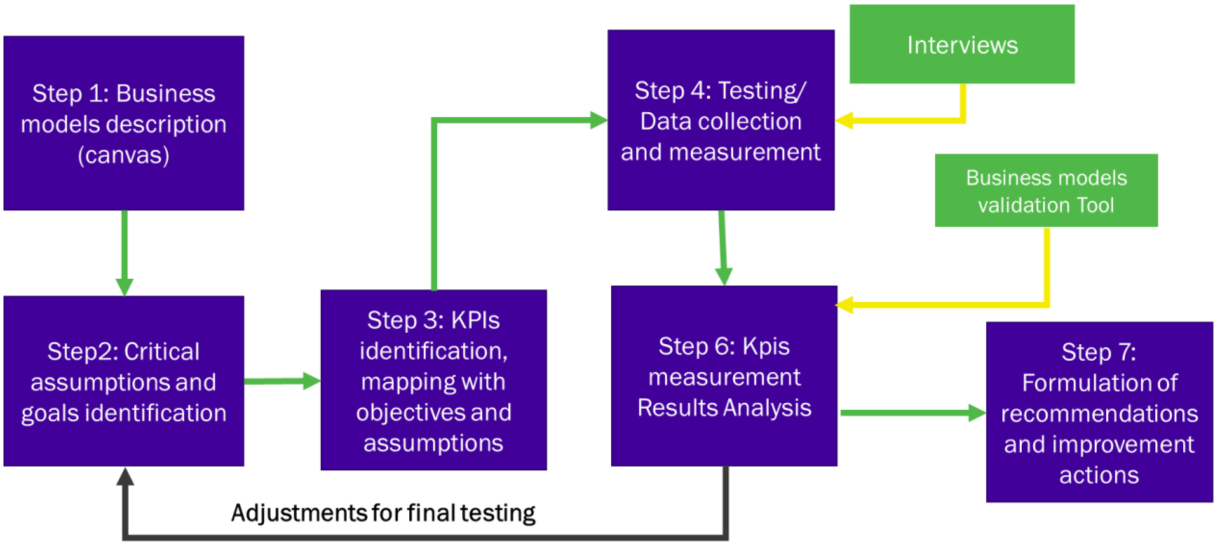

Figure 2 Steps for business/ operating models' validation

In the following, steps are described in more detail.

Step 1: Describe business models and mapping with pilot sites

Business models' validation requires a structured and coherent description of the business model and a relevant and representative collection of key success and failure factors. This description had been performed in *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites*, where ten (10) business / operating models had been identified. Error! Reference source not found. shows the template used to describe and mapping them with pilot sites.

1. Autonomous PT in combination with additional on-demand services
2. Autonomous Bus Depots
3. Advanced MaaS in urban environments
4. Combined MaaS and LaaS
5. Peri-urban automated transportation and C-ITS connectivity
6. Robotaxi services for short distance trips
7. Sustainable living areas with autonomous public transportation
8. First/Last mile autonomous transportation to mobility HUBs
9. Integrated automated and electric shuttle busses for large scale events
10. Interoperable IoT platforms for automated mobility

Mapping BMs with pilot sites

USE CASE Nº: ________
SITE ________
PARTNER ________
RESPONSIBLE ________

Pilot Site Name of pilot site

	Service Description	Selection	Deviation from Main Description
1. Autonomous PT in combination with additional on-demand services		☐	
2. Autonomous Bus Depots		☐	
3. Advanced MaaS in urban environments		☐	
4. Combined MaaS and LaaS (for the hospital campus)		☐	
5. Peri-urban automated transportation and C-ITS connectivity		☐	
6. Robotaxi services for short distance trips		☐	
7. Sustainable living areas with autonomous public transportation		☐	
8. First/Last mile autonomous transportation to mobility HUBs		☐	
9. Integrated automated and electric shuttle busses for large scale events		☐	
10. Interoperable IoT platforms for automated mobility		☐	

Figure 3 Mapping Business Models with Pilot Sites

Furthermore, based on discussions with pilots, the business model canvas was adjusted to cover better the particularities of all of them.

Step 2: Identify goals and critical assumption of each business/ operating model

So far, business and operating models have been built on a set of assumptions or hypotheses. It is through testing and validating these assumptions, whether fully or partially, that the business project begins to take shape and become a reality.

In order to identify assumptions to be tested/ validated, it is essential to first generate all potential assumptions and then determine which ones are critical to the viability of the business model.

Generation of assumptions

An assumption is defined as a hypothesis "that the value proposition, business model, or strategy builds on and what it is needed to learn about to understand if your business idea might work" [12]. A well-formed business assumption describes a testable, precise, and discrete object that is investigated. For instance, one assumption related to customer satisfaction could be that "the business model is focused on pains that really matter to customers" or that "the segments that are targeted exist and are big enough".

The generation of assumptions is a challenging and complex task since they are in general made implicitly by the service/product provider or manager. A first challenge is then to make the implicit mental models explicit in order to understand the structure and its potential behavior.

Several techniques to reveal the assumptions exist and are effective such as the 5-whys and a fishbone diagram [30]. Assumptions can also be derived from existing situations (similar operating services) or from brainstorming sessions with involved stakeholders. Frameworks like PESTLE can be used to assure that multiple perspectives are covered. Bland and Osterwalder [12] propose to start from the main building blocks of the business model canvas to generate assumptions block by block: customer and market, market growing strategies, channels, competition, partners' capabilities, investment, etc. Adopting these "conventional" approaches ensures that assumptions are tailored to the use case at hand, but does pose the risk of bias as people tend to select the assumptions they are already familiar with. An alternative approach is to generate assumptions based on previous/ similar experiences and/ or best practices [13], [14]. While collected developments are less tailored, blind spots can be avoided.

Considering these two approaches, the generation of assumptions in SHOW is performed in following steps. Error! Reference source not found. describes the steps in more detail.

1) Firstly, the business model canvas and value proposition canvas as proposed by *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites* will be a starting point to identify main assumptions. In addition, the interviews that had been conducted by D2.2 with main pilot sites touch on indirectly several assumptions that could be revealed when describing the business model, its proposition value, success keys, failure risks, etc. The outcome of this analysis will be an objective and non-exhaustive list of assumptions.
2) Secondly, additional assumptions could be identified by SHOW partners based on their previous experience or/and best practices.

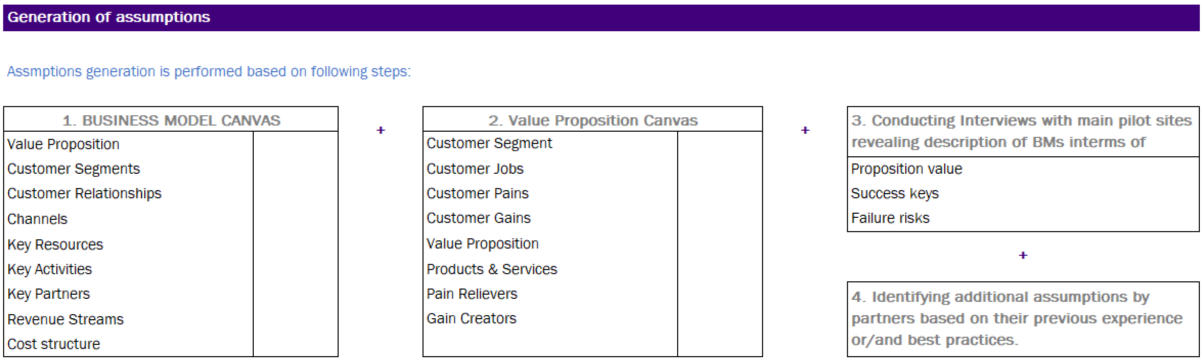

Figure 4 Procedure to generate assumptions

Mapping assumptions with objectives of business/ operating models

Upon analyzing the business / operating models identified for SHOW business operating models, it is observed that they could be classified into four specific goal areas:

Goal 1: Accessibility, Equity and community vitality – Ensures that all people can access to their destination using safe, healthy, convenient, and affordable transportation choices. Supports communities, enhances quality of life, and improves accessibility of residents who live in the vicinity of the service.

Goal 2: Economic and business ecosystem development – Proposes more cost-effective solution for passengers and service providers as well. Involves new players, including OEMs, ITS providers, SMEs, associations, and local authorities, and allows creating collaborations that support their respective development and growth.

Goal 3: Environment, congestion and modal share– Improves sustainability through saving more space and reduction of noise, of emissions of greenhouse gases and pollutants, and of energy consumption. Improves also the travel time reliability, which is affected by uncertainties caused by the congestion, reduces the traffic flows and contributes to the modal shift to shared and sustainable mobility solutions.

Goal 4: Technology and associated quality of service (service quality, efficiency, productivity, safety)– Proves the technical feasibility of the service and tests its reliability. Enhances the safety of mobility services' users by providing for the safe movement of people and goods and reducing injuries and fatalities. Provides passengers a service allowing to reach in an efficient, rapid, and comfortable way to their destination. Ensures better vehicles' utilization through providing higher supplied traffic (e.g. seat-kilometers), better quality of service (e.g. higher speeds, higher frequencies, lower delays, etc.) and then attracting more passengers.

Depending on each business/ operating model's specifications, the weighting metrics of these goals should be established (**Error! Reference source not found.**). One method to estimate these weightings is to consider them proportional to the number of assumptions generated for each goal. This straightforward approach is applied in this document. The initial estimations are then consolidated and validated through interviews conducted with representatives from the pilot sites.

Calculation - For Each Assumption of the Buisness Model determine the Goals, their Weight and its applicability				
For each assumptions, score the relative goals:	Typology - Defined weigth of goals by Pilots	Weight of Goals	Applicability of goal for assumption	Score of each assumption
Goal 1: Accessibility and Equity		-	☐	-
Goal 2: Service quality		-	☐	-
Goal 3: Community vitality and Local priorities		-	☐	-
Goal 4: Economic		-	☐	-
Goal 5: Congestion and Modal share		-	☐	-
Goal 6: Safety and security		-	☐	-
Goal 7: Environment		-	☐	-
Goal 8: Business ecosystem and Development		-	☐	-
Goal 9: Technology		-	☐	-
Goal 10: Efficiency and productivity		-	☐	-

Legend: Low, Medium, High

Figure 5 Procedure to determine goals, their weights, and its applicability for assumptions

Step 3: Identify KPIs, mapping with objectives and assumptions

KPIs are used to measure the achievement of business objectives for given deployment assumptions. Tracking irrelevant KPIs will distract us from focusing on what truly matters. Thus, it is required to determine for each business model which are the performance metrics that need to be measured in priority according to its objectives and to identified assumptions **(Figure 6)**.

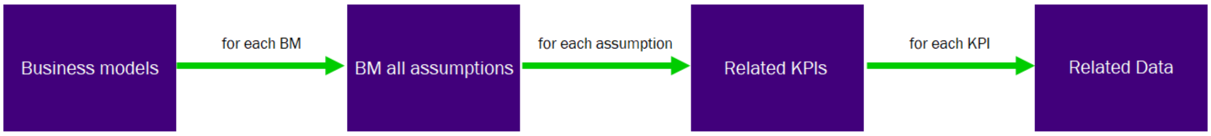

Figure 6: Procedure for KPI identification

Figure 7The data needed for calculating the KPI is then identified (**Figure 7**). The test pilots determine whether data collection is feasible, which in turn indicates whether the assumption can be evaluated or not.

KPIs identification, Data required and Feasibility

For each BM

Assumptions/Hypothesis	KPI	Data	Type of Hypothesis		Feasibility (Yes or no)
			Qualitative	Quantitative	
Assumption 1	-	-	-	-	-
Assumption 2	-	-	-	-	-
Assumption 3	-	-	-	-	-
Assumption 4	-	-	-	-	-
Assumption 5	-	-	-	-	-
.	-	-	-	-	-
.	-	-	-	-	-

Figure 7 KPIs identification, data required and feasibility

Step 4: Design of testing methods and data collection

Methods of testing are designed to test the business models in terms of desirability, viability and/or operational feasibility. Different testing methods are used in SHOW project. They include performing:

- Expert Surveys
- Acceptance surveys (a priori and during)

- Static and dynamic data collection: Vehicle data, Traffic Efficiency Data, Infrastructure Data, Passenger Data, Logistics Data, Trip Itinerary Data, Environment Data and Energy Data
- Economic and socioeconomic analysis: Cost-Benefit Analysis, Total Cost Ownership Analysis, Cost Efficiency Analysis
- Simulation: Microscopic simulation, Agent-based simulation
- Project Success KPIs

These methods could be defined based on main aspects as proposed by [12], such as the cost, the energy and the time that are required for testing a specific assumption. In addition, data required to validate business / operating models is collected by other SHOW WPs. Close coordination is essential to ensure that all necessary data is included in the collection process. The measurement of KPIs is also a collaborative effort with other WPs. In particular:

- The importance of goals, the challenges and maturity levels of the demonstrated and envisioned service are established based on interviews with site leaders by WP2,
- The willingness to pay, the willingness to share and the sensitivity to the quality of service are calculated based on the survey by WP2,
- The performances of vehicles and proposed services are compiled by using dynamic collected data by WP5,
- The performance indicators for future and upscaled services are measured by WP10,
- The environmental indicators are provided by WP13,
- The economic indicators are estimated by WP16.

Step 5: Measure the KPIs

The business/ operating models are scored in order to (in)validate their robustness and provide a cross-validation. The scoring model utilizes static and dynamic test data, surveys, qualitative responses of test leaders, and forecasted data to evaluate the business/ operating model.

In particular, each assumption is evaluated through at least one KPI. This KPI could be:

- **Qualitative:** in that case it is scored 0 or 1 depending on if it is validated or not. For instance, a qualitative KPI could be the “Existence of common user application providing real time information on service state” or the “involvement of new OEMs in the pilot”.
- **Quantitative:** in that case, it is scored based on data collected. The raw value is compared to that of other existing alternatives. In order to obtain the score on a scale from 0 to 1, each value is divided by the highest value among alternatives’ values.

The score of the assumption is then calculated as the mean of all KPIs scores. In a second step, the business/ operating model’s goals are scored by grouping all assumptions that contribute to each goal.

Step 6: Analyze results and formulate recommendations and improvement actions

The results will be analyzed by evaluating the performance of each business or operating model in relation to its specific goals and contributing to a discussion on its performances compared to other business/ operating models.

The analysis of the results of business models is further enriched with a PESTEL analysis and the measurement of users’ willingness to pay.

To conduct the PESTEL analysis, a series of interviews were held with various stakeholders involved in the SHOW project. The willingness to pay was assessed through questionnaires targeted at users, specifically within the a priori acceptance survey conducted as part of *WP1 - Ecosystem Views & SHOW UCs.*

After consolidating and discussing the results, the final step is to define actionable conclusions. Recommendations are typically made on how to improve weak business models or improve consistency across its components.

The analysis of future situations could rely on simulation, with defining the best- and worst-case scenario of the business model's development and evaluate the impact on KPIs and success indexes. This step should be performed together with WP16 to ensure that all results for business and economic impact fits together.

3 Application on SHOW business models and first results

3.1. Business models description

Business models are identified and described in the previous document *D2.2: Proposed business / operating models and mapping to UCs and Pilot sites*. It explored sustainable business schemes and services that are cost efficient and modular; in accordance with the existing/planned infrastructure in SHOW and fleets and each city/region as well as the relevant operational and legal framework. As a result, eight business/ operating models have been developed. Additionally, two more business models not derived from SHOW pilots have been identified: *BM9 – Integrated automated and electric shuttle busses for large scale events* and *BM10 – Interoperable IoT platforms for automated mobility.*

In this section, the business models' canvasses are reviewed based on the current pilots tested and/ or ongoing within the SHOW project.

3.1.1. BM1 – Autonomous PT in combination with additional on-demand services

The business model canvas is displayed in Table 1.

Table 1 Business model - Autonomous PT in combination with on-demand services

BUSINESS MODEL CANVAS – BM1	
Value Proposition	• On demand automated Mobility as a complement of Public Transport of underserved areas • CCAM contributing minimisation of ICE vehicles use in the city and the development of multimodal mobility that will lead to healthier, safer, more affordable, more sustainable, more cost-effective and responsive transport
Customer Segments	• Commuters • Visitors • Students
Customer Relationships	• Onboard supervisors • Local news • Local events (pilots and workshops) • Campus information • Booking application • Fleet management
Key Resources	• Automated vehicles and PT vehicles • Personnel (for supervision, onboarding, etc.) • Traffic management control and remote control • Digital map • Road infrastructure and stations
Key Activities	• Providing mobility service • Raising the acceptance • Showcase the performances of the technology • Demonstrate the interconnection with other existing PT modes • Marketing and sales • Infrastructure setup and maintenance including own vehicles • Enhancement of provided services

BUSINESS MODEL CANVAS – BM1	
	• R&D on new mobility solutions
Key Partners	• PTO, PTA • University/ Research • Vehicle manufacturer • Software Companies • Engineering companies
Revenue Streams	• Cost savings in the long term • Subsidies • Sale of tickets in the long term.
Cost structure	• Costs for purchasing vehicles, developing the remote control center, equipping the infrastructure • Personnel costs (training, onboarding, etc.) • Data management

3.1.2. BM2 – Autonomous bus depot

Carabanchel's depot business model is focused on optimizing operations and reducing costs and the space needed thanks to introducing automation of bus circulation within the depot, requiring less qualified personnel to manage depot operations and reducing operation times for routineer depot activities like parking, cleaning, charging, etc.

The business model canvas is displayed in Table 2.

Table 2 Business model - Autonomous bus depots

BUSINESS MODEL CANVAS – BM2	
Value Proposition	• Automated bus depots • Less time consuming • Cost savings • Space saving • Safety increase
Customer Segments	• Public Transport Operators • Public Transport Authorities • Cities/ Municipalities
Customer Relationships	• Licensing • Public-Private Partnerships
Key Resources	• Usage of „old“ fleet that is upgraded for autonomous vehicle functions • Private Public Partnership to build upon
Key Activities	• Testing an Automated Bus Depot as a mean to optimize management and increase efficiency • Marketing and sales • Real-time monitoring of network status • Management of operational hazards/incidents • Sending instructions to vehicles • R&D on new mobility solutions
Key Partners	• OEM's and transport operators • Telecom operators, technology providers • University/ Research • Authorities (Municipalities)

BUSINESS MODEL CANVAS – BM2	
Revenue Streams	• OPEX savings
Cost structure	• Costs for purchasing vehicles, equipping the infrastructure • Personnel costs (training, etc.)

3.1.3. BM3 – Advanced MaaS in urban environments

The aim of the MaaS and autonomous solutions is to offer several new mobility options at different locations, which can act as a substitute for private owned cars and reduce emissions and the volume of traffic within the city.

The business model's canvas is presented in Table 3.

Table 3 Business model - Advanced MaaS in urban environments

BUSINESS MODEL CANVAS – BM3	
Value Proposition	• Improving end-to-end transport service through providing driverless transportation • Optimizing the ride with AVs as much as possible in regards to speed, comfort and safety
Customer Segments	• Passenger transport for population ranging from urban areas to rural areas (Commuting, Business, Leisure) • PT users with additional mobility needs
Customer Relationships	• Onboard supervisors • Local news • Local events (pilots and workshops) • Booking application
Key Resources	• Vehicles • Supervision center with fleet control room, smart infrastructure and secure telecommunications networks • Infrastructure for parking/hand-over, charging • Digital map • Mobility application
Key Activities	• Infrastructure setup and maintenance including own vehicles • Supervision center & fleet control • Enhancement of provided services and future services such as of intelligent communication infrastructure & ITS • Marketing and sales • Real-time monitoring of network status • Management of operational hazards/incidents • Sending instructions to drivers/vehicles • R&D on new mobility solutions
Key Partners	• PTA • OEM's and transport operators • PT control center • Insurance companies • University/ Research
Revenue Streams	• Subsidies • In long term, ticketing

BUSINESS MODEL CANVAS – BM3	
	◦ Subscription (annually, monthly) ◦ Pay per use (ticket, SMS ticket) • Marginal revenue from advertising
Cost structure	• Costs for purchasing vehicles, developing the remote-control center, equipping the infrastructure • Personnel costs (training, onboarding, etc.) • Data management

3.1.4. BM4 – Combined MaaS and LaaS

The aim of this business model is to provide innovative services and vehicle concepts, combining passenger and cargo transport, as a first and last mile solution to the existing public transport with automated shuttles

The business model canvas is displayed in Table 4.

Table 4 Business model - Combined MaaS and LaaS

BUSINESS MODEL CANVAS – BM4	
Value Proposition	• Transportation of small goods in the shuttle together with passenger transportation • Integration of CCAM to minimize individual car use
Customer Segments	• Commuters • Residents • Visitors/ tourists • Students • Retailers • Distributors
Customer Relationships	• Onboard supervisors • Local news • Local events (pilots and workshops) • PT or on-demand service applications • Delivery app and shuttle app • Freight marketplace
Key Resources	• Automated shuttles with integrated cargo services • Transport Box • Personnel (for supervision, onboarding, etc.) • Traffic management control and remote control • Digital map • Road infrastructure • Stops and stations
Key Activities	• Providing mobility and delivery services • Showcasing the potential of innovative vehicle concepts • Raising acceptance and optimizing of passenger experience in services combining passenger and cargo transport • Enhancing safety of VRUs • Marketing and sales • Real-time monitoring of network status • Management of operational hazards/incidents • Sending instructions to drivers/vehicles • R&D on new mobility solutions

BUSINESS MODEL CANVAS – BM4	
Key Partners	• PTO, PTA • University/ Research • Vehicle manufacturer • Software Companies • Engineering companies
Revenue Streams	• Cost savings in the long term • Subsidies • Ticketing in the long term.
Cost structure	• Development of modular vehicles • C-ITS infrastructure • Booking app • Personnel costs (training, onboarding, etc.) • Data management

3.1.5. BM5 – Peri-urban automated transportation and C-ITS connectivity

This business model is focusing on strengthening the public transport into peri-urban areas, and to improve the connection of the peri-urban environment with the urban area supported by C-ITS services and thus increased road safety.

Table 5 Business model - Peri-urban automated transportation and C-ITS connectivity

BUSINESS MODEL CANVAS – BM5	
Value Proposition	• Complement of public transport in a peri-urban area • Improving the quality of public transportation by providing an additional mobility solution in peri-urban area to support the existing public transport with automated shuttles • Increase road safety

Customer Segments	• In peri-urban areas:
	  ◦ Commuters
	  ◦ Residents
	  ◦ Visitors/ tourists
	  ◦ Students
	• PT users with additional mobility needs

Customer Relationships	• Onboard supervisors • Local news • Local events (pilots and workshops) • PT or on-demand service applications
Key Resources	• Automated vehicles and PT vehicles • Personnel (for supervision, onboarding, etc.) • Traffic management control and remote control • HD map • C-ITS infrastructure and stations • R&D on new mobility solutions
Key Activities	• Testing an automated passenger transport service on the first-/last-mile • Raising the acceptance • Showcase the performances of the technology • Infrastructure setup and maintenance including own vehicles

BUSINESS MODEL CANVAS – BM5	
	• Enhancement of provided services and future services such as of intelligent communication infrastructure & ITS • Marketing and sales • Real-time monitoring of network status • Management of operational hazards/incidents • Sending instructions to drivers/vehicles
Key Partners	• PTO, PTA • University/ Research • Vehicle manufacturer • Software Companies • Engineering companies
Revenue Streams	• Cost savings in the long term • Subsidies • Sale of tickets in the long term.
Cost structure	• Vehicles, remote-control center, investment in infrastructure • Personnel costs (training, onboarding, etc.) • Data management

3.1.6. BM6 – Robotaxi services for short distance trips

The specificity of this business model is that it is based on automated taxis (robo-taxis), that are serving short distance first/ last-mile trips, especially into areas which are underserved by the existing public transportation.

Table 6 Business model - Robotaxi services for short distance trips

BUSINESS MODEL CANVAS – BM6	
Value Proposition	• Flexible, fast connection into the area • Robotaxi service • CCAM contributing to minimisation of individual car use in the city • Smooth connection with public transportation: integration at train stations and bus terminals, automated curb management for efficient use of bus bays
Customer Segments	• Children and elderly people • Commuters • Residents • Visitors/ tourists • Students
Customer Relationships	• Onboard supervisors • Local news • Local events (pilots and workshops) • Booking application
Key Resources	• Automated vehicles • Personnel (for supervision, onboarding, etc.) • Digital maps • Remote control/ fleet management • *C-ITS infrastructure (provisional)*
Key Activities	• Providing mobility service using robotaxis • Raising the acceptance

BUSINESS MODEL CANVAS – BM6	
	• Enhancing safety of passenger VRUs • Showcase the performances of the technology • Demonstrate the interconnection with other existing public transportation modes • R&D on new mobility solutions
Key Partners	• University/ Research • Vehicle manufacturer • Software Companies • Engineering companies
Revenue Streams	• Cost savings in the long term due to economy of scale and density (supervision for several vehicles, more attractiveness and less empty trips, etc.) • Usage fares in the long term.
Cost structure	• Vehicles, C-ITS infrastructure • Booking app • Remote supervision • Depot and charging facilities • Personnel costs (training, onboarding, etc.) • Data management

3.1.7. BM7 – Sustainable living areas with autonomous public transportation

The business model canvas is displayed in Table 7Table 1.

Table 7 Business model - Sustainable living areas with autonomous public transportation

BUSINESS MODEL CANVAS – BM 7	
Value Proposition	• Offer automated PT for future, car-free urban living space • Improve the user experience, especially for residents living in restricted areas and for elderly people and children • Door to Door perspective, services for "special" needs: blind, limited mobility
Customer Segments	• Children and elderly people • Commuters • Students
Customer Relationships	• Onboard supervisors • Local news • Booking application • Local events (pilots and workshops)
Key Resources	• Automated vehicles • Parking and charging facilities • Digital maps • Personnel (for supervision, onboarding, etc.) • Traffic management control and remote control • C-ITS infrastructure
Key Activities	• Providing mobility • Raising the acceptance • Showcase the performances of the technology • Demonstrate the interconnection with other existing public transportation modes

BUSINESS MODEL CANVAS – BM 7	
	• Marketing and sales • Infrastructure setup and maintenance including own vehicles • Enhancement of provided services • R&D on new mobility solutions
Key Partners	• PTO, PTA • University/ Research • Vehicle manufacturer • Shared mobility companies (e.g. car and bike rentals) • Software Companies • Engineering companies • Real-estate companies
Revenue Streams	• Cost savings in the long term • Subsidies • Sale of tickets in the long term. • Value increase in land
Cost structure	• Costs for purchasing vehicles, developing the remote-control center, equipping the infrastructure • Personnel costs (training, onboarding, etc.) • Data management

3.1.8. BM8 – First/Last mile autonomous transportation to mobility hubs

The business model is focused on first/last mile automated transport from/to mobility hubs, such as the commuting train and metro train station, to reduce individual traffic, parking spaces and emissions in the area.

The business model canvas is displayed in Table 8.

Table 8 Business model - First/Last mile autonomous transportation to mobility hubs

BUSINESS MODEL CANVAS – BM8	
Value Proposition	• Provide a free service connected to public transport hubs • Improving the quality of public transportation by providing a first and last mile solution integrated into the existing public transport with automated shuttles
Customer Segments	• Commuters • Residents • Visitors/ tourists • Students
Customer Relationships	• Onboard supervisors, • Local news, • Booking application • Local events (pilots and workshops)
Key Resources	• Automated vehicles • Digital map • Personnel (for supervision, onboarding, etc.) • Remote-control center • C-ITS infrastructure

BUSINESS MODEL CANVAS – BM8	
Key Activities	• Providing mobility • Raising the acceptance • Showcase the performances of the technology • Demonstrate the interconnection with other existing public transportation modes • Marketing and sales • Infrastructure setup and maintenance including own vehicles • Enhancement of provided services • R&D on new mobility solutions
Key Partners	• PTO, PTA • University/ Research • Vehicle manufacturer • Software Companies • Engineering companies
Revenue Streams	• Cost savings in the long term • Subsidies • Sale of tickets in the long term.
Cost structure	• Cost of vehicles, the remote-control center, C-ITS infrastructure • Personnel costs (training, onboarding, etc.) • Booking app • Data management

3.1.9. BM9 – Integrated automated and electric shuttle buses for large scale events

The BM9, as defined into *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites*, is not tested into the SHOW project. Consequently, the following canvas is not reviewed and corresponds to Table 17 of D2.2.

The business model canvas is displayed in Table 9Table 1.

Table 9 Business model - Integrated automated and electric shuttle busses for large scale events

BUSINESS MODEL CANVAS – BM9	
Value Proposition	• Bringing autonomous public transportation onto the market • Cooperation between large scale events and the automotive industry
Customer Segments	• Visitors/ tourists
Customer Relationships	• Large Scale events • Onboard supervisors, • Local news, • Booking application
Key Resources	• Automated vehicles • Digital map • Personnel (for supervision, onboarding, etc.) • Remote-control center • C-ITS infrastructure

BUSINESS MODEL CANVAS – BM9	
Key Activities	• Get in touch with the automotive sector • Identify feasible large-scale events in Europe • Apply as a sponsor/ partner • Providing the service • Raising the acceptance • Showcase the performances of the technology • Demonstrate the interconnection with other existing public transportation modes
Key Partners	• PTO, PTA • University/ Research • Vehicle manufacturer • Software Companies • Engineering companies
Revenue Streams	• Marketing • Ticketing
Cost structure	• Cost of vehicles, the remote-control center, C-ITS infrastructure • Sponsoring • Personnel costs (training, onboarding, etc.) • Data management

3.1.6. BM10 – Interoperable IoT platforms for automated mobility

Interoperable automated driving platforms are needed for any go-to-market strategy linked with automated driving and all its complex sensor hardware. Given the many actors involved in automated driving it becomes clear, that it is necessary to integrate as many different IoT platforms and sensors as possible.

The business model canvas is displayed in Table 10.

Table 10 Business model - Interoperable IoT platforms for automated mobility

BUSINESS MODEL CANVAS – BM10	
Value Proposition	• Connecting automated vehicles to the traffic management control • Expanding the field of view and finally ODD of the vehicle by combining in-vehicle sensors and additional perception provided by infrastructure (road-side units, traffic lights, smart devices, infra cameras, etc.) • Increasing traffic safety • Supporting the decision making of the automated vehicle
Customer Segments	• Automotive industry • PTO and PTA • PDI service providers • IoT platform holders/ providers • Cloud-edge solutions providers • Traffic managers
Customer Relationships	• Partnerships between interoperability platform providers and vehicle manufacturers/ public authorities

BUSINESS MODEL CANVAS – BM10	
Key Resources	• Automated vehicles • IoT compatible platforms • Interoperability platform • ITS providers • Personnel (for supervision, onboarding, etc.) • Telco companies • Traffic management control and remote control • Strong projects • Pilotss
Key Activities	• Get in touch with the automotive sector • Build and connect different kinds of platforms • Identify feasible • Build demonstrators
Key Partners	• Automotive • Non-profit organizations • Public Transportation • ITS provider • Infrastructure providers • Telcos • SME/ start ups
Revenue Streams	• Marketing • Tickets • Platform service • Data in general
Cost structure	• Technological costs • Implementation • Maintenance

3.2. Mapping business/ operating models with test sites

The mapping of SHOW business/ operating models with test sites has been performed based on discussions with pilot sites. In particular, they have indicated for their large-scale field trials which are the closest business/ operating models and described - when it is relevant - the deviation from the original description of chosen business/ operating models.

3.2.1. Mega sites

3.2.1.1. The Monheim Mega Pilot

Corresponding business / operating models:

- BM3 – Advanced MaaS in urban environments
- BM7 – Sustainable living areas with autonomous public transportation

Closest business / operating models: BM3 – Advanced MaaS in urban environments

Deviation from the original description: No deviation

3.2.1.2. The Frankfurt Mega Pilot

Corresponding business / operating models:

- BM1 – Autonomous PT in combination with additional on-demand services
- BM8 – First/Last mile autonomous transportation to mobility hubs

Closest business / operating models: BM1 – Autonomous PT in combination with additional on-demand services

Deviation from the original description: No deviation

3.2.1.3. The Karlsruhe Mega Pilot

Corresponding business / operating models:

- BM4 – Combined MaaS and LaaS
- BM5 – Peri-urban automated transportation and C-ITS connectivity
- BM8 – First/Last mile autonomous transportation to mobility hubs

Closest business / operating models: BM8 – First/Last mile autonomous transportation to mobility hubs

Deviation from the original description: No deviation

3.2.1.4. The Madrid Mega Pilot

Corresponding business / operating models:

- BM2 - Autonomous Bus Depots

Closest business / operating models: BM2 - Autonomous Bus Depots

Deviation from the original description: No deviation

3.2.1.5. The Les Mureaux & Escrennes Mega Pilot

Corresponding business / operating models:

- BM1 – Autonomous PT in combination with additional on-demand services
- BM8 – First/Last mile autonomous transportation to mobility hubs

Closest business / operating models:

- BM8 – First/Last mile autonomous transportation to mobility hubs

Deviation from the original description: No deviation

3.2.1.6. The Crest Val de Drome Mega Pilot

Corresponding business / operating models:

- BM1 – Autonomous PT in combination with additional on-demand services
- BM4 – Combined MaaS and LaaS
- BM7 – Sustainable living areas with autonomous public transportation

Closest business / operating models: BM4 – Combined MaaS and LaaS

Deviation from the original description: No deviation

3.2.1.7. The Linkoping Mega Pilot

Corresponding business / operating models:

- BM1 - Autonomous PT in combination with additional on-demand services
- BM7 - Sustainable living areas with autonomous public transportation
- BM8 - First/Last mile autonomous transportation to mobility hubs

Closest business / operating models: BM7 - Sustainable living areas with autonomous public transportation

Deviation from the original description: No deviation

3.2.1.8. The Gothenburg Mega Pilot

Corresponding business / operating models:

- BM7 - Sustainable living areas with autonomous public transportation
- BM8 - First/Last mile autonomous transportation to mobility hubs
- BM10 - Interoperable IoT platforms for automated mobility

Closest business / operating models: BM8 - First/Last mile autonomous transportation to mobility hubs

Deviation from the original description: No deviation

3.2.1.9. The Salzburg Mega Pilot

Corresponding business / operating models:

- BM5 - Peri-urban automated transportation and C-ITS connectivity
- BM8 - First/Last mile autonomous transportation to mobility hubs

Closest business / operating models: BM5 - Peri-urban automated transportation and C-ITS connectivity

Deviation from the original description: No deviation

3.2.1.10. The Graz Mega Pilot

Corresponding business / operating models:

- BM6 - Robotaxi services for short distance trips
- BM10 - Interoperable IoT platforms for automated mobility

Closest business / operating models: BM6 - Robotaxi services for short-distance trips

Deviation from the original description: No deviation

3.2.1.11. The Carinthia Mega Pilot

Corresponding business / operating models:

- BM1: Autonomous PT in combination with additional on-demand services
- BM4 - Combined MaaS and LaaS
- BM8 - First/Last mile autonomous transportation to mobility hubs
- BM10 - Interoperable IoT platforms for automated mobility

Closest business / operating models:

- BM4 - Combined MaaS and LaaS

Deviation from the original description:

- BM4 - Combined MaaS and LaaS

MaaS and LaaS provided with the same automated vehicle.

- BM8 - First/Last mile autonomous transportation to mobility HUBs

In Klagenfurt the train station is connected with the university, a business/science park, residential area, recreation area and shops/restaurants. In Pörtschach the train station is connected with the lake, hotels, shops, restaurants and the town center.

3.2.2. Satellite sites

3.2.2.1. The Brno Satellite Pilot

Corresponding business / operating models:

- BM1: Autonomous PT in combination with additional on-demand services
- BM6: Robotaxi services for short distance trips
- BM8: First/Last mile autonomous transportation to mobility HUBs

Closest business / operating models: BM1: Autonomous PT in combination with additional on-demand services

Deviation from the original description: No deviation

3.2.2. The Tampere Satellite Pilot

Corresponding business / operating models:

- BM7 - Sustainable living areas with autonomous public transportation
- BM8 - First/Last mile autonomous transportation to mobility hubs
- BM10 - Interoperable IoT platforms for automated mobility

Closest business / operating models: BM8 - First/Last mile autonomous transportation to mobility hubs

Deviation from the original description: No deviation

3.2.3; The Brainport Satellite Pilot

Corresponding business / operating models:

- BM10 - Interoperable IoT platforms for automated mobility

Closest business / operating models: BM10 - Interoperable IoT platforms for automated mobility

Deviation from the original description: No deviation

3.2.4. The Turin Satellite Pilot

Corresponding business / operating models:

- BM1: Autonomous PT in combination with additional on-demand services
- BM10 - Interoperable IoT platforms for automated mobility

Closest business / operating models: BM1: Autonomous PT in combination with additional on-demand services

Deviation from the original description: No deviation

3.2.5. The Trikala Satellite Pilot

Corresponding business / operating models:

- BM1: Autonomous PT in combination with additional on-demand services
- BM3: Advanced MaaS in urban environments
- BM6: Robotaxi services for short distance trips

Closest business / operating models: BM1: Autonomous PT in combination with additional on-demand services

Deviation from the original description: No deviation

3.2.3. Summary

For each SHOW test site, at least one business / operating model is identified. To give an overview of all business / operating models developed within SHOW and beyond, Figure 8 shows the mapping between test sites and business / operating models. The business/ operating model which is best corresponding to each site is marked in green color. We note that all business/ operating models are tested in at least one test site, except the *Business Model 9: Integrated automated and electric shuttle buses for large scale event.*

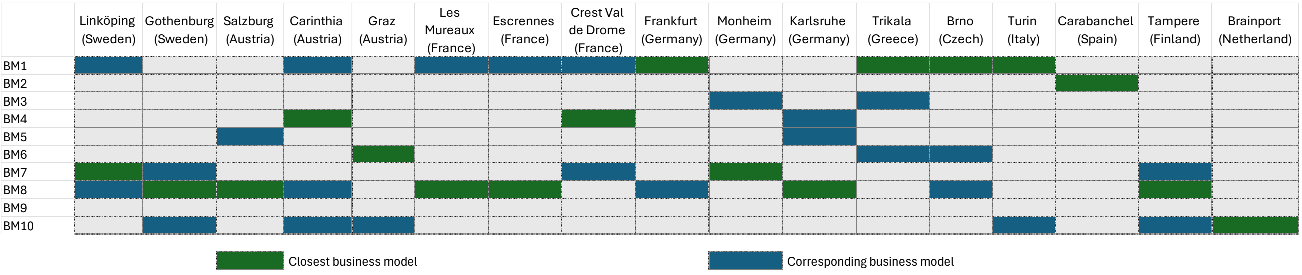

Figure 8 Mapping business/ operating models and test sites

3.2.4. Matching with the Business Models defined into WP16 – A16.3: Exploitation plans per partner and stakeholder groups

In WP16 - A16.3: Exploitation plans per partner and stakeholder groups, another classification of Business Models had been defined, based on the service characteristics. Interrelations and synergies are discussed to enrich both classifications. The matching between those classifications is presented in the table below:

Table 11 Matching between Business Models based on proposition value (WP2) and Business Models based on the service characteristics (WP16)

A2.3 (based on proposition value)	Test Sites for WP2 Business Models	A16.3 (based on the service characteristics)	Test Sites for WP16 Business Models
BM1: Autonomous PT in combination with additional on-demand services	Linköping (Sweden) Salzburg (Austria) Carinthia (Austria) Trikala (Greece) (*) Brno (Czech) (*) Turin (Italy) (*) Les Mureaux (France) Frankfurt (Germany) (*)	Demand responsive transportation	Frankfurt (Germany) Karlsruhe (Germany Carinthia (Austria) Turin (Italy) Trikala (Greece)
BM2: Autonomous Bus Depots	Carabanchel (Spain)	Depot Management	Carabanchel (Spain)
BM3: Advanced MaaS in urban environments	Monheim (Germany) Trikala (Greece)	Mobility as a Service (MaaS)	Monheim (Germany) Frankfurt, Tampere, Trikala (as a vision)
BM4: Combined MaaS and LaaS	Carinthia (Austria) Karlsruhe (Germany) Trikala (Greece)	Mixed transport (Passengers + logistics)	Carinthia (Austria) Karlsruhe (Germany) Gothenburg (Sweden)
BM5: Peri-urban automated transportation and C-ITS connectivity	Salzburg (Austria) Karlsruhe (Germany)	Integration of automated services into existing public transportation (Level4 + higher level automation) *fixed public transport services*	Monheim (Germany) Linköping, Gothenburg (Sweden) Brno (Czech) Tampere, Lahti (Finland) Crest Val de Drome, Les Mureaux

			(France) Salzburg (Austria)
BM6: Robotaxi services for short distance trips	Graz (Austria) Trikala (Greece) Brno (Czech)	Fleet owned robo-taxis	Graz (Austria) Trikala (Greece) Brno (Czech) Tampere (Finland)
BM7: Sustainable living areas with autonomous public transportation	Monheim (Germany) Linköping (Sweden) Gothenburg (Sweden)	Integration of automated services into existing public transportation (Level4 + higher level automation) *fixed public transport services*	Monheim (Germany) Linköping, Gothenburg (Sweden) Brno (Czech) Tampere, Lahti (Finland) Crest Val de Drome, Les Mureaux (France) Salzburg (Austria)
BM8: First/Last mile autonomous transportation to mobility HUBs	Frankfurt, Karlsruhe (Germany) Linköping, Gothenburg (Sweden) Brno (Czech) Tampere (Finland) Les Mureaux (France) Salzburg, Carinthia (Austria)	Integration of automated services into existing public transportation (Level4 + higher level automation) *fixed public transport services* Demand responsive transportation	Monheim, Frankfurt, Karlsruhe (Germany) Linköping, Gothenburg (Sweden) Brno (Czech) Tampere, Lahti (Finland) Crest Val de Drome, Les Mureaux (France) Salzburg, Carinthia (Austria) Turin (Italy) Trikala (Greece)
BM9: Integrated automated and electric shuttle busses for large scale events	No specific Test site in SHOW	Demand responsive transportation	Frankfurt (Germany) Karlsruhe (Germany Carinthia (Austria) Turin (Italy) Trikala (Greece)
BM10: Interoperable IoT platforms for automated mobility	Gothenburg (Sweden) Graz (Austria) Tampere (Finland) Carinthia (Austria) Turin (Italy)	No such Business Model foreseen in WP16	
No such Business Model foreseen in WP2		Automated logistics (LaaS)	Trikala (Greece) Crest Val de Drome (France)

3.3. Definition of assumptions for BM stakeholders

The assumptions underlying the ten business models are outlined in *D2.3 - First Version of Validated Business/Operating Models* and are reiterated here in Annex 1.

3.4. Characterization of business/ operating models based on their assumptions

3.4.1. Mapping assumptions and business/ operating models' goals

As presented in section 2.2, four goals are considered. Each assumption among those defined above is associated with at least one goal. The objective is then to assign each assumption to at least one goal, and then to identify the relevant KPIs to perform the validation. When no assumption is identified for a goal, that means that it is not a priority of the business/ operating model and is not required to be tested. In the following sections, we present the assumptions assigned to each goal for each business or operating model, along with the relevant KPIs used for validation.

3.4.1.1. BM1 – Autonomous PT in combination with additional on-demand services

Table 12 presents the assumptions per goal for BM1. The analysis of the number of assumptions generated for each goal, along with the related indicators, reveals that the main goals of BM1 are to provide high service quality through technology, improve accessibility, and reduce congestion.

Table 12 Assumptions per goal for BM1

Goal	Assumptions	Indicators
Goal 1: Accessibility and Equity, Community vitality and Local priorities	**H1:** We believe that we could generate a fully integrated (physically and digitally) autonomous PT and on-demand operation (APT-ODS). **H4:** We believe that we could generate an integrated operation (APT-ODS) that serves students, commuters and personnel within the service area. **H15:** We believe that by introducing integrated APT-ODS we can eliminate existing mobility gaps in the area.	Physical and digital integration Variety of users Elimination of mobility gap
Goal 2: Economic and business ecosystem development	**H8:** We believe that through integrated operation (APT-ODS) we can provide cheap and flexible service to users. **H17:** We believe that by introducing integrated APT-ODS we can provide a better cost-effective operation compared to private cars.	Cost for the user
Goal 3: Environment Congestion and Modal share	**H2:** We believe that we could generate an automated shuttle bus fixed line at peak time that connects the different facilities around the campus area and reduce travel times. **H3:** We believe that we could generate an on-demand services at off peak times that reduce travel times. **H16:** We believe that by introducing integrated APT-ODS we can reduce private car usage in the area.	GHG emissions Noise Speed performance Peak hour performance Modal shift from cars

Goal	Assumptions	Indicators
	H12: We believe that by introducing integrated APT-ODS we can build a sustainable urban environment in the area: by reducing emissions. **H13:** We believe that by introducing integrated APT-ODS we can build a sustainable urban environment in the area: by reducing noise.	
Goal 4: Technology and associated quality of service	**H1:** We believe that we could generate a fully integrated (physically and digitally) autonomous PT and on-demand operation (APT-ODS). **H2:** We believe that we could generate an automated shuttle bus fixed line at peak time that connects the different facilities around the campus area and reduce travel times. **H3:** We believe that we could generate an on-demand services at off peak times that reduce travel times. **H5:** We believe that through integrated operation (APT-ODS) we can reduce the waiting time of service users at peak time. **H6:** We believe that through integrated operation we can increase service frequency. **H7:** We believe that through integrated operation (APT-ODS) we can provide comfortable and at-standard seating capacity to service users. **H8:** We believe that through integrated operation (APT-ODS) we can provide cheap and flexible service to users. **H11:** We believe that through integrated operation we could provide real-time information about traffic volume in the area and riders for the shuttle. **H14:** We believe that by introducing integrated APT-ODS we can build a sustainable urban environment in the area: by increasing safety.	Speed performance Peak hour performance Operating hours User satisfaction Cost for the user Pre-booking availability Conflicts / road accidents / Hard braking events Physical and digital integration Real-time information availability

3.4.1.2. BM2 - Autonomous Bus Depots

Table 13 presents the assumptions per goal for BM2. Number of assumptions generated for each goal, along with the related indicators, reveals that the main goals of the autonomous bus depots in BM2 are to reduce operational costs while improving service quality.

Table 13 Assumptions per goal for BM2

Goal	Assumptions	Indicators
Goal 1: Accessibility and Equity, Community vitality and Local priorities	**H6:** We believe that through an autonomous bus depot we will contribute to a PT ticket price reduction in the near future, which suppose a benefit from social side. **H10:** We believe that through an autonomous bus depot we will contribute to reducing tedious labor and increase job satisfaction (also contributing with new jobs in control tower for instance).	PT price ticket reduction Performances regarding job conditions
Goal 2: Economic and business ecosystem development	**H1:** We believe that through an autonomous bus depot OPEX costs will decrease significantly. **H2:** We believe that through an autonomous bus depot there will be associated space savings. **H4:** We believe that through an autonomous bus depot we will reach lower levels of idle times and increase vehicle usage, increase productivity/speed of depot operations. **H5:** We believe that PTOs and city and regional authorities will be interested in the implementation of an autonomous bus depot**.** **H8:** We believe that PTOs and city and regional authorities will contribute to the cost reduction we can deliver via an autonomous bus depot. **H9:** We believe that homologation and authorization for an autonomous bus depot should not be extremely lengthy and complicated (controlled environment). **H13:** We believe that initial investment & maintenance costs for an autonomous bus depot will be higher than a regular one, but the increase will not be drastic.	OPEX cost Space Savings Productivity Stakeholders involvement Cost reduction
Goal 3: Environment Congestion and Modal share		
Goal 4: Technology and associated quality of service	**H7:** We believe that through an autonomous bus depot we will increase services (frequency and variety) as more vehicles will be available and drivers will have extra hours too**.** **H11:** We believe that through autonomous bus depot operations will be easier to handle and coordinate. **H12:** We believe that an autonomous bus depot will not be severely conditioned for functioning due to weather issues.	Safety Speed Service performances

Goal	Assumptions	Indicators
	H3: We believe that through an autonomous bus depot the safety within the depot will increase. **H4:** We believe that through an autonomous bus depot we will reach lower levels of idle times and increase vehicle usage, increase productivity/speed of depot operations.	

3.4.1.3. BM3 - Advanced MaaS in urban environments

Table 14 presents the assumptions per goal for BM3. The main goals of deploying MaaS in an urban environment are to enhance community vitality, address local priorities, and provide high-quality service to travelers.

Table 14 Assumptions per goal for BM3

Goal	Assumptions	Indicators
Goal 1: Accessibility and Equity, Community vitality and Local priorities	**H2:** We believe that we could generate an autonomous mobility service for population ranging from urban areas to rural areas. **H4:** We believe that we can provide a real-Time information about traffic volume in the area and riders for the shuttle (with application). **H3:** We believe that we could generate a mobility service for different trip purposes including commuting, shopping, groceries leisure and tourism. **H11:** We believe that by introducing MaaS services we could achieve sustainability in urban cities by providing more space and more comfortable services to passengers. **H13:** We believe that by introducing MaaS services we could reduce delays.	Mobility gap Real-time information availability Comfort Delays
Goal 2: Economic and business ecosystem development		
Goal 3: Environment Congestion and Modal share	**H8:** We believe that by introducing MaaS services we could achieve sustainability in urban cities by providing less noise. **H9:** We believe that by introducing MaaS services we could achieve sustainability in urban cities by providing less emission. **H7:** We believe that by introducing MaaS services we could reduce private car usage in urban areas and decrease level of congestion.	Noise GHG Emissions Congestion
Goal 4: Technology and associated quality of service	**H1:** We believe that we could generate a mobility as a service (MaaS) operation integrated with existing conventional services.	Digital integration

Goal	Assumptions	Indicators
	H4: We believe that we can provide a real-Time information about traffic volume in the area and riders for the shuttle (with application). **H5:** We believe that a real-time information about traffic volume in the area and riders for the shuttle can provide added value to the passengers. **H6:** We believe that we could generate a pre-booking application for ticketing and seat selection. **H10:** We believe that by introducing MaaS services we could achieve sustainability in urban cities by providing more safety. **H12:** We believe that by introducing MaaS services we could have control over fleet operation and monitoring of network status. **H13:** We believe that by introducing MaaS services we could reduce delays.	Real-time information availability Pre-booking availability Safety Delays

3.4.1.4. BM4 - Combined MaaS and LaaS

Table 15 presents the assumptions per goal for BM4. Results reveal that the combination of MaaS and LaaS, relying on advanced technologies, aims at providing higher service quality and reducing congestion.

Table 15 Assumptions per goal for BM4

Goals	Assumptions	Indicators
Goal 1: Accessibility and Equity, Community vitality and Local priorities	**H4:** We believe that mobility services are for population for visiting or living in the testing area. **H11:** We believe that mobility service will be used mainly by existing public transport users. **H15:** We believe that with autonomous mobility services more reliable service can be provided between train stations and business hubs (i.e. commercial area, hospitals, campus, …).	Users' characteristics Public transport users among users Connection to business hubs
Goal 2: Economic and business ecosystem development	**H13:** We believe that we could generate autonomous services that can provide cost effectiveness in comparison to the private car. **H14:** We believe that autonomous services can attract more users and increase revenue by optimizing transit time.	Cost for the user Travel time

Goal 3: Environment Congestion and Modal share	**H6:** We believe that the sequential MaaS and LaaS service model can provide less congestion. **H7:** We believe that the sequential MaaS and LaaS service model can provide less noise. H8: We believe that the sequential MaaS and LaaS service model can provide less emission. **H11:** We believe that mobility service will be used mainly by existing public transport users. **H12:** We believe that mobility service will attract almost all private car users by transforming area into a private car free zone (Reduction of private car usage in urban areas).	Congestion Noise reduction GHG emission
Goal 4: Technology and associated quality of service	**H1:** We believe that we could generate autonomous services connected through all available mobility services including train, metro, bus (conventional and autonomous shuttle), bike and private vehicles (include taxi). **H2:** We believe that we could generate autonomous services connected through all available logistic services. **H3:** We believe that we could generate sequential services; mobility for passengers and logistics for goods. **H5:** We believe that users can access to service information at stations and website; through on-site intelligent signs and totem for passengers (use of ITS, 5G networks). **H9:** We believe that the sequential MaaS and LaaS service model can provide more safety. **H10:** We believe that we can provide an integrated ticketing system among autonomous and existing public transport modes. **H13:** We believe that we could generate autonomous services that can provide cost effectiveness in comparison to the private car. **H15:** We believe that with autonomous mobility services more reliable service can be provided between train stations and business hubs (i.e. commercial area, hospitals, campus, …). **H16:** We believe that with autonomous mobility services can increase the comfort of reduced mobility passengers.	Physical and digital integration Real-time information availability Logistics & passengers services Safety Cost for the user Connection to business hubs Comfort

3.4.1.5. BM5 – Peri-urban automated transportation and C-ITS connectivity

Table 16 presents the assumptions per goal for BM5. The main goals of BM5 are to improve the community vitality, to satisfy local priorities and to increase the service quality. That should also benefit global efficiency and productivity.

Table 16 Assumptions per goal for BM5

Goals	Assumptions	Indicators
Goal 1: Accessibility and Equity, and Community vitality and Local priorities	**H1:** We believe that the peri-urban on-demand service could connect the sub-urban area with the well-established transit network. **H3:** We believe that we can implement automated passenger transport for commuting, leisure, tourism and business reasons for the population at peri-urban areas. **H4:** We believe that we can implement an automated passenger transport for PT users with additional mobility needs. **H5:** We believe that with the implementation of an automated service higher flexibility is given to the residents. **H10:** We believe that with the automated service the challenges of a hilly area (especially for elderly people & PwD) can be tackled. **H11:** We believe that with the implementation of the automated service the walking distances in peri-urban areas can be reduced to 1 – 2 km to the next PT line with higher frequencies.	Connection to the suburban area Trips purposes Benefits for users with special needs Flexibility Hilly area performance
Goal 2: Economic and business ecosystem development	**H13:** We believe that by introducing an automated service we can provide a better cost-effective operation compared to private cars.	Cost effectiveness
Goal 3: Environment Congestion and Modal share	**H7:** We believe that with the electric buses used for the automated service sustainability can be boosted, through reduction of noise. **H8:** We believe that with the electric buses used for the automated service sustainability can be boosted, through reduction of emissions. **H12:** We believe that by introducing an automated service we can reduce private car usage in the peri-urban area.	Noise GHG emissions Private car reduction
Goal 4: Technology and associated quality of service	**H1:** We believe that the peri-urban automated service could connect the sub-urban area with the well-established transit network. **H2:** We believe that the established regional transit network could be benefiting from C-ITS cooperative traffic management features such as in-vehicle speed limits, emergency electronic braking light, road works warnings, weather conditions and intersection safety. **H5:** We believe that with the implementation of an automated service higher flexibility is given to the residents. **H6:** We believe that with the implementation of an automated service higher frequencies could	Connection to the suburban area Frequency Weather conditions Safety

Goals	Assumptions	Indicators
	be achieved. **H9:** We believe that with the electric buses used for the automated service sustainability can be boosted, through providing more safety. **H11:** We believe that with the implementation of the automated service the walking distances in peri-urban areas can be reduced to 1 – 2 km to the next PT line with higher frequencies.	

3.4.1.6. BM6 - Robotaxi services for short distance trips

Table 17 presents the assumptions per goal for BM6. The main goals of BM6 are to improve the community vitality, to satisfy local priorities and to increase the service quality.

Table 17 Assumptions per goal for BM6

Goal	Assumptions	Indicators
Goal 1: Accessibility and Equity, and Community vitality and Local priorities	**H4:** We believe that the integration of the robotaxi service is especially valuable for PT users with additional mobility needs (buses are often complicated to enter for people with these needs). **H2:** We believe that the robotaxi service will be attractive. **H3:** We believe that we can implement a robotaxi service for commuting, leisure, and shopping reasons for the visitors of the Shopping Center West.	Benefits for users with special needs Attractiveness Trip purposes
Goal 2: Economic and business ecosystem development		
Goal 3: Environment Congestion and Modal share	**H6:** We believe that with the implementation of robotaxis the usage of public modes will increase.	Modal shift to public transports
Goal 4: Technology and associated quality of service	**H2:** We believe that the robotaxi service will be attractive. **H5:** We believe that with the implementation of the robotaxi service waiting times can be reduced. **H7:** We believe that the implementation of robotaxis will increase the comfort in public modes, in particular concerning the maximum load section. **H9:** We believe that robotaxis passengers will be satisfied. **H8:** We believe that we could synchronize robotaxis operations given demand and real-time state of public modes.	Attractiveness Waiting times Comfort Satisfaction of users Synchronization with PT efficiency

Goal	Assumptions	Indicators
	H1: We believe that with the implementation of the robotaxi service the transportation efficiency from the train station to the Shopping Center West can be increased.	

3.3.1.7. BM7 - Sustainable living areas with autonomous public transportation

Table 18 presents the assumptions per goal for BM7. The goals of this BM are more social, aiming at improving the community vitality, the accessibility and the equity.

Table 18 Assumptions per goal for BM7

Goal	Assumptions	Indicators
Goal 1: Accessibility and Equity, Community vitality and Local priorities	**H1:** We believe that fewer parents will drive their children to school by car, which will increase the accessibility for paratransit and other critical road users. **H2:** We believe that fewer relatives will drive their car for visits at the elderly home and increasing accessibility for relatives in rush hour. **H3:** We believe that children, elderly and users with special needs will have an increased transport offer through providing a first and last mile solution. **H4:** We believe that general users will have an increased transport offer through providing a first and last mile solution. **H5:** We believe users will accept this solution - regardless of vehicles' low speeds. **H6:** We believe that the AV shuttle will contribute to increase the quality of life in the area. **H7:** We believe that efficient autonomous first and last mile solutions will increase land and facility value, and increase ability for employers to retain and attract new employees.	Accessibility for vulnerable users Ratio of people who would have use their car Job creation Acceptance Quality of life
Goal 2: Economic and business ecosystem development	**H7:** We believe that efficient autonomous first and last mile solutions will increase land and facility value and increase ability for employers to retain and attract new employees.	Job creation
Goal 3: Environment Congestion and Modal share	**H6:** We believe that the AV shuttle will contribute to increase the quality of life in the area.	Noise GHG Emissions
Goal 4: Technology and associated quality of service	**H2:** We believe that fewer relatives will drive their car for visits at the elderly home and increasing accessibility for relatives in rush hour. **H4:** We believe that general users will have an increased transport offer through providing a first and last mile solution.	Private car reduction Willingness to pay / use the service regardless of speed

Goal	Assumptions	Indicators
	H5: We believe users will accept this solution - regardless of vehicles' low speeds.	

3.4.1.8. BM8 - First/Last mile autonomous transportation to mobility HUBs

Table 19 presents the assumptions per goal for BM8. Its main goals are to improve the accessibility to / from mobility hubs and to improve the overall quality of service of public modes.

Table 19 Assumptions per goal for BM8

Goal	Assumptions	Indicators
Goal 1: Accessibility and Equity, Community vitality and Local priorities	**H1:** To create a connected and automated passenger transport service between station-to-station and stations-to-university and stations-to-shopping mall. **H2:** To create a connected and automated passenger transport service between different organizations as shopping mall-to-university, shopping mall-to-business district, and business district -to-university. **H5:** To provide the information about the transportation (such as arrival/departure time, shuttle location, estimated travel time, etc.) by using a digital platform such as an application and/or website (5G connection). **H3:** To create a connected and automated cargo transport service between shopping mall-to-stations **H4:** To serve for the passengers as students, workers, visitors, and shoppers.	Connection to business hubs Real-time information availability Trip purposes
Goal 2: Economic and business ecosystem development	**H3:** To create a connected and automated cargo transport service between shopping mall-to-stations **H11:** To provide a promotion, the public transport tickets and subscriptions would be accepted for automated shuttle service without any additional payment required.	Cost for the user Link to shopping mall
Goal 3: Environment Congestion and Modal share	**H6:** The deployment of connected and automated vehicle will reduce the congestion around mobility HUBs thanks to dedicated lines or some promotions. **H12:** To reduce the time-loss that caused by parking and congestion, the connected automated shuttle would serve as comfortable as private transport. **H8:** To reduce parking-area-use and illegal parking, the connected automated shuttle would avoid any time-loss for parking.	Comfort Time-loss avoided Ratio of people who would have used their car

Goal	Assumptions	Indicators
Goal 4: Technology and associated quality of service	**H7:** The deployment of connected and automated vehicle will reduce the travel time to mobility HUBs thanks to dedicated lines or some promotions. **H8:** To reduce parking-area-use and illegal parking, the connected automated shuttle would avoid any time-loss for parking. **H9:** To be preferred, the automated shuttle service would provide a cheaper service to the users by saving travel and waiting time. **H10:** The users may reach the free Wi-Fi and USB Charging stations on the automated shuttle. **H11:** To provide a promotion, the public transport tickets and subscriptions would be accepted for automated shuttle service without any additional payment required. **H12:** To reduce the time-loss that caused by parking and congestion, the connected automated shuttle would serve as comfortable as private transport. **H1:** To create a connected and automated passenger transport service between station-to-station and stations-to-university and stations-to-shopping mall. **H2:** To create a connected and automated passenger transport service between different organizations as shopping mall-to-university, shopping mall-to-business district, and business district -to-university. **H5:** To provide the information about the transportation (such as arrival/departure time, shuttle location, estimated travel time, etc.) by using a digital platform such as an application and/or website (5G connection). **H13:** To be more reliable, the connected and automated service would be supported by providing current location of the vehicle (5G connection). **H14:** To increase the accessibility of the connected automated shuttle, IoT and 5G digital assistance systems would be provided for users who need assistance.	Average speed Cost for the user User satisfaction Comfort Digital assistance availability Real-time information availability Connection to business hubs

3.4.1.9. BM9 - Integrated automated and electric shuttle busses for large scale events

Table 20 presents the assumptions per goal for BM9. Through the deployment of automated services within large scale events, the aims are to facilitate the involvement of new actors in the ecosystem, the promotion of the technology and of its benefits to the community.

Table 20 Assumptions per goal for BM9

Goal	Assumptions	Indicators
Goal 1: Accessibility and Equity, and Community vitality and Local priorities	**H1:** We believe that the automotive industry will be interested in testing AV-based services during large events. **H2:** We believe that automated services deployed for large scale events will be used by event visitors and inhabitants as well. **H8:** We believe that using autonomous services during the event will improve the experience of visitors and their satisfaction.	Not evaluated in the project
Goal 2: Economic and business ecosystem development	**H3:** We believe that testing automated services during large events will involve the automotive industry, event associations, ITS providers, infrastructure providers and SMEs. **H6:** We believe that providing an automated service during large scale events will promote the technology and create a great image to show around the world. **H7:** We believe that testing and sponsoring automated services during large scale events will be costly and only big corporations would be able to pay. **H8:** We believe that using autonomous services during the event will improve the experience of visitors and their satisfaction.	Not evaluated in the project
Goal 3: Environment Congestion and Modal share		
Goal 4: Technology and associated quality of service	**H8:** We believe that using autonomous services during the event will improve the experience of visitors and their satisfaction. **H5:** We believe that service automation will be safe for visitors of the event. **H4:** We believe that testing automated services during large-scale events will challenge the limits of the service in terms of capacity and service performances.	Not evaluated in the project

3.4.1.10. BM10 – Interoperable IoT platforms for automated mobility

Table 21 presents the assumptions per goal for BM10. This BM aims to validate the social and environmental impacts of IoT technologies.

Table 21 Assumptions per goal for BM10

Goal	Assumptions	Indicators
Goal 1: Accessibility and Equity, Community		

Goal	Assumptions	Indicators
vitality and Local priorities		
Goal 2: Economic and business ecosystem development	**H7:** We believe that IoT interoperability for connected and automated driving will enhance the possibility for new players to join the market and contribute with new data-driven business models. **H8:** We believe that to stay profitable OEMs will have to enter digital ecosystems (joint acquisition of HERE from Daimler, Audi and BMW; alignment of BMW with Intel/ Mobileye).	Stakeholders' integration Digital ecosystem
Goal 3: Environment Congestion and Modal share	**H4:** We believe that the possibility of interconnecting surrounding sensors will reduce implementation costs. **H6:** We believe that the possibility of interconnecting surrounding sensors will enhance the traffic flow, therefore also reducing emissions and noise.	GHG emissions Noise Implementation cost
Goal 4: Technology and associated quality of service	**H2:** We believe that IoT interoperability for connected and automated driving will provide more comfort for driving. **H1:** We believe that IoT interoperability for connected and automated driving will increase safety. **H3:** We believe that the possibility of interconnecting surrounding sensors (e.g. cameras, traffic light radars, road sensors) in addition to on-board sensors (e.g., LiDAR, radar, cameras) will add detection robustness. **H5:** We believe that the possibility of interconnecting surrounding sensors will enable pushing the SAE (Society of Automotive Engineers) level of driving automation to full automation. **H9:** We believe that IoT interoperability for connected and automated driving will allow for higher speed (due to higher safety and higher detection rate).W	Comfort Safety Detection robustness Average Speed SAE Level

3.4.2. Goals of business / operating models

In order to identify the objectives of SHOW business models, two approaches are combined:

a) Analyzing the assumptions identified for each goal (among the four goals described in section 2.2;
b) Conducting interviews with representatives of pilots.

In the following, we present a detailed description of both methods and their outputs when applied on SHOW demos.

3.4.2.1. Based on the analysis of assumptions and goals

The previous analysis shows that for each business / operating model, some goals are involving more assumptions than others. These goals could be then considered as more critical and important for the considered business/ operating model.

Table 22 presents for each business/ operating model, which goals are involving more assumptions (green colour) and which are involving less (yellow colour). For instance, if we consider BM1, service quality associated to the automation technology is one of the main goals. Similarly, the business ecosystem development is one of the main goals of BM9.

Table 22 Weights of goals per business/ operating model

Goal	BM1	BM2	BM3	BM4	BM5	BM6	BM7	BM8	BM9	BM10
Goal 1: Accessibility and Equity, and Community vitality and Local priorities	0,15	0,14	0,33	0,18	0,38	0,30	0,58	0,24	0,30	0,00
Goal 2: Economic and business ecosystem development	0,10	0,50	0,00	0,12	0,06	0,00	0,08	0,10	0,40	0,22
Goal 3: Environment Congestion and Modal share	0,25	0,00	0,20	0,24	0,19	0,10	0,08	0,14	0,00	0,22
Goal 4: Technology and associated service quality	0,50	0,36	0,47	0,47	0,38	0,60	0,25	0,52	0,30	0,56

3.4.2.2. Based on interviews with stakeholders

The analysis of the objectives is also enriched by conducting interviews with pilot sites. Based on Figure 8, which presents the mapping between the sites and the business models, the interviews are scheduled with the sites to ensure that all business models are studied. Thus, for each business model, at least one site is interviewed.

In the following, we present the goals for each site, and compared results with those of Table 22, in order to have robust consolidation of goals.

The Monheim Mega Pilot

The closest business / operating model for the Monheim Pilot is **BM3 – Advanced MaaS in urban environments.**

Other corresponding business / operating models:

- BM7 – Sustainable living areas with autonomous public transportation

The viability of the business model in Monheim hinges on creating a seamless service chain—connecting regional train stations to different city parts through buses, bikes, etc. The pilot successfully constructed a multimodal ecosystem, promoting the service to the public to assess its value for users. Simultaneously, it empowered the operator to gather usage data in diverse scenarios, accelerating technological development. For the local authority, this pilot served as a potent tool for service promotion.

This proposition value is aligned with the estimation of Table 22.

Table 23 Matching evaluation between the assumptions-based approach and the interviews and consolidated goals for the Monheim site

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
BM3	0,33	0	0,2	0,47
Monheim Priorities (from interviews)	Strong	Not considered for this BM	Moderate	Strong
Matching	**Yes**	**X**	**Yes**	**Yes**
Comments on objectives				Safety Operating, deploying, and challenging suppliers on their technology

The Frankfurt Mega Pilot

The closest business / operating model for the Frankfurt Pilot is **BM1 – Autonomous PT in combination with additional on-demand services.**

Other corresponding business / operating models:

- BM8 – First/Last mile autonomous transportation to mobility hubs

In Frankfurt, the SHOW pilot project aims to validate autonomous public transport and first/last mile transportation to mobility hubs. The primary goals are to improve accessibility, enhance economic viability, reduce environmental impact, and ensure technological safety. The service, particularly beneficial for elderly and disabled users, faces economic challenges due to high costs. Future plans include expanding autonomous services, collaborating with vehicle manufacturers, and integrating these solutions into the city's Sustainable Urban Mobility Plan (SUMP) for broader climate and accessibility benefits. The long-term vision is to make autonomous services economically sustainable with improved technology and centralized software management.

The priorities of Frankfurt based on interviews are aligned with the estimation of Table 22 for goals 2 to 4.

Table 24 Matching evaluation between the assumptions-based approach and the interviews and consolidated goals for the Frankfurt site

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
BM1	0,15	0,1	0,25	0,5

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
Frankfurt Priorities (from interviews)	Moderate	Not a priority	Moderate	Strong
Matching	**No**	**Yes**	**Yes**	**Yes**
Comments on objectives		Does not yield economic benefits	For the future	reliable booking software and reduced waiting times

The Karlsruhe Mega Pilot

The closest business / operating model for the Karlsruhe Pilot is **BM8 – First/Last mile autonomous transportation to mobility hubs.**

Other corresponding business / operating models:

- BM4 – Combined MaaS and LaaS
- BM5 – Peri-urban automated transportation and C-ITS connectivity

The SHOW pilot project in Karlsruhe focuses on autonomous public transport combined with on-demand services, connecting public transport stations and tram stations. The main objectives include improving accessibility, reducing congestion and emissions, and advancing technological and safety standards. Stakeholders, including the city, PTO, and research institutes, assess success based on accessibility, economic feasibility, environmental impact, business ecosystem development, and technological robustness. Challenges include high costs, low speeds, and interaction with other road users. While the service received positive feedback, it faced complaints about low speed from other road users. The pilot demonstrated the need for more affordable and reliable shuttles, with further research and development required to make the service economically viable. Expansion plans are limited due to economic constraints, and future efforts will focus on improving technology and exploring collaborations with tech startups and PT providers.

The priorities of Karlsruhe based on interviews are aligned with the estimation of Table 22 as shown in Table 25.

Table 25 Matching evaluation between the assumptions-based approach and the interviews and consolidated goals for the Karlsruhe site

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
BM8	0,24	0,1	0,14	0,52
Karlsruhe Priorities (from interviews)	Moderate	Not a priority	Moderate	Strong

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
Matching	Yes	Yes	Yes	Yes
Comments on objectives	Provide connection to the neighborhood to the station			Improvement needed in the interaction between the shuttle and other vehicles due to its low speed. The area has mixed traffic, narrow streets, and few traffic lights, as traffic is generally light. Focus should be on enhancing robustness, speed, and interaction with other participants. No issues with safety.

The Madrid Mega Pilot

The closest business / operating models for the Madrid Pilot is **- BM2 - Autonomous Bus Depots.**

In Madrid, the pilot aims to explore the integration of automated vehicle technology within their operations, particularly in depot management. The primary motivation is not to automate their entire fleet but to understand how automation works, improve operational efficiency, and prepare for future interactions with suppliers. They are particularly interested in small-scale automation tasks like parking buses to reduce unproductive driver hours. The pilot faced significant challenges, especially with the installation of mechatronic systems, but provided valuable insights. Key lessons learned include the cost-ineffectiveness of retrofitting older buses with automation, suggesting a preference for factory-automated buses in the future. Positive outcomes include a deeper understanding of automation and its potential to streamline operations. Current services remain financially dependent on public subsidies. Future plans do not include an immediate increase in the number of vehicles but involve discussions with OEMs for testing new automated features. The city's strategic plans, such as the EMT Strategic Plan 2025 and the PMUS, mention AVs in the context of innovation and research, without explicit commitments to large-scale deployment. The focus remains on pilot projects to gain knowledge and prepare for a more intelligent and automated mobility future.

The priorities of Madrid based on interviews are aligned with the estimation of Table 22 as shown in Table 26Table 25.

Table 26 Matching evaluation between the assumptions-based approach and the interviews and consolidated goals for the Madrid site

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
BM2	0,14	0,5		0,36

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
Madrid Priorities (from interviews)	Moderate	Strong	Not considered for this BM	Strong
Matching	**Yes**	**Yes**	**X**	**Yes**
Comments on objectives		Cost analysis performed- reduction on personal cost- challenge on inflation in future		Efficiency (bus can perform several operations)

The Les Mureaux and Escrennes Mega Pilots

The closest business / operating model for Les Mureaux and Escrennes Pilots is **- BM8 – First/Last mile autonomous transportation to mobility hubs**

Other corresponding business / operating models:

- BM1 – Autonomous PT in combination with additional on-demand services

In both pilots, concerning the on-site private service, the objectives are the same for PTOs and local authorities (i.e., municipalities or cities). They strive to deliver an efficient, reliable, and indispensable mobility service to the site's employees. The pilot specifically aimed to validate the service's value for users, while allowing PTOs to explore technological maturity and enabling Public Transport Authorities (PTAs) to evaluate safety.

The priorities of Les Mureaux based on interviews are aligned with the estimation of Table 22 as shown in Table 27Table 26Table 25. For Escrennes, the priorities are quite similar.

Table 27 Matching evaluation between the assumptions-based approach and the interviews and consolidated goals for the Les Mureaux site

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
BM8	0,24	0,1	0,14	0,52
Les Mureaux Priorities (from interviews)	Moderate	Not a priority	Not a priority	Strong
Matching	Yes	Yes	Yes	Yes
Comments on objectives				

The Linkoping Mega Pilot

The closest business / operating model for The Linkoping Pilot is **- BM7 - Sustainable living areas with autonomous public transportation.**

Other corresponding business / operating models:

- BM1 - Autonomous PT in combination with additional on-demand services
- BM8 - First/Last mile autonomous transportation to mobility hubs

For the Linköping pilot, the initial motivation was to reduce the high number of taxis operating in the area, aiming to offer a more efficient and sustainable transport solution. The pilot has faced technical challenges but has provided significant learning opportunities. The project involves local partners who contribute both in-kind and financially, with annual costs around €400-500k, supported by VTI bank and other stakeholders. While there is no baseline for comparison, direct observations suggest potential benefits. The project's success is measured by innovation rather than a solid business case, as the technology maturity remains a concern. Future plans include possibly increasing the number of vehicles and expanding to other areas, driven by local board decisions and ongoing discussions. The long-term goal is to integrate autonomous vehicles into the broader transport network, potentially replacing the need for safety drivers with remote operations. This could make the service more viable and cost-effective. The municipality is also exploring the broader impact on public transport and active mobility, aiming to ensure that AVs complement rather than compete with other forms of transport. The project is part of the city's Sustainable Urban Mobility Plan (SUMP), with a focus on quantifying benefits through simulations and identifying expansion opportunities

The priorities of Linkoping based on interviews are aligned with the estimation of Table 22 as shown in Table 28Table 26Table 25.

Table 28 Matching evaluation between the assumptions-based approach and the interviews and consolidated goals for the Linkoping site

Objectives	**Goal 1** **Accessibility and Equity**	**Goal 2** **Economic and business development**	**Goal 3** **Environment and Modal share**	**Goal 4** **Technology and associated service quality**
BM7	0,58	0,08	0,08	0,25
Linköping Priorities (from interviews)	Strong	Not a priority	Not a priority	Moderate
Matching	Yes	Yes	Yes	Yes
Comments on objectives	Priority for this pilot			

The Gothenburg Mega Pilot

The closest business / operating model for the Gothenburg Pilot is **BM8 – First/Last mile autonomous transportation to mobility hubs.**

Other corresponding business / operating models:

- BM7 - Sustainable living areas with autonomous public transportation
- BM10 - Interoperable IoT platforms for automated mobility

In Gothenburg, Sweden, the SHOW pilot project led by RISE's Group Mobility Transformation, focuses on integrating automated vehicle technology into the public transport ecosystem to improve accessibility and address parking issues. The pilot, involving two autonomous vehicles operated by Keolis with 5G connectivity from Ericsson and vehicles supplied by Navya, aims to reduce traffic by connecting with existing public transport and testing ecosystem cooperation. Despite initial technical challenges and limited real-time app functionality, user feedback has been positive, highlighting the flexibility and potential for route optimization. The project, currently reliant on public subsidies, plans to introduce a third vehicle, expand to new areas like the airport and hospitals, and increase vehicle speed. Success metrics include passenger numbers and improved accessibility, with future collaborations needed to enhance vehicle maturity, speed, and flexibility, and integrate AVs into the city's Sustainable Urban Mobility Plan (SUMP).

The priorities of Gothenburg based on interviews are aligned with the estimation of Table 22 as shown in Table 29Table 26Table 25.

Table 29 Matching evaluation between the assumptions-based approach and the interviews and consolidated goals for the Gothenburg site

Objectives	**Goal 1** **Accessibility and Equity**	**Goal 2** **Economic and business development**	**Goal 3** **Environment and Modal share**	**Goal 4** **Technology and associated service quality**
BM8	0,24	0,1	0,14	0,52
Gothenburg Priorities (from interviews)	Moderate	Not a priority	Not a priority	Strong
Matching	Yes	Yes	Yes	Yes
Comments on objectives				Shuttle performances and integration with existing public transport system

The Salzburg Mega Pilot

The closest business / operating model for the Salzburg Pilot is **- BM5 - Peri-urban automated transportation and C-ITS connectivity.**

Other corresponding business / operating models:

- BM8 - First/Last mile autonomous transportation to mobility hubs

The SHOW pilot project in Salzburg focuses on demonstrating the viability of autonomous public transport combined with first/last mile transportation to mobility hubs and peri-urban automated transportation. The project aims to raise awareness of autonomous technology, enhance community benefits, and improve public transport connectivity. It involves two Level 4 autonomous vehicles equipped with C-ITS functionality, operating with safety drivers due to legislative and technical constraints. Despite challenges such as vehicle availability and an accident, public acceptance has been positive. The pilot aims to increase trust in automated technology and integrate these services into the existing public transport system, ultimately contributing to a more efficient and resilient urban mobility ecosystem. Future plans include expanding first and last mile services and exploring collaborations to ensure economic viability and broader implementation.

The priorities of Salzburg based on interviews are aligned with the estimation of Table 22 as shown in Table 30Table 26Table 25.

Table 30 Matching evaluation between the assumptions-based approach and the interviews and consolidated goals for the Salzburg site

Objectives	**Goal 1** **Accessibility and Equity**	**Goal 2** **Economic and business development**	**Goal 3** **Environment and Modal share**	**Goal 4** **Technology and associated service quality**
BM5	0,38	0,06	0,19	0,38
Salzburg Priorities (from interviews)	Moderate	Not a priority	Not a priority	Moderate
Matching	Yes	Yes	Yes	Yes
Comments on objectives	Raise awareness of technology and demonstrate its benefits for the community's daily life.			C-ITS functionality between hub and the city

The Graz Mega Pilot

The closest business / operating models for the Graz Pilot is **- BM6 - Robotaxi services for short-distance trips.**

Other corresponding business / operating models:

- BM10 - Interoperable IoT platforms for automated mobility

The SHOW project in Graz, led by the research center Virtual Vehicle, aims to demonstrate the functionality of autonomous vehicle technology. The primary objectives are to validate the capabilities of autonomous vehicles, enhance urban mobility, and explore future partnerships for services like robotaxis. The project also seeks to address technical and legislative challenges while gathering user feedback to improve the attractiveness and acceptance of autonomous shuttle services.

The priorities of Graz based on interviews are aligned with the estimation of Table 22 as shown in Table 31Table 30Table 26Table 25.

Table 31 Matching evaluation between the assumptions-based approach and the interviews and consolidated goals for the Graz site

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
BM6	0,3	0	0,1	0,6
Graz Priorities (from interviews)	Moderate	Not a priority	Not a priority	Strong
Matching	Yes	Yes	Yes	Yes
Comments on objectives	Priority for the city			Priority for the PTO

The Carinthia Satellite Pilot

The closest business / operating model for the Carinthia Pilot is **- BM4 - Combined MaaS and LaaS.**

Other corresponding business / operating models:

- BM1: Autonomous PT in combination with additional on-demand services
- BM8 - First/Last mile autonomous transportation to mobility hubs
- BM10 - Interoperable IoT platforms for automated mobility

In the Austrian site of Carinthia, the Business Model's viability was initially driven by the need to provide first and last mile solutions and to address future driver shortages. The pilot sites, Pörtschach and Klagenfurt, were selected for their distinct characteristics: Pörtschach being a tourist town with seasonal population variations and Klagenfurt as the region's capital with complex, mixed traffic conditions. The primary challenge was the limited speed of the automated shuttles, which impacted user satisfaction. However, the positive feedback from tourists, seniors, and handicapped individuals highlighted the service's potential benefits. To make the service cost-effective, it is crucial to implement teleoperation and eliminate the need for a safety driver, particularly given the high costs compared to conventional services. The pilot demonstrated the need for further technological and operational improvements to address weather-related challenges and enhance overall service reliability. Despite these challenges, the pilot's acceptance rate was notably high, indicating strong community support and a foundation for future expansions and improvements in autonomous mobility solutions.

The priorities of Carinthia based on interviews are aligned with the estimation of Table 22 as shown in Table 32Table 30Table 26Table 25.

Table 32 Matching evaluation between the assumptions-based approach and the interviews and consolidated goals for the Carinthia site

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
BM4	0,18	0,12	0,24	0,47
Carinthia Priorities (from interviews)	Moderate	Not a priority	Not a priority	Strong
Matching	Yes	Yes	No	Yes
Comments on objectives				

The Brno Satellite Pilot

The closest business / operating model for the Brno Pilot is **- BM1: Autonomous PT in combination with additional on-demand services.**

Other corresponding business / operating models:

- BM6: Robotaxi services for short distance trips
- BM8: First/Last mile autonomous transportation to mobility HUBs

The priorities of Brno based on interviews are aligned with the estimation of Table 22 as shown in Table 33Table 32Table 30Table 26Table 25.

Table 33 Matching evaluation between the assumptions-based approach and the interviews and consolidated goals for the Brno site

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
BM1	0,15	0,1	0,25	0,5
Brno Priorities (from interviews)	Not a priority	Not a priority	Not a priority	Strong
Matching	Yes	Yes	No	Yes
Comments on objectives				Technology and safety are the main reason to start the pilot. PT connected to other bus lanes,

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
				connection with other modes. Passengers scan QR codes and bus can adjust time schedule but not the route.

The Tampere Satellite Pilot

The closest business / operating model for the Brno Pilot is **- BM8 - First/Last mile autonomous transportation to mobility hubs.**

Other corresponding business / operating models:

- BM10 - Interoperable IoT platforms for automated mobility

The priorities of Tampere based on interviews are aligned with the estimation of Table 22 as shown in Table 34Table 33Table 32Table 30Table 26Table 25.

Table 34 Matching evaluation between the assumptions-based approach and the interviews and consolidated goals for the Tampere site

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
BM8	0,24	0,1	0,14	0,52
Tampere Priorities (from interviews)	Moderate	Not a priority	Not a priority	Strong
Matching	Yes	Yes	Yes	Yes
Comments on objectives	Work with the accessibility working group to improve vehicles for impaired people		Decrease emissions goal but not the priority.	Collect digital maps and traffic data real time data to build the system.

The Brainport Satellite Pilot

The closest business / operating model for the Brainport Pilot is **- BM10 - Interoperable IoT platforms for automated mobility.**

The priorities of Brainport based on interviews are aligned with the estimation of Table 22 as shown in Table 35Table 33Table 32Table 30Table 26Table 25.

Table 35 Matching evaluation between the assumptions-based approach and the interviews and consolidated goals for the Brainport site

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
BM10	0	0,22	0,22	0,56
Brainport Priorities (from SHOW pilot objectives)	Not considered for this BM	Moderate	Moderate	Strong
Matching	X	Yes	Yes	Yes
Comments on objectives				Obtain data from operational service, extended user surveys Evaluate C-ITS functions for intersection crossing of low-speed automated vehicles Disseminate CCAM capability to citizens with a variety vehicles and functionality

The Turin Satellite Pilot

The closest business / operating models for the Turin Pilot is **- BM1: Autonomous PT in combination with additional on-demand services.**

Other corresponding business / operating models:

- BM10 - Interoperable IoT platforms for automated mobility

The priorities of Turin based on interviews are aligned with the estimation of Table 22 as shown in Table 36.

Table 36 Matching evaluation between the assumptions-based approach and the interviews and consolidated goals for the Turin site

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
BM1	0,15	0,1	0,25	0,5
Turin Priorities (from SHOW pilot objectives)	Moderate	Not a priority	Moderate	Strong
Matching	No	Yes	Yes	Yes
Comments on objectives				Turin aims to foster multimodality and improve accessibility by improving the public transport system and integrating it with automated transport services and ITS infrastructure

The Trikala Satellite Pilot

The closest business / operating models for the Trikala Pilot is **- BM1: Autonomous PT in combination with additional on-demand services.**

Other corresponding business / operating models:

- BM3: Advanced MaaS in urban environments
- BM6: Robotaxi services for short distance trips

The SHOW pilot project in Trikala focuses on three use cases: logistics delivery robots, autonomous public transport (PT) shuttles, and autonomous cars for evening robotaxi services. The primary motivation is to enhance urban mobility and reduce reliance on traditional delivery trucks and taxis. The project includes 2 AV shuttles and 2 AV cars operating on high-demand routes, supported by a 5G network. Initial challenges involved procurement, training personnel, and securing legal permits, with high initial costs due to the need for extensive training and supervision. Despite these challenges, public acceptance has been high, especially during events like the Christmas festival. Future plans involve partnering with the local mail operator and exploring the expansion of services to other areas, aiming to improve operational efficiency and reduce costs. The long-term goal is to integrate autonomous vehicles into the city's public transport and logistics systems, contributing to a greener and more efficient urban environment.

The priorities of Trikala based on interviews are aligned with the estimation of Table 22 as shown in Table 37Table 33Table 32Table 30Table 26Table 25.

Table 37 Matching evaluation between the assumptions-based approach and the interviews and consolidated goals for the Trikala site

Objectives	Goal 1 Accessibility and Equity	Goal 2 Economic and business development	Goal 3 Environment and Modal share	Goal 4 Technology and associated service quality
BM1	0,15	0,1	0,25	0,5
Trikala Priorities (from SHOW pilot objectives)	Moderate	Not a priority	Moderate	Strong
Matching	Yes	Yes	Yes	Yes
Comments on objectives	To improve the quality of life for citizens; data collected for citizens and users' acceptance			Measured through raw data, provided by the vehicle and smart infrastructures – considering safety standards

3.5. Definition of KPIs measurement methods and data collection process

3.5.1. KPIs measurement approaches

These KPIs are used to measure goals of each business model. Additionally, a PESTEL analysis is conducted to explore the barriers and enablers for the business models, enriching the assessment of these goals. Furthermore, evaluating the willingness to pay offers additional insights into the conditions necessary for the business model's viability. In the following, we present how are measured KPIs related to (1) scoring the business model's goals, (2) understanding the maturity level of automated services, and (3) estimating the willingness to pay.

3.5.1.1. Scoring business models' goals

In the previous section, we outlined the KPIs for each business model, which are crucial for evaluating the business model and its specific goals. Table 38 presents this list of KPIs along with their respective measurement methods. As stated in Chapter 2.2, the KPI could be:

- **Qualitative:** in that case it is scored 0 or 1 depending on if it is validated or not. For instance, a qualitative KPI could be the "Existence of common user application providing real time information on service state" or the "involvement of new OEMs in the pilot".
- **Quantitative:** in that case, it is scored based on data collected. The raw value is compared to that of other existing alternatives. In order to obtain the score on a scale from 0 to 1, each value is divided by the highest value among alternatives' values.

Table 38 Key performance indicators and measurement method

KPI	Definition	Measurement method and value ranges
Physical and digital integration	Digital integration: Does the service is integrated in existing/dedicated mobility apps Physical integration: Does the service is physically integrated to existing public transport offer (usable in intermodality)	1: Physically and digitally integrated 0.5: Physically or digitally integrated 0 No integration
Profiles of users	Is the service useful for different types of users for different trip purposes?	1: Serving all 3: students, commuters and personnel 0,75: Only two 0,5: Only one 0: 0
Elimination of mobility gap	Does the service help address a mobility gap issue?	1: Eliminating a gap in the area 0: Competitiveness with existing mode
Speed performance	Speed performance regarding maximum speed	Ratio: average speed / maximum speed
Off Peak hour performance	Does the service address an issue of insufficient off-peak hour service?	1: Service mostly used at off peak hours 0.5: Service used for peak hours and off-peak hours 0: Service only used at peak hours
Operating hours	Range of functioning hours	Ratio of functioning hours per day
User satisfaction	Are the users satisfied with the service?	Ratio of satisfied users
Cost for the end-user	Cost per trip for the end-user	1: free service 0.5: Public transit integration / cost = PT ticket cost 0: more expensive than PT
Pre-booking availability	Does the service offer pre-booking?	1: pre-booking availability 0: No pre-booking
Modal shift from cars	Does the service promote a modal shift from cars?	Percentage of users that would have use their car
Conflicts / road accidents / Hard braking events	Does the service increase safety?	1 - ((Conflicts + road accidents + HBE) / Kilometers travelled)
GHG emissions	Does the service contribute to the reduction of GHG emissions?	1: Electric vehicle 0: Thermal vehicle
Noise	Does the service contribute to the reduction of noise pollution?	1: Electric vehicle 0: Thermal vehicle
Space savings	Does the service result in space savings?	1: Yes 0: No

OPEX	Does the service reduce capital expenditures (CAPEX)	1: Decrease 0: Increase
CAPEX	Does the service reduce operational expenditures (OPEX)	1: Decrease 0: Increase
Stakeholder's interest	What was the interest of the involved stakeholders?	1: Strong interest 0.5: Moderate interest 0: Low interest
Impact on jobs	Does the service contribute to job creation?	1: Jobs creation 0.5: No impact on jobs 0: Jobs cuts
Weather resistance	During the pilot, were there technical issues due to bad weather?	1: No weather issues during pilot 0: Weather issues during pilot
Benefits for users with special needs	Does the service target users with special needs?	1: Yes 0: No
Comfort	Are the users satisfied regarding comfort?	1: Users satisfied about comfort 0: No significant enhancement
Connection to business hubs	Is the service connected to business hubs?	1: Connected to business hubs (commercial area, hospital, campus…) 0: Not connected
Real-time information availability	Does the service provide real-time information	1: Real-time information available 0: No real time information

3.5.1.2. PESTEL analysis

PESTEL analysis is a strategic tool used to identify and analyze the external factors that can impact the service. The acronym PESTEL stands for Political, Economic, Social, Technological, Environmental and Legal:

Political: Examines the influence of government policies, political stability, tax policies, trade regulations, and any political changes that might affect the business environment.

Economic: Looks at economic factors such as economic growth, exchange rates, inflation rates, interest rates, and economic cycles that can influence the service's performance.

Social: Considers social factors like cultural trends, demographics, population growth rates, age distribution, career attitudes, and lifestyle changes.

Technological: Analyzes the impact of technological innovations, research and development activities, automation, technological awareness, and the rate of technological change.

Environmental: Evaluates environmental factors including climate, weather, geographical location, environmental regulations, and ecological impacts.

Legal: Involves the analysis of legal factors such as employment laws, consumer protection laws, health and safety regulations, antitrust laws, and other legal constraints.

By systematically examining these factors, it is possible to gain a comprehensive understanding of the external environment and how it might influence their operations and strategic decisions. This analysis helps in identifying opportunities and threats, ensuring better strategic planning and risk management.

3.5.1.3. Willingness to pay

Willingness to pay, sometimes abbreviated as WTP, is the maximum price a customer is willing to pay for a product or service. Several approaches to measure the WTP are used in the literature:

- The method of **Gabor-Granger: identifies based on direct questions** the **maximum price** each respondent is willing to pay to determine **demand** at different price points and the **revenue maximizing price point**.
- The method of **Van Westendorp: determines the acceptable price range through questioning different price levels, mainly which are "too cheap"**, **"cheap"**, **"expensive"**, and **"too expensive"**.
- The conjoint analysis method: used discrete choice models to identify the **marginal willingness to pay** for specific features and determine the **optimal pricing** of products while considering competitor offerings.

One of the main limitations of the last approach is that respondents have to evaluate price in conjunction with other features, rather than considering price independently. However, since each site has its own specific characteristics, the comparison between sites, even belonging to the same BM, could be biased.

Consequently, the analysis of the willingness to pay will be based on the Van Westendorp approach, and will be performed at the pilot site and BM levels.

The willingness to pay is evaluated through a priori acceptance survey, regarding four types of services: automated train or metro, automated shuttle, automated cars with ridesharing, automated cars without ridesharing.

On the other hand, the services that are piloted into the project SHOW are either based on shuttles or automated passenger cars (with ride-sharing), as shown in the following Table 39.

Table 39 Mapping business models and types of service

Business models	Automated train/ metro	Automated shuttles	Automated cars with ridesharing	Automated cars without ridesharing
BM1: Autonomous PT in combination with additional on-demand services		X		
BM2: Autonomous Bus Depots		X		
BM3: Advanced MaaS in urban environments		X	X	
BM4: Combined MaaS and LaaS		X		
BM5: Peri-urban automated transportation and C-ITS connectivity		X		
BM6: Robotaxi services for short distance trips			X	

BM7: Sustainable living areas with autonomous public transportation		X		
BM8: First/Last mile autonomous transportation to mobility HUBs		X		
BM9: Integrated automated and electric shuttle busses for large scale events		X		
BM10: Interoperable IoT platforms for automated mobility		X	X	

The WTP will be then evaluated accordingly by considering two perspectives:

a) What is the WTP of individuals from all SHOW pilots for these four types of services?
b) What is the WTP of individuals towards the types of services that are demonstrated into their specific territory?

3.5.2. Data collection

As mentioned in Chapter 2, data required to evaluate KPIs could be obtained based on different studies, that are performed by all WPs of SHOW.

In the following, we present in detail the data collection approaches.

3.5.2.1. Interviews

To assess the viability and maturity of various business models, a comprehensive series of expert interviews was conducted with demo pilots (PTO, city, academia).

Subsequently, two distinct series of online structured interviews were held with local transport operators (PTOs), public transport authorities (PTAs), technology providers, and/ or researchers from SHOW project. In particular:

- The first session was aimed at understanding the intricacies of the Business Model (value proposition, key partners, channels, cost structure, etc.) and the initial learnings from the field trials. In total, 13 experts were interviewed at this phase, 3 from PTO (23%), 1 from PTA (8%), 3 from SMEs and technology providers (23%) and 6 from research organizations (46%).
- The second round was another session with the same stakeholders to explore their perceptions of the critical aspects of viability for different stakeholders, as well as the factors influencing the scalability of the Business Models. In total, 14 experts were interviewed at this phase, 5 from PTO (36%), 1 from PTA (7%), 1 from SMEs and technology providers (7%) 6 from research organizations (43%) and 1 from umbrella associations (7%).

Table 40 presents the structure of the interviews:

Table 40 Structure and rounds of the interviews

Interview	Objectives	Structure
First round	Understanding the business model and initial learnings	**Section 1:** Presentation of city case: motivation, strategy **Section 2:** Main assumptions of the business model **Section 3:** Business model

		Section 4: Lessons learned **Section 5:** Future plans
Second round	Exploring viability and scalability conditions	**Section 1:** Presentation of city case: business model in place and change of business model in the future **Section 2:** Viability measurement and conditions **Section 3:** Scalability and replicability conditions

3.5.2.2. A priori acceptance survey

A priori acceptance survey was developed by the activity *A1.1 - SHOW Ecosystem* of SHOW and has been further refined in *WP9 - Pilot plans, tools & ecosystem engagement* during the course of the project. It is exploited in order to understand better the potential future profile of users, their potential perception of service characteristics, and to measure the provisional willingness to pay.

In particular, additional questions are designed and integrated into the a priori acceptance survey conducted within *WP1 - Ecosystem views & SHOW UCs.* By analyzing the responses from each site, the willingness to pay is then measured. These questions are presented below:

1. At which price in Euros and for a given trip, would you consider using the autonomous train/metro to go to work... : ...to be so expensive that you would not consider using it?
2. At which price in Euros and for a given trip, would you consider using the autonomous train/metro to go to work... : ...to be priced so low that you would feel the quality couldn't be very good?
3. At which price in Euros and for a given trip, would you consider using the autonomous train/metro to go to work... : ...starting to get expensive, so that it is not out of the question, but you would have to give some thought to using it?
4. At which price in Euros and for a given trip, would you consider using the autonomous train/metro to go to work... : ...to be a bargain?
5. At which price in Euros and for a given trip, would you consider using the autonomous bus/shuttle to go to work... : ...to be so expensive that you would not consider using it?
6. At which price in Euros and for a given trip, would you consider using the autonomous bus/shuttle to go to work... : ...to be priced so low that you would feel the quality couldn't be very good?
7. At which price in Euros and for a given trip, would you consider using the autonomous bus/shuttle to go to work... : ...starting to get expensive, so that it is not out of the question, but you would have to give some thought to using it?
8. At which price in Euros and for a given trip, would you consider using the autonomous bus/shuttle to go to work... : ...to be a bargain?
9. At which price in Euros and for a given trip, would you consider using the autonomous car without other passengers to go to work... : ...to be so expensive that you would not consider using it?
10. At which price in Euros and for a given trip, would you consider using the autonomous car without other passengers to go to work... : ...to be priced so low that you would feel the quality couldn't be very good?
11. At which price in Euros and for a given trip, would you consider using the autonomous car without other passengers to go to work... : ...starting to get expensive, so that it is not out of the question, but you would have to give some thought to using it?
12. At which price in Euros and for a given trip, would you consider using the autonomous car without other passengers to go to work... : ...to be a bargain?
13. At which price in Euros and for a given trip, would you consider using the autonomous car with other passengers to go to work... : ...to be so expensive that you would not consider using it?

14. At which price in Euros and for a given trip, would you consider using the autonomous car with other passengers to go to work... : ...to be priced so low that you would feel the quality couldn't be very good?
15. At which price in Euros and for a given trip, would you consider using the autonomous car with other passengers to go to work... : ...starting to get expensive, so that it is not out of the question, but you would have to give some thought to using it?
16. At which price in Euros and for a given trip, would you consider using the autonomous car with other passengers to go to work... : ...to be a bargain?

3.5.2.3. Pilot performance data

Pilot performance data concern static and dynamic data, including Vehicle data, Traffic Efficiency Data, Infrastructure Data, Passenger Data, Logistics Data, Trip Itinerary Data, Environment Data and Energy Data. These data are aggregated by the Data Management Platform, within *WP5 - Big Data collection, processing and analytics*. The resulted KPIs are used to validate assumptions and then the Business Models.

3.5.2.4. Summary

Table 41 indicates for each KPI the suitable approach to collect required data.

Table 41 KPIs and corresponding data collection approach

Indicator	Interviews (WP2)	Acceptance /Satisfaction survey (WP1)	Pilot performance data (WP5)	Simulation (WP10)	Cost-benefits analysis (WP16)	Impacts assessment (WP13)
Physical and digital integration	X		X			
Profiles of users	X	X				
Elimination of mobility gap	X					
Speed performance		X	X			
Peak hour performance			X			
Operating hours	X		X			
User satisfaction	X	X				
Cost for the user	X	X				
Pre-booking availability	X				X	
Modal shift from cars		X		X		X
Conflicts / road accidents / Hard braking events	X		X	X		
GHG emissions	X					X
Noise	X					X
Space savings	X					
OPEX	X				X	
CAPEX	X				X	

Indicator	Interviews (WP2)	Acceptance /Satisfaction survey (WP1)	Pilot performance data (WP5)	Simulation (WP10)	Cost-benefits analysis (WP16)	Impacts assessment (WP13)
Stakeholder's interest	X					
Impact on jobs						X
Weather resistance	X		X			
Benefits for users with special needs	X	X				X
Comfort		X				X
Connection to business hubs	X					

3.6. Scoring goals of BM

In this section, we present and discuss the results of calculating scores of each BM and each site according to the four goals: Accessibility and Equity, Economy and business ecosystem, Technology and Environment. In order to understand in detail the calculation, a case example is presented in Annex 2.

3.6.1. BM1 – Autonomous Public Transport (PT) in combination with additional on-demand services

3.6.1.1. Linkoping

For the Linkoping site, here are the scores obtained for Business Model 1: Autonomous Public Transport (PT) in combination with additional on-demand services.

Goal 1 concerns accessibility and equity assessed regarding physical and digital integration, mobility gap elimination and usefulness of the service for different kinds of users. The Linköping service offers a fully integrated solution. The users include both commuters and residents, and the service is also widely used by campus students and visitors. The experimental area is not directly connected to public transportation, so the service addresses the issue of a mobility gap in the area. The service is then noted with the maximum score.

Goal 2 concerns economic performances regarding the cost of the service for the user. The service is free for this site.

Goal 3 concerns the environment and congestion. Even if the average speed is low (no reduction of travel time) and only 24% of the users would have use their car, the service is electric, so it has good performances regarding noise and emissions.

Goal 4 concerns service quality assessed regarding average speed, service usage during the day, satisfaction of users, cost and pre-booking availability. The service is highly appreciated by users, with 89% expressing satisfaction. The service is free for users but does not offer prebooking. The average rating is due to the average speed, which does not imply that the overall service quality is average. Commercial speed is a major issue in the deployment of autonomous vehicles and will be improved with large-scale deployment. Therefore, this score should be nuanced as it does not accurately reflect the success of this experimentation.

Table 42 Scores of BM1 goals for Linkoping

Goals	Linkoping score
Goal 1 : Accessibility, equity and community vitality	1
Goal 2 : Economic and business development	1

Goals	Linkoping score
Goal 3 : Environment and congestion	0,68
Goal 4 : Technology and associated quality of service	0,75

3.6.1.2. Frankfurt

For the Frankfurt site, here are the scores obtained for Business Model 1: Autonomous Public Transport (PT) in combination with additional on-demand services.

Goal 1 concerns accessibility and equity assessed regarding physical and digital integration, mobility gap elimination and usefulness of the service for different kinds of users. The Frankfurt service offers a fully integrated solution. The users include both commuters and residents, and the service is also widely used by campus students and visitors. The experimental area is not directly connected to public transportation, so the service addresses the issue of a mobility gap in the area. The service is then noted with the maximum score.

Goal 2 concerns economic performances regarding the cost of the service for the user. The service is free for this site.

Goal 3 concerns the environment and congestion. Even if the average speed is very low (no reduction of travel time) the service is electric, so it has good performance regarding noise and emissions.

Goal 4 concerns service quality assessed regarding average speed, service usage during the day, satisfaction of users, cost and pre-booking availability. The service is free for users but does not offer prebooking. The average rating is due to the average speed, which does not imply that the overall service quality is average. Commercial speed is a major issue in the deployment of autonomous vehicles and will be improved with large-scale deployment. Therefore, this score should be nuanced as it does not accurately reflect the success of this experimentation.

Table 43 Scores of BM1 goals for Frankfurt

Goals	Frankfurt score
Goal 1 : Accessibility, equity and community vitality	1
Goal 2 : Economic and business development	0,8
Goal 3 : Environment and congestion	0,75
Goal 4 : Technology and associated quality of service	0,79

3.6.1.3. Les Mureaux

For the French site, here are the scores obtained for Business Model 1: Autonomous Public Transport (PT) in combination with additional on-demand services.

Goal 1 concerns accessibility and equity assessed regarding physical and digital integration, mobility gap elimination and usefulness of the service for different kinds of users. The Les Mureaux service offers partial integrated solution. The users include mostly employees using the service at mealtime. The experimental area is not directly connected to public transportation, so the service addresses the issue of a mobility gap in the area. The service is then noted with the maximum score.

Goal 2 concerns economic performances regarding the cost of the service for the user. The service is free for this site.

Goal 3 concerns the environment and congestion. Even if the average speed is very low (no reduction of travel time) the service is electric, so it has good performances regarding noise and emissions.

Goal 4 concerns service quality assessed regarding average speed, service usage during the day, satisfaction of users, cost and pre-booking availability. The service is highly appreciated by users, with 91% expressing satisfaction. The service is free for users and offer an on-demand booking app. The average rating is due to the average speed, which does not imply that the overall service quality is average. Commercial speed is a major issue in the deployment of autonomous vehicles and will be improved with large-scale deployment. Therefore, this score should be nuanced as it does not accurately reflect the success of this experimentation.

Table 44 Scores of BM goals for Les Mureaux

Goals	Les Mureaux score
Goal 1 : Accessibility, equity and community vitality	1
Goal 2 : Economic and business development	1
Goal 3 : Environment and congestion	0,85
Goal 4 : Technology and associated quality of service	0,7

3.6.2. BM2 – Autonomous Bus Depots

For the Madrid site, here are the scores obtained for Business Model 2: Autonomous Bus Depots

Goal 1 concerns accessibility and equity assessed regarding the contribution of the service to the reduction of PT ticket price, and regarding job performances. The anticipated reduction in PT ticket prices is expected to stem from decreased bus operating costs as a result of automation.

Goal 2 concerns economic performances regarding the cost of the service for the user, OPEX/CAPEX, space savings, PTOs and stakeholders' involvement.

Goal 3 : No assumptions are identified for this goal for business model 2

Goal 4 : concerns service quality assessed regarding frequency, weather resistance, safety, and productivity.

Table 45 Scores of BM goals for Madrid

Goals	Madrid score
Goal 1 : Accessibility, equity and community vitality	0,5
Goal 2 : Economic and business development	0,8
Goal 3 : Environment and congestion	X
Goal 4 : Technology and associated quality of service	0,9

3.6.3. BM3 – Advanced MaaS in urban environments

3.6.3.1 Trikala

For the Trikala site, here are the scores obtained for Business Model 3: Advanced MaaS in urban environments.

Goal 1 concerns accessibility and equity. It includes real-time information availability, space and comfort and benefits for users with special needs.

The Trikala service offers many benefits to active populations and with special needs according to the local authority. The area of the pilot is underserved so a lot of benefits to make the area accessible through AV. The service is well integrated with public transport and provides real time information.

Goal 2: No assumptions are identified for this goal for business model 3.

Goal 3 concerns environment and congestion assessed regarding noise, pollution and private car reduction. The service is electric, so it has good performances regarding noise and emissions. There was no relevant information about private car reduction for this pilot.

Goal 4 concerns service quality assessed regarding delays, real-time information and prebooking availability, safety and integration. For this service, the technology is mature. There is a supervision from the center and data on accidents of automated vehicles but not data on accidents on network.

There is real-time information for users. Users are aware when the vehicle will come exactly, know the route, the length, etc., it is well designed compared to the traditional bus system (where real-time is not shared).

Table 46 Scores of BM goals for Trikala

Goals	Trikala score
Goal 1 : Accessibility, equity and community vitality	0,9
Goal 2 : Economic and business development	X
Goal 3 : Environment and congestion	0,87
Goal 4 : Technology and associated quality of service	0,75

3.6.3.2 Monheim

For the Monheim site, here are the scores obtained for Business Model 3: Advanced MaaS in urban environments.

Goal 1 concerns accessibility and equity assessed regarding accessibility for urban to rural areas, real-time information availability, space and comfort and benefits for users with special needs. The Monheim service offers benefits for all users including users with special needs and was also used a lot by tourists. It offers real-time information. The service is pretty mature and well established, in Monheim its running for 4 years. Customers are quite satisfied with the service.

Goal 2: No assumptions are identified for this goal for business model 3.

Goal 3 concerns environment and congestion assessed regarding noise, pollution and private car reduction. The service is electric, so it has good performances regarding noise and emissions. There was no relevant information about private car reduction for this pilot.

Goal 4 concerns service quality assessed regarding average speed, service usage during the day, satisfaction of users, cost and pre-booking availability. The service provides real-time information but no prebooking. Average speed is low, but it offers more safety. Regarding integration, the service is fully integrated and complement the existing bus offer.

Table 47 Scores of BM goals for Monheim

Goals	Monheim score
Goal 1 : Accessibility, equity and community vitality	1
Goal 2 : Economic and business development	X
Goal 3 : Environment and congestion	1
Goal 4 : Technology and associated quality of service	0,8

3.6.4. BM4 – Combined MaaS and LaaS

3.6.4.1 Carinthia

For the Carinthia site, here are the scores obtained for Business Model 4: Combined MaaS and LaaS

Goal 1 concerns accessibility and equity assessed regarding connection between train stations and business hubs, and regarding the use of the service by public transport users, people visiting and living in the area. The service is connected to existing offers and 40% of public transport users declared that they would use the service.

Goal 2 concerns economic performances regarding the cost effectiveness of the service compared to private cars and the optimization of transit time. Service is free for the user but because of low speed, transit time is not significantly reduced.

Goal 3 concerns environment and congestion assessed regarding noise, pollution and private car reduction. The service is electric, so it has good performances regarding noise and emissions. Private car reduction is hardly measurable for this pilot, some of the users would have use their car.

Goal 4 concerns service quality assessed regarding physical and digital integration, real-time information, safety, comfort and connection with business hubs. The service offers real-time information and is fully integrated.

Table 48 Scores of BM goals for Carinthia

Goals	Carinthia score
Goal 1 : Accessibility, equity and community vitality	0,8
Goal 2 : Economic and business development	0,72
Goal 3 : Environment and congestion	0,76
Goal 4 : Technology and associated quality of service	0,91

3.6.4.2. Karlsruhe

For the Karlsruhe site, here are the scores obtained for Business Model 4: Combined MaaS and LaaS.

Goal 1 concerns accessibility and equity assessed regarding connection between train stations and business hubs, and regarding the use of the service by public transport users, people visiting and living in the area.

Goal 2 concerns economic performances regarding the cost effectiveness of the service compared to private cars and the optimization of transit time. Service is free for the user but because of low speed, transit time is not significantly reduced.

Goal 3 concerns environment and congestion assessed regarding noise, pollution and private car reduction. The service is electric, so it has good performances regarding noise and emissions. However, there is no private car reduction observed for this site.

Goal 4 concerns service quality assessed regarding physical and digital integration, real-time information, safety, comfort and connection with business hubs. The service is well integrated, provides safety and comfort but it doesn't have full real-time information.

Table 49 Scores of BM4 goals for Karlsruhe

Goals	Karlsruhe score
Goal 1 : Accessibility, equity and community vitality	1
Goal 2 : Economic and business development	0.69

Goals	Karlsruhe score
Goal 3 : Environment and congestion	0.75
Goal 4 : Technology and associated quality of service	0.85

3.6.5. BM5 – Peri-urban automated transportation and C-ITS connectivity

3.6.5.1. Karlsruhe

For the Karlsruhe site, here are the scores obtained for Business Model 5: Peri-urban automated transportation and C-ITS connectivity

Goal 1 concerns accessibility and equity assessed regarding connection to the suburban area, benefits for users with special needs, flexibility, hilly area issues and walk distances. The service provides flexibility for users, offering a new transport mode which is used for different trip purposes. It is well connected to the sub-urban area.

Goal 2 concerns economic performances regarding the cost effectiveness of the service compared to private car. The service is free of charge for all passengers, even if it might not be economically sustainable in the future.

Goal 3 concerns environment and congestion assessed regarding noise, pollution and private car reduction. The service is electric, so it has good performances regarding noise and emissions. However, due to the limited scale of the pilot, no reduction in private car usage was observed at this site, rendering this indicator inapplicable.

Goal 4 concerns service quality assessed regarding C-ITS features, flexibility, frequency, and safety. The service offers flexibility but regarding frequencies, as it is a pilot, there are not a lot of vehicles. Regarding safety, the pilot is successful.

Table 50 Scores of BM5 goals for Karlsruhe

Goals	Karlsruhe score
Goal 1 : Accessibility, equity and community vitality	0.96
Goal 2 : Economic and business development	1
Goal 3 : Environment and congestion	1
Goal 4 : Technology and associated quality of service	0.78

3.6.5.2. Salzburg

For the Salzburg site, here are the scores obtained for Business Model 5: Peri-urban automated transportation and C-ITS connectivity

Goal 1 concerns accessibility and equity assessed regarding connection to the suburban area, benefits for users with special needs, flexibility, hilly area issues and walk distances. During the pilot, fixed route service for shuttles because of challenge in technology and topology of the area. Capability of AV in per urban environment was limited (narrow roads) and therefore on demand service not doable.

Goal 2 concerns economic performances regarding the cost effectiveness of the service compared to private car. Service was free of charge so more cost effective than private car during the pilot.

Goal 3 concerns environment and congestion assessed regarding noise, pollution and private car reduction. The service is electric, so it has good performances regarding noise and emissions. No information regarding private car reduction.

Goal 4 concerns service quality assessed regarding C-ITS features, flexibility, frequency, and safety. The service offers flexibility but regarding frequencies, as it is a pilot, there are not a lot of vehicles. Service used CITS on 1 vehicle (EVAN) with traffic light prisonizations. The whole route was equipped with CITS infrastructure in pilot track.

Table 51 Scores of BM goals for Salzburg

Goals	Salzburg score
Goal 1 : Accessibility, equity and community vitality	0.88
Goal 2 : Economic and business development	1
Goal 3 : Environment and congestion	0.8
Goal 4 : Technology and associated quality of service	0.78

3.6.6. BM6 – Robotaxi services for short distance trips

3.6.6.1. Graz

For the Graz site, here are the scores obtained for Business Model 6: Robotaxi services for short distance trips.

Goal 1 concerns accessibility and equity assessed regarding benefits for users with special needs, attractiveness and the implementation of robotaxis for commuting, leisure and shopping. The service has a good score regarding the different kinds of trip purposes. The service was attractive but good be more accessible specially for users with special needs.

Goal 2 : No assumptions are identified for this goal for business model 6

Goal 3 concerns environment and congestion assessed regarding the implementation of robotaxis to increase public mode usage in order to tackle emissions. Not really measurable but the service didn’t specifically target people who would use a car before the experimentation.

Goal 4 concerns service quality assessed regarding attractiveness, waiting times, user’s satisfaction, real-time adaptation of the service and efficiency. The service has a good score regarding comfort and waiting times. Users are satisfied (8/10 score)

Table 52 Scores of BM6 goals for Graz

Goals	Graz score
Goal 1 : Accessibility, equity and community vitality	0.69
Goal 2 : Economic and business development	X
Goal 3 : Environment and congestion	0.6
Goal 4 : Technology and associated quality of service	0.79

3.6.7. BM7 – Sustainable living areas with autonomous public transportation

3.6.7.1. Linkoping

For the Linköping site, here are the scores obtained for Business Model 7: Sustainable living areas with autonomous public transportation.

Goal 1 concerns accessibility and equity assessed regarding accessibility for vulnerable users, modal shift from cars, acceptance and quality of life. Thanks to the AV shuttle the children and elderly can access the public transport. Among users, 24% would have to use their car. The service is accessible and appreciated.

The site included both a mixed traffic with separate lanes for Vulnerable Road Users.

Goal 2 concerns economic performances regarding job creation caused by the implementation of the service. For this pilot, there were 9 shuttle operators and training for existing staff.

Goal 3 concerns the environment and congestion assessed regarding noise and pollution. The service is electric, so it has good performances regarding noise and emissions.

Goal 4 concerns service quality assessed regarding willingness to pay, modal shift from cars and acceptance. For the willingness to pay, more details are given in section 3.6.

Table 53 Scores of BM7 goals for Linkoping

Goals	Linköping score
Goal 1 : Accessibility, equity and community vitality	0.68
Goal 2 : Economic and business development	1
Goal 3 : Environment and congestion	1
Goal 4 : Technology and associated quality of service	0.75

3.6.7.2. Gothenburg

For the Gothenburg site, here are the scores obtained for Business Model 7: Sustainable living areas with autonomous public transportation

Goal 1 concerns accessibility and equity assessed regarding accessibility for vulnerable users, modal shift from cars, acceptance and quality of life. The service is accessible, but people mostly would have used their bicycles or they would have walked. For this pilot, it was hard to have disable people onboard.

Goal 2 concerns economic performances regarding job creation caused by the implementation of the service. Drivers were trained for new safety responsibilities. A dedicated safety responsible person was appointed from within Keolis, taking on a new role specific to the project. Looking ahead, the project anticipates the need for remote operators who could manage up to three autonomous vehicles, potentially an outsourced role. Additionally, maintenance of the vehicles and infrastructure, currently handled by drivers, could evolve into a specialized technical role, highlighting the future need for smart shuttle technical expertise.

Goal 3 concerns the environment and congestion assessed regarding noise and pollution. The service is electric, so it has good performances regarding noise and emissions.

Goal 4 concerns service quality assessed regarding willingness to pay, modal shift from cars and acceptance. For the willingness to pay, more details are given in section 3.6.

Table 54 Scores of BM7 goals for Gothenburg

Goals	Gothenburg score
Goal 1 : Accessibility, equity and community vitality	0.6
Goal 2 : Economic and business development	1
Goal 3 : Environment and congestion	1
Goal 4 : Technology and associated quality of service	0.79

3.6.8. BM8 – First/Last mile autonomous transportation to mobility HUBs

3.6.8.1. Linkoping

For the Linköping site, here are the scores obtained for Business Model 8: First/Last mile autonomous transportation to mobility HUBs

Goal 1 concerns accessibility and equity assessed regarding connectivity to business hubs (university, shopping mall, business and district, real-time information, benefits for students/workers/visitors. This pilot successfully connected key hubs such as the university and shopping malls, benefiting students, workers, and visitors. However, challenges like hard braking and integration issues, reduced comfort for passengers.

Goal 2 concerns economic performances cost for users and link to shopping mall. The service was free of charge and linked to business hubs, so it performed well regarding these two indicators.

Goal 3 concerns environment and congestion assessed regarding time-loss for parking, comfort and private car reduction.

Goal 4 concerns service quality assessed regarding average speed, user's satisfaction, comfort, real-time information and assistance for users with special needs. The average speed of the autonomous shuttles was lower than desired, which led to some user dissatisfaction and complaints from other road users. However, user satisfaction was generally positive, particularly among those who benefited from the service, such as elderly passengers accessing services. Comfort was an issue due to hard braking, which reduced comfort for passengers, especially for those with special needs, including visually and cognitively impaired individuals. The shuttles did offer real-time information through an integrated app, but the system faced challenges in providing consistent assistance. Despite these issues, the project highlighted the potential for improving service quality with further technological advancements and better integration into the existing transport network.

Table 55 Scores of BM8 goals for Linkoping

Goals	Linköping score
Goal 1 : Accessibility, equity and community vitality	0.63
Goal 2 : Economic and business development	0.8
Goal 3 : Environment and congestion	0.68
Goal 4 : Technology and associated quality of service	0.86

3.6.8.2. Gothenburg

For the Gothenburg site, here are the scores obtained for Business Model 8: First/Last mile autonomous transportation to mobility HUBs

Goal 1 concerns accessibility and equity assessed regarding connectivity to business hubs (university, shopping mall, business and district, real-time information, benefits for students/workers/visitors. The shuttles operate within the campus area, connecting key locations like the library and side park buildings to the main public transport routes. This service enhances accessibility for students, employees, and elderly visitors who might otherwise walk or cycle. While the service integrated well with the local public transport system, making it easier for users to access without extra charge, issues like hard braking and challenges in accommodating disabled passengers need addressing. Overall, the shuttles have improved connectivity within the campus, but there's room for improvement in accessibility feature.

Goal 2 concerns economic performances cost for users and link to shopping mall. The project faced significant economic challenges, particularly regarding the high costs of operation and maintenance, indicating the need for significant improvements to achieve a sustainable business mode.

Goal 3 concerns environment and congestion assessed regarding time-loss for parking, comfort and private car reduction. The environmental impact of the shuttle service was not fully measurable, but it aimed to reduce private car usage by providing an alternative transport mode within the campus. While the service likely contributed to a reduction in car usage among students and employees, many users were already walking or cycling. Emission reductions were not specifically noted, but the electric shuttles contributed to lower noise pollution.

Goal 4 concerns service quality assessed regarding average speed, users' satisfaction, comfort, real-time information and assistance for users with special needs. Service quality was a mixed aspect of the pilot. The shuttles faced reliability issues, with frequent sensor problems and integration challenges that affected real-time information availability. Users appreciated the service, particularly elderly passengers, but discomfort from hard braking and interactions with other road users (e.g., bicycles) reduced overall satisfaction. Real-time information and better assistance for users with special needs, like smoother braking systems and more accessible boarding options, are essential for improving service quality. The pilot demonstrated the need for technological advancements and more robust systems to enhance user satisfaction and operational efficiency.

Table 56 Scores of BM8 goals for Gothenburg

Goals	Gothenburg score
Goal 1 : Accessibility, equity and community vitality	0.6
Goal 2 : Economic and business development	0.7
Goal 3 : Environment and congestion	0.95
Goal 4 : Technology and associated quality of service	0.75

3.6.8.3. Frankfurt

For the Frankfurt site, here are the scores obtained for Business Model 8: First/Last mile autonomous transportation to mobility HUBs

Goal 1 concerns accessibility and equity assessed regarding connectivity to business hubs (university, shopping mall, business and district, real-time information, benefits for students/workers/visitors. The autonomous shuttles in Frankfurt aimed to enhance accessibility and equity by providing first/last mile transportation to key mobility hubs such as universities, shopping malls, and business districts. The service was particularly beneficial for elderly people and those with disabilities, as the shuttles were equipped with ramps for wheelchairs. Real-time information was available through an integrated booking software, but reliability issues with the service affected user satisfaction. Overall, the project improved connectivity to important locations but highlighted the need for more robust and faster service

Goal 2 concerns economic performances assessed regarding cost for users and link to shopping mall. The service was free of charge and linked to business hubs, so it performed well regarding these two indicators.

Goal 3 concerns environment and congestion assessed regarding time-loss for parking, comfort and private car reduction. The environmental impact of the autonomous shuttles was somewhat positive, as they were electric and thus contributed to reducing noise and emissions compared to traditional vehicles. However, due to the limited scale of the pilot and the slow speed of the shuttles, it was difficult to measure significant reductions in private car usage or improvements in congestion.

Goal 4 concerns service quality assessed regarding average speed, users' satisfaction, comfort, real-time information and assistance for users with special needs. Service quality was a mixed aspect of the Frankfurt pilot. The average speed of the shuttles was a major point of criticism, as it was slower than other public transport options and caused delays for other road users. User satisfaction varied, with elderly and disabled passengers appreciating the service for its accessibility features, while others found the slow speed and occasional technical issues problematic. Real-time information was available, but the integration with existing public transport schedules was not always reliable. Assistance for users with special needs was adequate, but the hard braking incidents and interactions with other road users highlighted the need for further technological improvements to enhance comfort and safety.

Table 57 Scores of BM8 goals for Frankfurt

Goals	Frankfurt score
Goal 1 : Accessibility, equity and community vitality	0.9
Goal 2 : Economic and business development	1
Goal 3 : Environment and congestion	0.9
Goal 4 : Technology and associated quality of service	0.82

3.6.9. BM9 – Integrated automated and electric shuttle busses for large scale events

No specific test site in SHOW.

3.6.10. BM10 – Interoperable IoT platforms for automated mobility

3.6.10.1. Gothenburg

For the Gothenburg site, here are the scores obtained for Business Model 10: Interoperable IoT platforms for automated mobility.

Goal 1: No assumptions are identified for this goal for BM10.

Goal 2 concerns economic performances assessed regarding stakeholders' integration to the project and digital ecosystem to increase profit. The project integrated various stakeholders, including the public transport authority, Keolis, and technology providers like Navya and Ericsson. While the integration was successful in terms of collaboration, the digital ecosystem's ability to generate profit was hindered by the high operational expenses and the immature technology. The fixed costs, such as safety drivers and vehicle maintenance, further strained the economic feasibility. Stakeholders were willing to fund the project initially, but the real cost of the service and the need for more passengers to justify the expenses were evident.

Goal 3 concerns environment and congestion assessed regarding emissions, noise pollution and implementation cost. The project's environmental impact and congestion mitigation were limited. Although the shuttles were electric and contributed to reducing emissions, noise pollution was not significantly addressed, and the slow speed of the shuttles caused congestion issues, particularly with other vehicles like garbage trucks and in bus stops. The implementation cost for infrastructure adjustments, such as cutting grass and dealing with snow barriers, also added to the environmental and operational challenge.

Goal 4 concerns service quality assessed regarding average speed, comfort, safety, SAE level and detection robustness. Service quality was a mixed bag, with issues related to average speed, comfort, and safety. The shuttles operated at a slow speed, leading to discomfort among passengers and frustrations from other road users. Hard braking incidents were particularly problematic, causing discomfort and safety concerns for elderly passengers and children. Although the shuttles were integrated into the public transport system, real-time information and detection robustness were lacking. The technology was not mature enough, resulting in reliability issues and minor accidents. The service did provide some benefits for users with special needs, but overall, the quality of the service was hampered by technological and operational limitations.

Table 58 Scores of BM10 goals for Gothenburg

Goals	Gothenburg score
Goal 1 : Accessibility, equity and community vitality	X
Goal 2 : Economic and business development	0,70
Goal 3 : Environment and congestion	0.85

Goals	Gothenburg score
Goal 4 : Technology and associated quality of service	0.72

3.6.10.2. Graz

For the Graz site, here are the scores obtained for Business Model 10: Interoperable IoT platforms for automated mobility.

Goal 1: No assumptions are identified for this goal for BM10.

Goal 2 concerns economic performances assessed regarding stakeholders' integration to the project and digital ecosystem to increase profit. The inclusion of various stakeholders, such as the City of Graz, the PTO, and technology providers, fostered a collaborative environment. However, the project's current stage is more research-focused rather than profit-driven, indicating a need for further advancements and cost reductions to achieve economic sustainability.

Goal 3 concerns environment and congestion assessed regarding emissions, noise pollution and implementation cost. The pilot's environmental impact and congestion reduction were positive, albeit limited in scope. The automated taxi service was designed to fill gaps where public transport was not attractive, thus potentially reducing private car usage. However, the pilot's limited scale made it difficult to assess its full impact on emissions and noise pollution comprehensively.

Goal 4 concerns service quality assessed regarding average speed, comfort, safety, SAE level and detection robustness. The technology showed promise but required further progress, especially concerning driver interventions and communication with infrastructure. Users appreciated the flexibility and frequency of the automated taxi service, which operated similarly to a traditional taxi. However, challenges such as hard braking and minor accidents highlighted the need for improved detection robustness and reliability. The service was integrated into the public transport system, but the need for real-time information and seamless user experience was still a work in progress. Overall, the quality of service was acceptable but required significant technological advancements to ensure safety and user satisfaction.

Table 59 Scores of BM10 goals for Graz

Goals	Graz score
Goal 1 : Accessibility, equity and community vitality	X
Goal 2 : Economic and business development	0,70
Goal 3 : Environment and congestion	0.88
Goal 4 : Technology and associated quality of service	0.79

3.7. Willingness to pay

The willingness to pay (WTP) is measured using the method of Van Westendorp, determining the optimal price and the range of acceptable prices.

WTP is evaluated through the acceptance survey, covering four types of automated services: automated train or metro, automated shuttle, automated cars with ridesharing, automated cars without ridesharing.

Consequently, the estimation of the WTP is performed at two levels:

- **Site level:** by being agnostic of the SHOW pilot, assessing the WTP of inhabitants in each SHOW city for the four types of services.

- **Business model level:** by considering the type of service closest to the tested and envisioned service at each site.

Accordingly, this section is structured into two parts to reflect these levels.

3.7.1. At site level

The data collected through the acceptance survey has been processed based on the following criteria:

(a) Each site must have more than five responses,
(b) Inconsistent responses are removed. They are considered inconsistent if:
  i. The maximum acceptable price is lower than the minimum acceptable price,
  ii. The price deemed too cheap, cheap, too expensive and expensive do not vary.

Based on data treatment, only eight sites are retained for the estimation of the WTP: Linkoping, Karlsruhe, Carinthia, Brno, Salzburg, Turin, Graz and Tampere.

The number of responses from each site are presented in the table below:

Table 60 Number of valid responses on the willingness to pay from each site

Site	Number of respondents
Linkoping	38
Karlsruhe	5
Carinthia	44
Brno	5
Salzburg	37
Turin	103
Graz	28
Tampere	29
Total	**289**

3.7.1.1. Automated train/ metro

We observe disparities between the different sites, with higher WTP values for Karlsruhe (reaching 2.6 euros) and the lowest for Carinthia (0.7 euros), Brno (0.7 euros), and Graz (0.8 euros). The optimal WTP across all sites ranges between 1 euro and 1.8 euros.

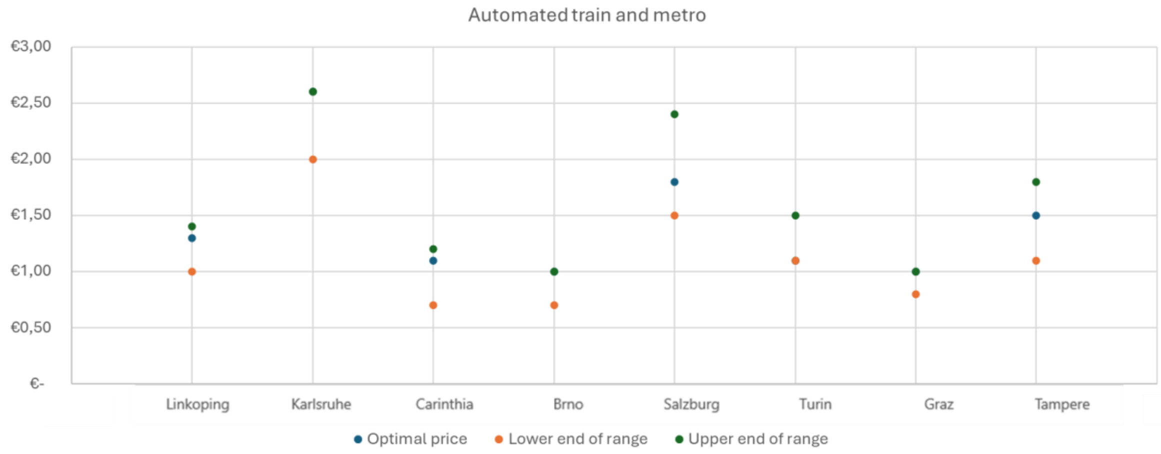

Figure 9 Willingness to pay for automated train/ metro across SHOW pilot sites

3.7.1.2. Automated shuttles

For shuttles, we generally observe lower WTP values compared to automated trains, except for Karlsruhe, where the WTP reaches 3 euros with an optimal price of 2.8 euros, and for Tampere, where the range shifts from [1.1 - 1.8] for the train to [1.4 - 2] for the shuttle.

Otherwise, the optimum for the other sites is below 1.5 euros. The lower WTP for shuttles compared to trains may be due to users perceiving trains as more essential and shuttles as more optional, with effective alternatives available.

For Karlsruhe, it seems that individuals are more favorable and receptive to shared modes of transport.

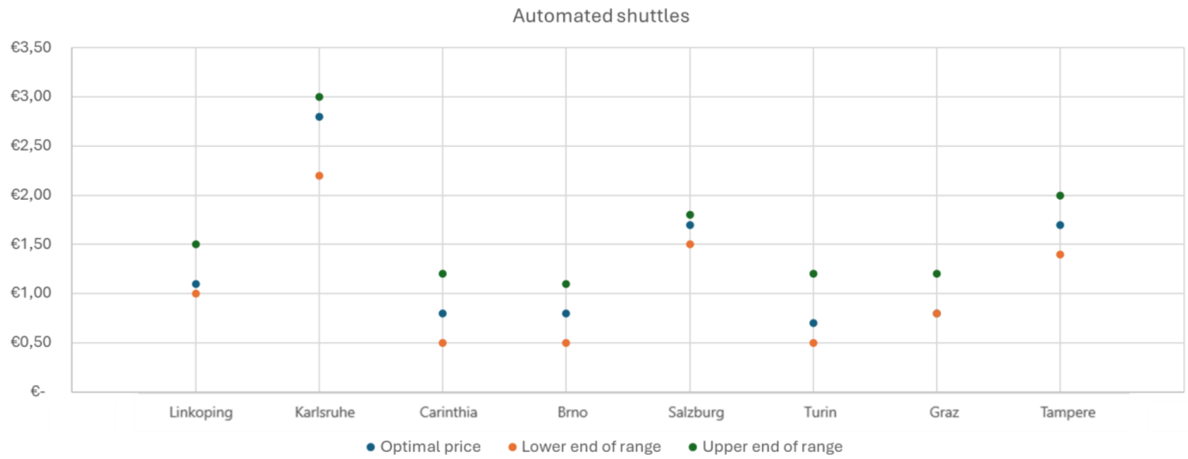

Figure 10 Willingness to pay for automated shuttles across SHOW pilot sites

3.7.1.3. Autonomous cars with ridesharing

For services based on vehicles with ridesharing (such as UberPool), the distribution of WTP across the sites is quite similar to that of shuttles.

The only site where we observe a significant inversion is Turin, where the range of acceptable prices shifts from [0.5 - 1.3] for trains and shuttles to [1.5 - 2.2] for automated cars.

For Karlsruhe, which consistently shows the highest values, the WTP ranges between 2 and 2.6 euros.

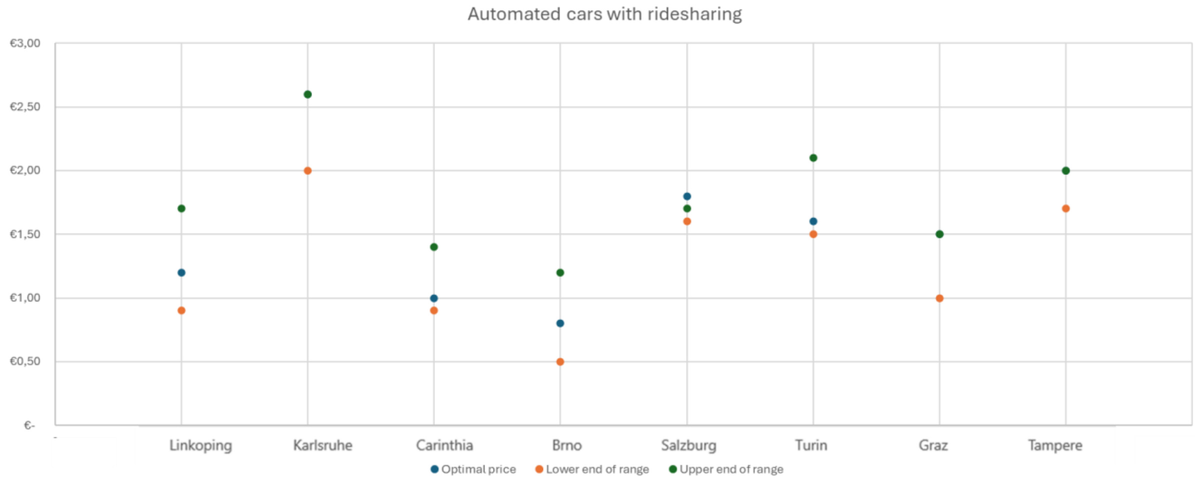

Figure 11 Willingness to pay for automated cars with ridesharing across SHOW pilot sites

3.7.1.4. Autonomous cars without ridesharing

For non-shared cars, the WTP varies significantly between sites, indicating that vehicle sharing has a substantial impact on WTP. In particular, the WTP reaches:

- 2.7 euros in Tampere (compared to a maximum of 2 euros for an automated shuttle)
- 2.5 euros in Salzburg (compared to 1.8 euros if the vehicle is shared)

Conversely, the WTP in Karlsruhe is much lower than for other modes, ranging between 1 and 1.4 euros.

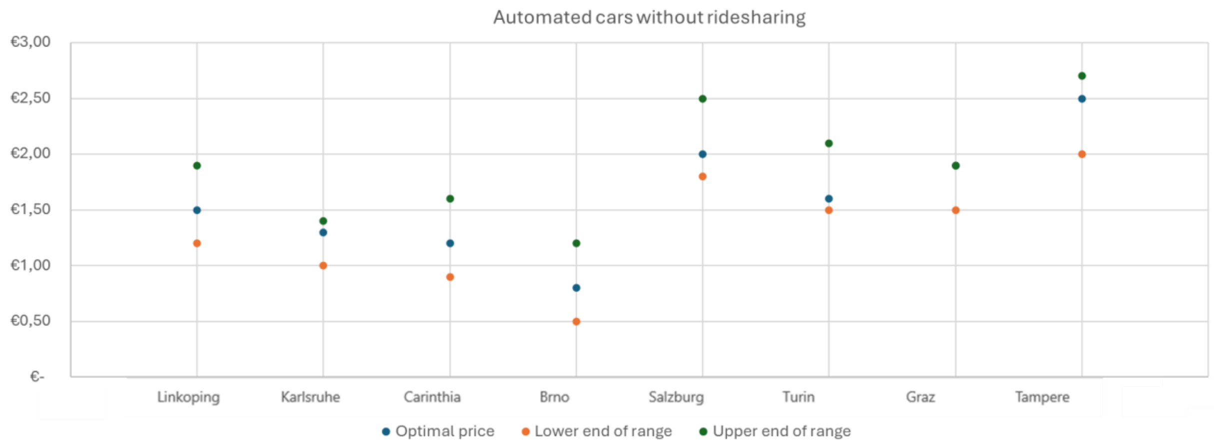

Figure 12 Willingness to pay for automated cars without ridesharing across SHOW pilot sites

3.7.2. At BM level

3.7.2.1. BM based on shuttle

BM1 - Autonomous PT in combination with additional on-demand services

The BM1 concerns:

- the Mega Sites of Linköping (Sweden), Salzburg (Austria), Carinthia (Austria), Frankfurt (Germany) and Les Mureaux (France)
- the Satellite Sites of Trikala (Greece), Brno (Czech) and Turin (Italy).

The optimal price is established at 1,1€, where consumer perceptions of "too expensive" and "too cheap" converge. At this price, the product strikes a balance, being neither overpriced nor undervalued in the eyes of potential customers. Additionally, the indifference price is set at €1.40, a point at which the utility for individuals is maximized regardless of whether they decide to use the service or not. This indicates that at 1,4€, consumers perceive the value of the service as equal to its cost, making their decision to purchase neutral. The acceptable price range for the product spans from 0,80€ to 1,50€, within which consumers find the price reasonable and are likely to consider the service. This range allows for pricing flexibility while maintaining customer satisfaction and market competitiveness.

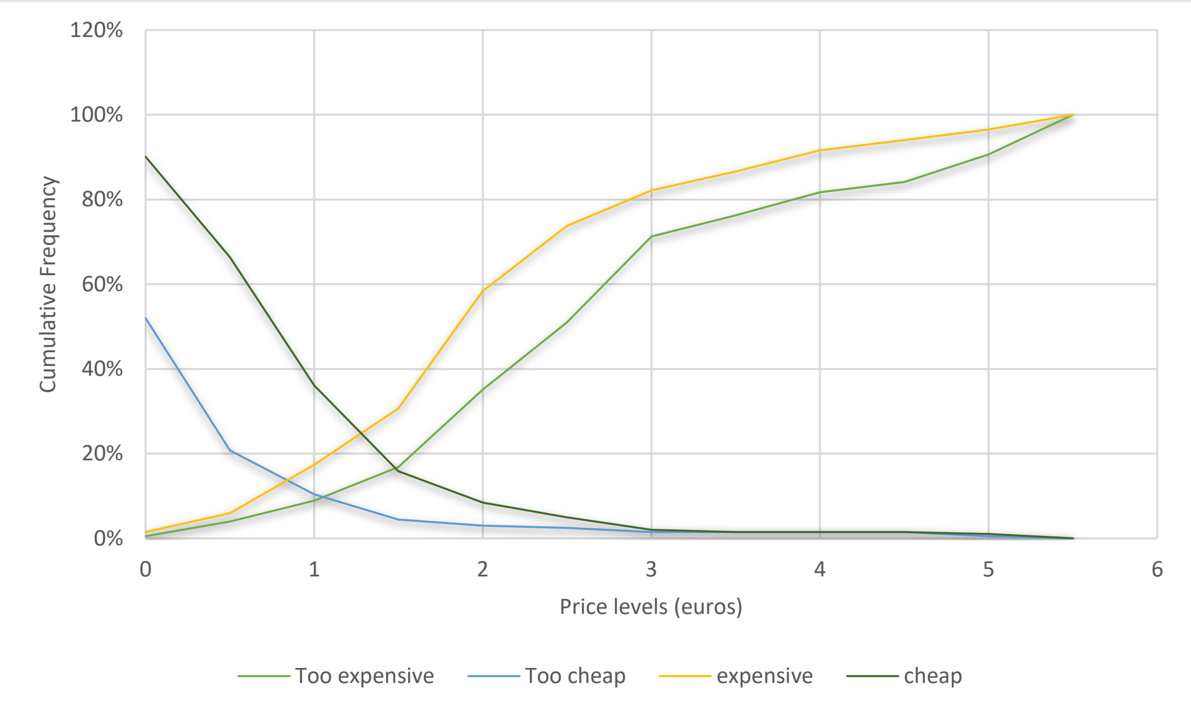

Figure 13 Van Westendorp's Price Sensitivity Meter for BM1

BM4 - Combined MaaS and LaaS

The BM4 concerns the Mega Site of Monheim (Germany) and the Satellite Site of Trikala (Greece).

The optimal price is identified at 0,95€, where consumer perceptions of "too expensive" and "too cheap" converge. This price point ensures that the product is neither perceived as overpriced nor undervalued by potential customers, making it the ideal balance for market acceptance. Additionally, the acceptable price range for the product extends from 0,70€ to 1,20€. Within this range, consumers find the product reasonably priced, offering a flexible pricing strategy while still appealing to a broad customer base. This range allows businesses to adjust prices in response to market conditions and competitive pressures without compromising customer satisfaction.

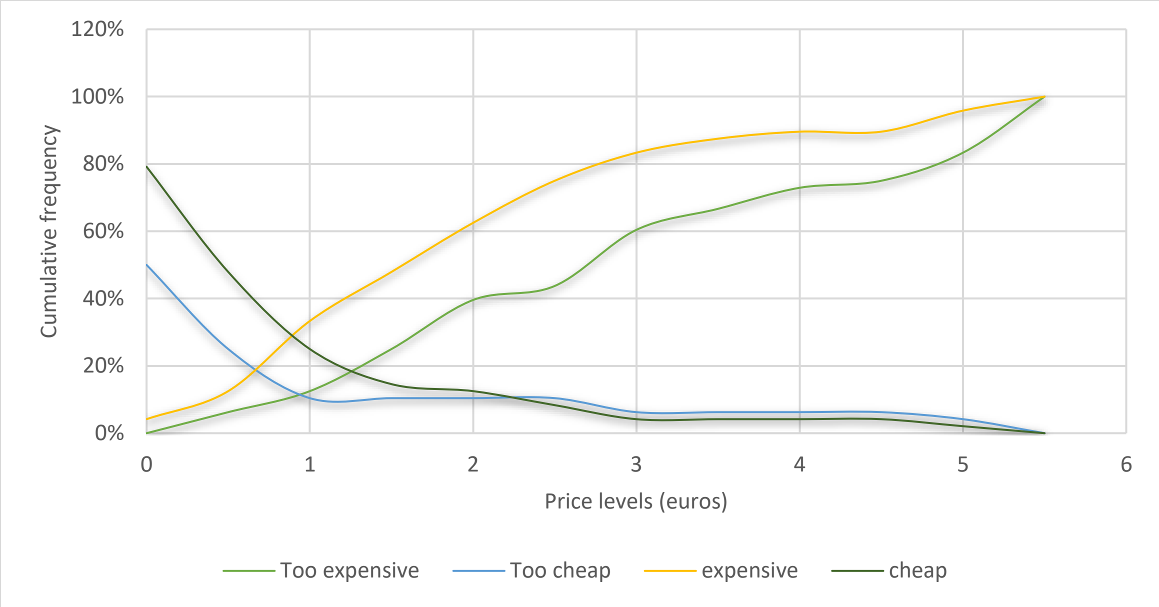

Figure 14 Van Westendorp's Price Sensitivity Meter for BM4

BM5 - Peri-urban automated transportation and C-ITS connectivity

The BM5 concerns the Mega Sites of Karlsruhe (Germany) and Carinthia (Austria), and the Satellite Site of Trikala (Greece).

The optimal price is set at 1,5€, where consumer perceptions of "too expensive" and "too cheap" intersect. This price ensures that the product is neither viewed as overpriced nor undervalued, achieving balanced market acceptance.

Moreover, the acceptable price range extends from 0,6€ to 1,8€. Within this range, consumers find the product reasonably priced, allowing for flexibility in pricing strategies while still appealing to a wide customer base.

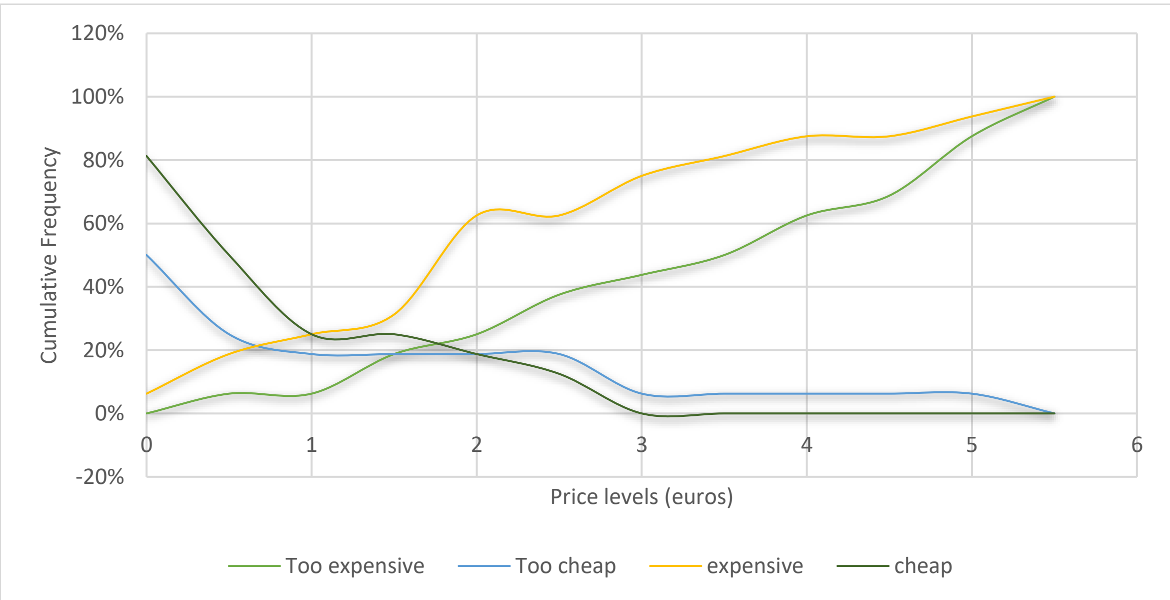

Figure 15 Van Westendorp's Price Sensitivity Meter for BM5

BM6 - Robotaxi services for short distance trips

The BM6 concerns the Mega Sites of Karlsruhe (Germany) and Salzburg (Austria).

The optimal price is established at 0,8€, determined by the intersection where consumer perceptions of "too expensive" and "too cheap" converge. This price point ensures that the product strikes a balance, being neither overpriced nor undervalued in the eyes of potential customers, thus maximizing market appeal.

Furthermore, the acceptable price range for the product extends from 0,5€ to 0,85€. Within this range, consumers find the product reasonably priced, which allows businesses to adjust their pricing strategies in response to market dynamics and competitive pressures while maintaining customer satisfaction. This range provides the flexibility needed to cater to different segments of the market, ensuring that the product remains attractive and accessible to a broad customer base.

In summary, pricing the product at 0,8€ optimizes consumer perception, while the acceptable range of 0,5€ to 0,85€ offers a strategic buffer to accommodate varying market conditions without compromising on consumer acceptance and satisfaction.

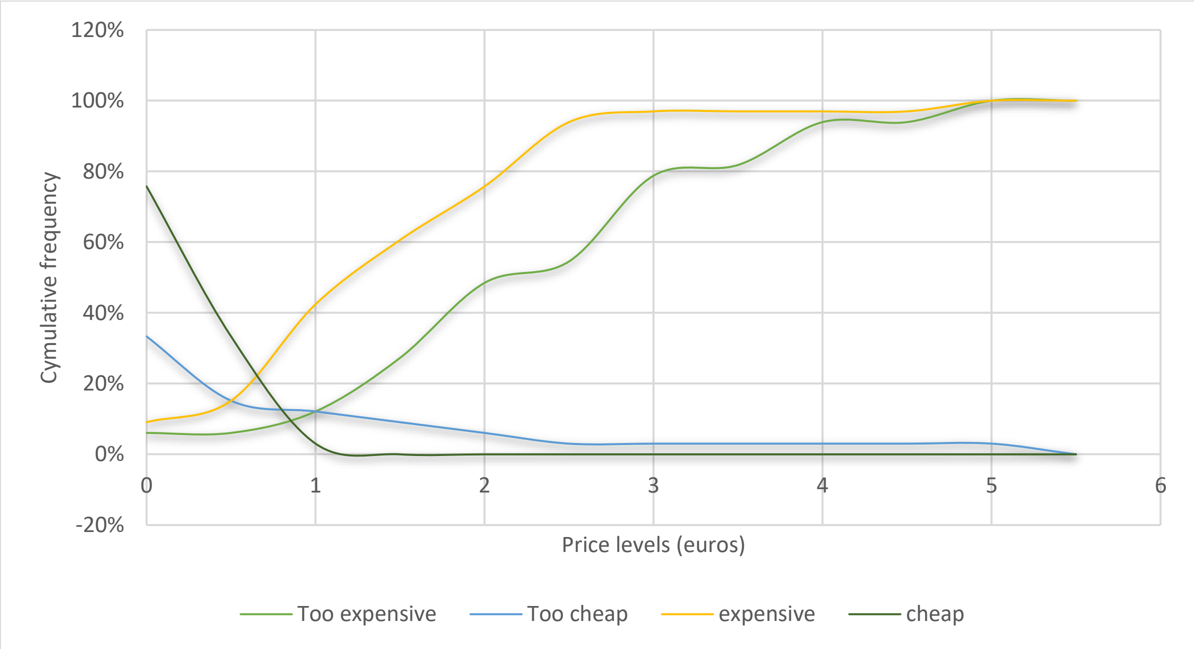

Figure 16 Van Westendorp's Price Sensitivity Meter for BM6

BM7 - Sustainable living areas with autonomous public transportation

The BM7 concerns the Mega Sites of Monheim (Germany), Linköping (Sweden) and Gothenburg (Sweden).

The optimal price point is determined to be €1.20, identified at the intersection of consumer perceptions of "too expensive" and "too cheap." This price point represents a balance where the product is neither considered overpriced nor undervalued by potential customers. Furthermore, the acceptable price range extends from €1.10 to €1.50. Within this range, consumers find the product reasonably priced, ensuring broad market acceptance while allowing for some flexibility in pricing strategy.

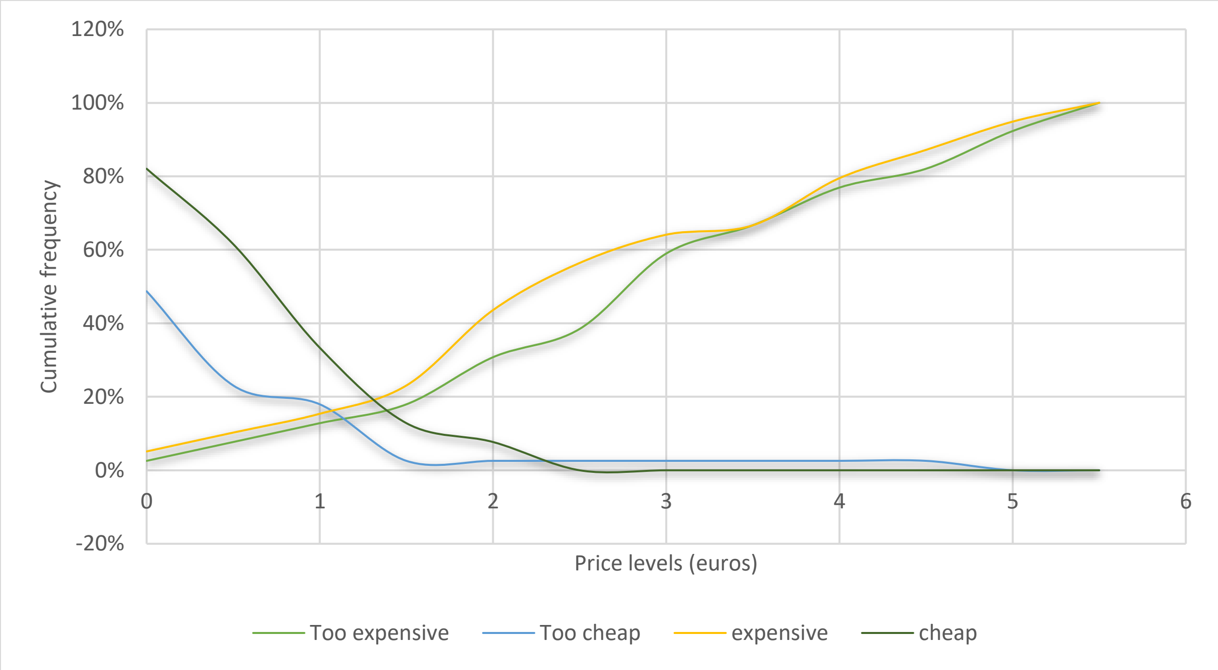

Figure 17 Van Westendorp's Price Sensitivity Meter for BM7

BM8 - First/Last mile autonomous transportation to mobility HUBs

The BM8 concerns:

- The Mega Sites of Frankfurt (Germany), Karlsruhe (Germany), Linköping (Sweden), Gothenburg (Sweden), Salzburg (Austria), Carinthia (Austria) and Les Mureaux (France),
- The Satellite Site of Brno (Czech) and Tampere (Finland).

The optimal price is set at 1,2€, determined by the intersection where consumer perceptions of "too expensive" and "too cheap" meet. This price ensures the product is seen as fairly valued, striking the right balance for market appeal.

The acceptable price range spans from 0,8€ to 1,5€. Within this range, consumers find the product reasonably priced, allowing for flexibility in pricing strategies while maintaining broad customer acceptance.

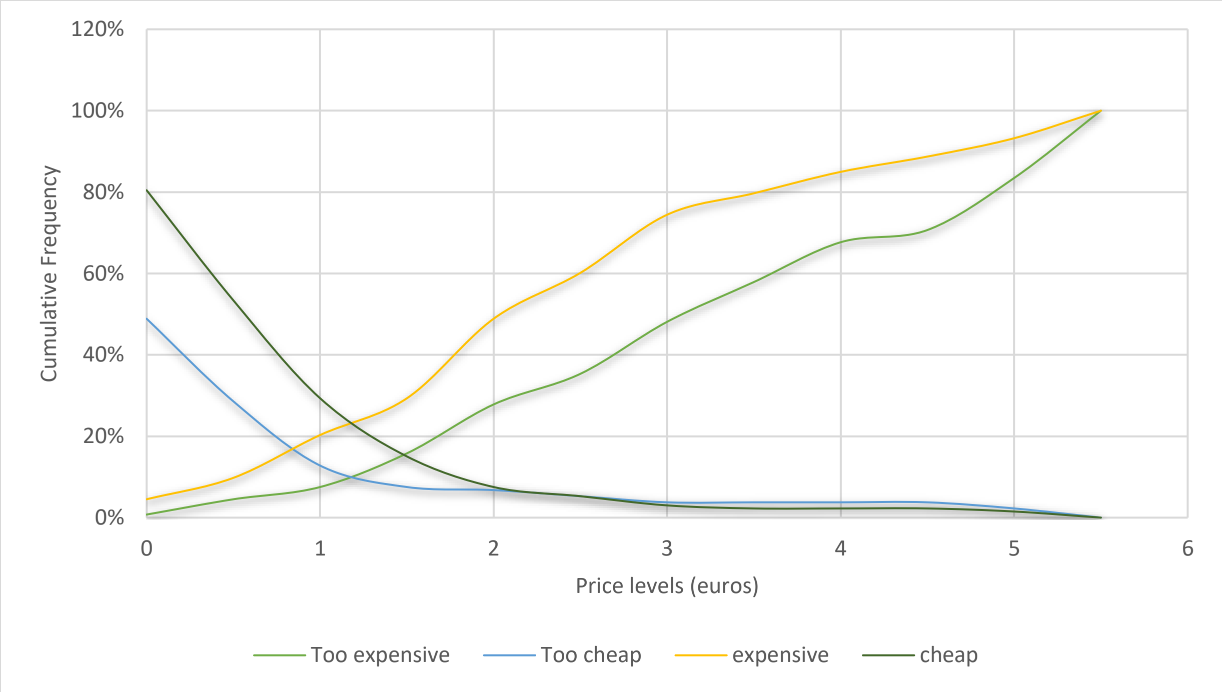

Figure 18 Van Westendorp's Price Sensitivity Meter for BM8

BM10 - Interoperable IoT platforms for automated mobility

The BM10 could be based on shuttles or on cars with or without ridesharing. It concerns:

- The Mega Sites of Gothenburg (Sweden), Graz (Austria) and Carinthia (Austria),
- The Satellite Sites of Turin (Italy) and Tampere (Finland).

The optimal price is 1,2€, identified at the intersection where consumer perceptions of "too expensive" and "too cheap" converge. This price point ensures the product is seen as fairly valued, striking an ideal balance to maximize market appeal.

The acceptable price range spans from 0,9€ to 1,5€. Within this range, consumers find the product reasonably priced, providing flexibility for businesses to adjust their pricing strategies based on market conditions and competitive pressures. This range ensures that the product remains attractive and accessible to a broad customer base, accommodating different segments of the market while maintaining customer satisfaction and acceptance.

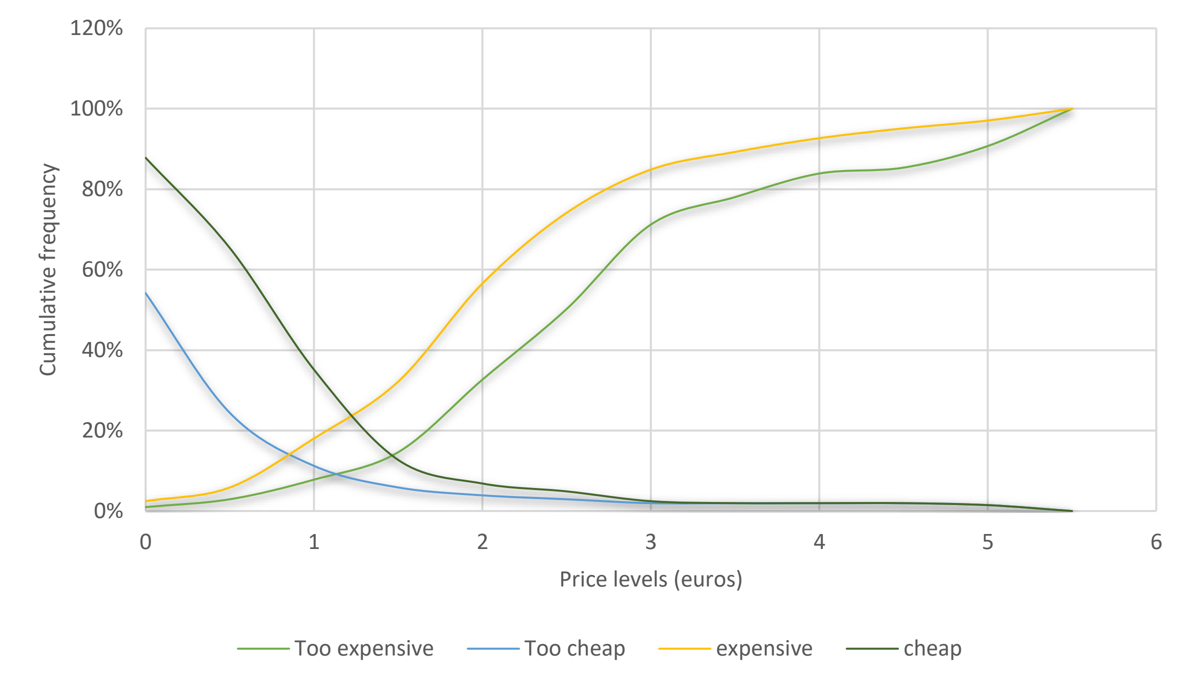

Figure 19 Van Westendorp's Price Sensitivity Meter for BM10

3.7.2.2. BM based on cars with ridesharing

BM4 - Combined MaaS and LaaS

The optimal price is 0,9€, found at the point where consumer perceptions of "too expensive" and "too cheap" meet. This price strikes a balance, ensuring the product is perceived as appropriately priced for its value. Moreover, the acceptable price range extends from 0,9€ to 1,4€. Within this range, consumers consider the product reasonably priced, allowing businesses to adjust their pricing strategies to meet market demands while maintaining broad customer appeal.

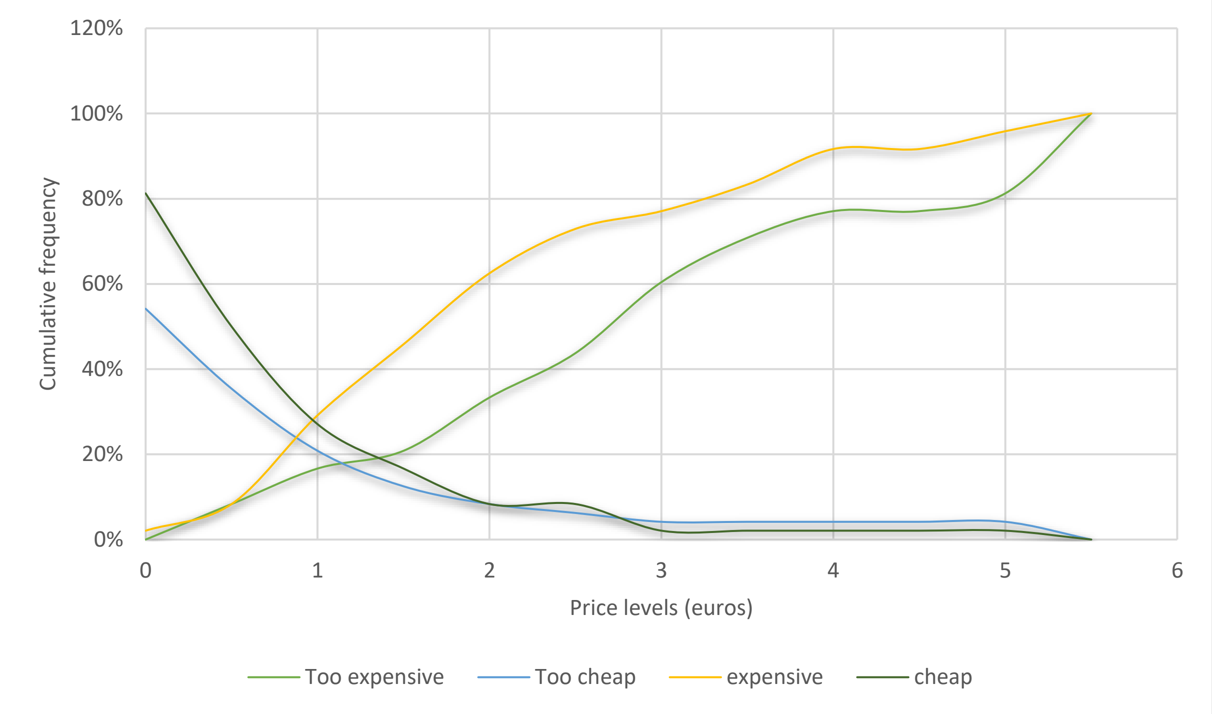

Figure 20 Van Westendorp's Price Sensitivity Meter for BM4

BM10 - Interoperable IoT platforms for automated mobility

BM10 is priced optimally at 1,4€, striking a balance where perceptions of being "too expensive" and "too cheap" converge effectively. Moreover, the acceptable price range for BM10 spans from 1€ to 1,7€, ensuring that consumers perceive the product as reasonably priced across different market conditions and competitive landscapes. This range allows for strategic pricing adjustments while maintaining broad appeal and customer satisfaction.

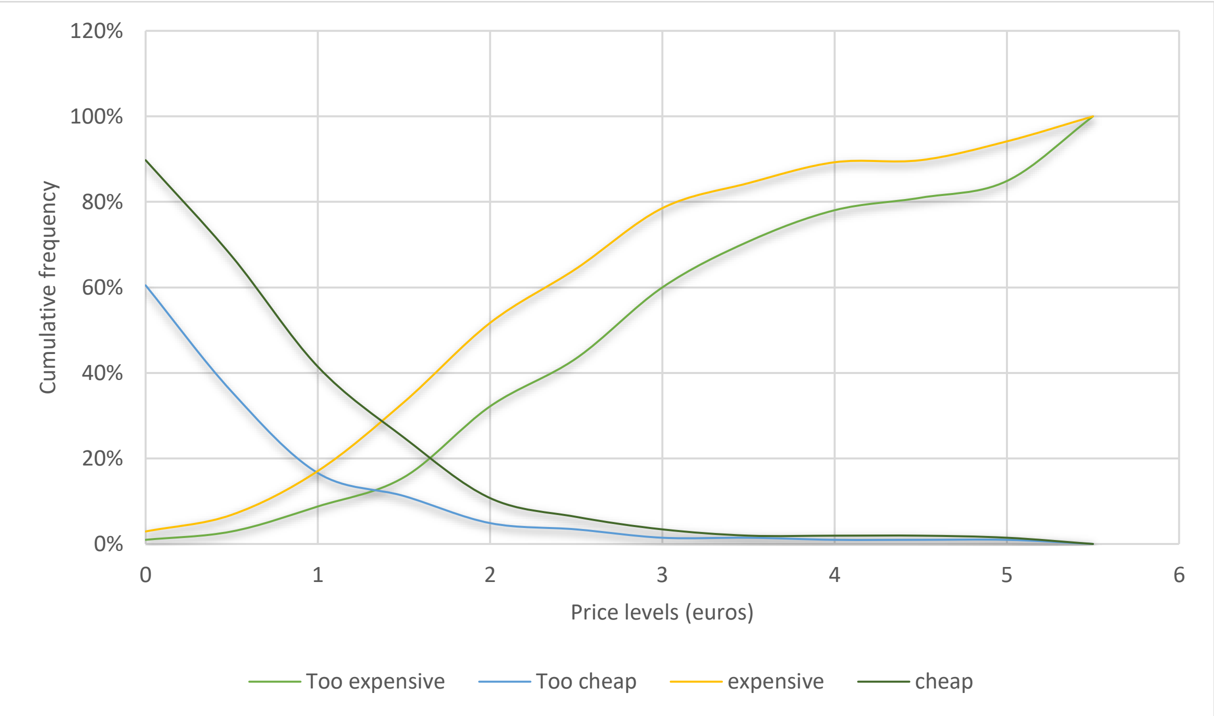

Figure 21 Van Westendorp's Price Sensitivity Meter for BM10

3.7.2.3. Summary

The following table presents a summary for the three business models: autonomous shuttle, autonomous car with ridesharing, as the autonomous train and autonomous cars without ridesharing are not part of the SHOW project.

For autonomous shuttles, we observe consistent values across the different business models. The optimal WTP ranges from 0.8 to 1.5 €, with the majority of cases exceeding 1€.

For the business models based on cars with ridesharing, the values vary significantly between BM4, BM6, and BM10.

In addition, the average value of the optimal price for BM based on cars is 1.2 times higher than that of BM based on autonomous shuttles.

Table 61 Summary of results of the Van Westendorp's Price Sensitivity Meter

	Business model	Optimal price	Lower acceptable price	Upper acceptable price
Based on automated shuttles	BM1	1,10 €	0,80 €	1,50 €
	BM4	0,95 €	0,70 €	1,20 €
	BM5	1,50 €	0,60 €	1,80 €
	BM7	1,20 €	1,20 €	1,50 €
	BM8	1,20 €	0,80 €	1,50 €
	BM10	1,20 €	0,70 €	1,50 €
	Average	**1,09 €**	**0,74 €**	**1,38 €**
Based on cars with ridesharing	BM4	0,90 €	0,90 €	1,40 €
	BM6	0,80 €	0,50 €	0,85 €
	BM10	1,50 €	1,00 €	1,70 €
	Average	**1,20 €**	**0,95 €**	**1,55 €**

3.8. PESTEL Analysis

3.8.1. Carinthia

Political, Legal and Governance

Establishing a good relationship with the municipality, local government, and federal authorities in Carinthia is crucial for the successful validation of business models for autonomous vehicle projects. This positive rapport ensures smooth communication and cooperation, which significantly reduces potential issues. Comprehensive risk analyses are conducted to obtain the necessary permissions, reflecting a proactive approach to compliance and safety. However, it is important to highlight that teleoperation is strictly prohibited on public streets, presenting a notable operational limitation. The vehicles are also subject to a speed limit of 20 km/h, a restriction aimed at enhancing safety in urban environments. Furthermore, the presence of a safety driver is mandatory, underscoring the commitment to maintaining high safety standards throughout the testing and operational phases.

Economy

The cost of operating autonomous vehicle shuttles presents significant challenges, especially given the experience with Navya, which eventually went bankrupt. Despite the lack of infrastructure issues or the need for changes, the technology remains prohibitively expensive. The shuttles are free for users, but the high purchase price and ongoing costs, such as license and maintenance fees, are substantial. The mandatory presence of a safety operator in Austria further exacerbates these costs, making the operation of autonomous buses more expensive for public transport operators compared to conventional buses. As a result, the financial burden is considerable unless there is a reduction in these costs. Currently, public transport authorities find it nonsensical to bear these high maintenance and license fees along with the safety operator requirements. To bridge this gap, government funding is essential, as all public transport operations are typically subsidized by the government. Only with decreased costs will this technology become viable for public transport operators. Additionally, only the SHOW surveys (including pre-acceptance and acceptance surveys with questions about willingness to pay) have been conducted to gauge public reception and potential user engagement.

Social and Acceptability

The autonomous shuttle has tested positively, particularly regarding accessibility, as it is equipped with an electric ramp. Tests conducted with seniors and disabled individuals have shown that the shuttle is well-received by these groups. The integration of the shuttle with other public transport services, including booking platforms, enhances its usability and convenience. While it serves tourists during peak seasons, elderly residents, and children during special school events effectively, it sees limited use by middle-aged commuters. The shuttle connects key points of interest, such as the train station, city center, and lake, making it an attractive option for tourists. Additionally, SURAAA organizes numerous events with citizen participation to boost acceptance and engagement with the autonomous shuttle. This proactive approach helps to familiarize the community with the technology and its benefits, thereby fostering greater acceptance.

Technology

The service is suspended in winter due to challenges posed by snow piles, which hinder the shuttle's operation. A recent software update has led to significant improvements, particularly in reducing hard braking incidents, thereby enhancing passenger safety and comfort.

Environment and Congestion

To accommodate the shuttle, a one-way street was created because the usual two-way streets were too narrow. In Klagenfurt, only two parking spaces had to be removed to make room for the shuttle, demonstrating minimal disruption. Despite these efforts, having only one shuttle limits its overall impact and makes it challenging to achieve a significant difference in the transportation network.

3.8.2. Frankfurt

Political, Legal and Governance

The stakeholders involved in the project include the Public Transport Authority of Frankfurt, responsible for overseeing public transportation operations, as well as the Public Transport Operator for metro and tram services within the city. Additionally, the local government's involvement through the city's PTA is crucial for project success. While stakeholders have shown interest in the project and actively engage in learning and collaboration, there is less enthusiasm from the city itself. One of the main challenges encountered is communication with local stakeholders, particularly those entrenched in traditional political structures. To overcome this challenge, there is a need to rethink the process within public transport frameworks and emphasize the benefits to local authorities and customers alike. Convincing stakeholders of the project's benefits, both in terms of improved transportation services and increased public transport usage overall, is key to its success.

Economy

The pilot project, does not generate any economic benefit since the shuttle service is offered free of charge. To achieve economic sustainability, it is essential to centralize and harmonize the shuttle's software through a control center that can manage multiple cities efficiently. Despite these efforts, the costs remain prohibitively high, particularly for the vehicles themselves, and are expected to stay elevated in the coming years. Therefore, substantial funding is required at both the EU and local levels to support the continuation and expansion of this initiative.

Social and Acceptability

Due to the limited speed of the autonomous shuttle, it has proven to be an excellent service for elderly individuals and people with disabilities, including those using wheelchairs. The elderly population found the public transport offer particularly attractive, especially in neighborhoods with limited metro access. With only one metro station within a 15-minute walking distance, the shuttle provided a much-needed solution for higher-distance travel. The safety record of the shuttle service is commendable, with no accidents reported due to its frequent stops.

The implementation required 7-8 safety drivers, without creating entirely new positions, as existing metro drivers partly filled these roles. In terms of job creation and reduction, the public transport authority (PTA) does not foresee a reduction in positions over the next decade. Any reduced positions will be needed for other roles within the organization. Currently, a few shuttles are managed by one controller, supported by technicians on the road. In the long run, it is anticipated that 50% fewer shared robotaxis on demand will be needed after ten years, depending on technological advancements. However, finding staff for driving jobs is currently challenging, making it difficult to scale up operations. The optimal ratio of controllers to vehicles (currently one operator per ten vehicles) is not yet clear, but the goal is to achieve a high rate of vehicles per operator.

Safety operators are highly motivated to learn their new roles and are open to discussions and interviews. These roles were previously decided among metro and tram drivers, who were keen to take on the new responsibilities. Communication with local customers, who wished to engage with service roles that will not exist in the future, has been positive. Looking ahead, new roles will emerge, particularly in managing an on-demand fleet. This fleet will include a small share of vehicles with guidance for children and the elderly. However, these vehicles will need to be upgraded, similar to metro systems without onboard personnel, incorporating advanced communication systems and AI-driven call functionalities.

Technology

The booking software for the autonomous shuttle service is highly efficient, resulting in not too long waiting times for users. Despite this, the current technology operates at Level 4 but is effectively more aligned with Level 3. This limitation means that the shuttle cannot function without an operator in various situations, such as encountering obstacles. Efforts are ongoing to achieve true Level 4 automation through other projects, but not within the scope of the SHOW initiative.

Future advancements in communication with traffic lights could enhance the system's efficiency. Additionally, road markings for parking and waiting positions have been implemented, though they required the removal of two parking spaces. Some negative feedback has been received from other drivers due to the shuttle's slow driving speed.

The app associated with the shuttle service allows users to see the arrival time and live position of the shuttle, providing convenience and transparency. To ensure the success of such services, the technological infrastructure must be robust and flexible. The vehicle must be capable of navigating through different areas independently, without incurring significant infrastructure costs, making it affordable for cities to implement.

3.8.3. Graz

Political, Legal and Governance

The City of Graz and its Public Transport Operator have shown considerable interest in automated mobility, largely driven by the ongoing challenges related to bus driver shortages. However, obtaining the necessary permits for testing automated vehicles remains a complicated and lengthy process, involving extensive safety documentation and regulatory compliance.

One of the significant challenges faced was acquiring an extraordinary permit to operate the shuttle in bus lanes, which are typically restricted to other vehicles. The Navya shuttles were granted this permit, but it required establishing a new legal framework to allow such operations.

Furthermore, current regulations in Austria mandate that a safety driver must be inside the vehicle, at least for the next 1.5 to 2 years, ensuring immediate human intervention if necessary. This requirement underscores the importance of safety and regulatory adherence during the transitional phase towards fully autonomous public transport solutions.

Economy

Including a safety driver in the autonomous shuttle service is expensive. If the technology advances to a point where the service driver can be removed, it is anticipated that the system could operate successfully. Users are expected to pay the same amount as they would for a taxi, provided the service quality is equivalent. In Graz, there is a higher willingness to pay for robotaxis compared to shuttles, as robotaxis offer the flexibility to choose the destination. Economic success for this model relies on having a high number of individual vehicles and achieving economies of scale.

Social and Acceptability

Insights from a super user event revealed that users who tested the autonomous shuttle service expressed interest in an extended service, similar to a taxi, where they could choose their destination for a more flexible experience. This feedback highlights the potential for a more adaptable service with multiple stops. The event also provided insights into job creation, with two new roles focusing on developing programmers, testing, implementing, and preparing HD maps. The safety driver role was filled by researchers, eliminating the need for additional hires.

The prototype cars were developed at a research center. From the Public Transport Operator (PTO) perspective, scaling up the project would not require hiring new drivers but would necessitate establishing new service centers at pilot sites and employing remote operators. This expansion would impact all types of users, including students, and would involve using the public bus terminal along a bus line with higher frequency.

The service was operated for a limited duration during the week over a few weeks each year, led by researchers. This model provided valuable data on user interactions and service feasibility in a real-world setting.

Technology

During the pilot, no critical safety situations were encountered, demonstrating the overall robustness and reliability of the autonomous shuttle system. However, there were instances where driver intervention was occasionally required, highlighting areas where the technology still needs improvement. The pilot also successfully tested communication with existing infrastructure, validating the integration capabilities of the shuttle within the urban environment.

While the results were promising, with high levels of user satisfaction and operational success, there is still a need for further progress to fully enhance the system's autonomy and reliability. This includes refining the shuttle's ability to handle more complex driving scenarios independently, reducing the need for human intervention, and improving its interaction with dynamic urban environments. Continued advancements in these areas are crucial for the future scalability and acceptance of autonomous shuttle services as a viable component of the public transport network.

The positive outcomes of the pilot provide a strong foundation for future developments, but they also underscore the importance of ongoing research and iterative testing. This will ensure that autonomous shuttle technology can meet the safety, efficiency, and convenience expectations of all stakeholders, paving the way for broader adoption in diverse urban settings.

Environment and Congestion

The pilot program for the autonomous shuttle service was limited in scope, ensuring that it did not compete directly with existing public transport (PT) services. Instead, it aimed to fill gaps in areas where public transport was not as attractive or convenient for users. The shuttle shared the bus lane with conventional buses, which allowed for an efficient use of existing infrastructure without negatively impacting public space.

Despite these constraints, the pilot demonstrated the potential of autonomous shuttles to complement and enhance the public transport network by providing flexible and convenient transportation options in underserved areas. This approach allowed the service to address specific mobility needs without disrupting or displacing existing public transport services. The pilot's successful integration with bus lanes also showcased the feasibility of shared infrastructure use, reducing the need for additional dedicated lanes and minimizing urban space consumption.

3.8.4. Linkoping

Political, Legal and Governance

The pilot project involved eight key stakeholders, each playing a vital role in its execution and success. These stakeholders included the Linköping Municipality, which provided local governance and support; the regional authorities, and the owner of housing developments. Linköping Park contributed by providing essential infrastructure and public space for the shuttle's operations.

Linköping University offered research and technological insights. Transdev, the operational partner, managed the day-to-day functioning of the shuttle service. The Swedish National Road and Transport Research Institute (VTI) handled depot management and logistical support, while RISE, the government research institute, provided overarching research and innovation guidance. This collaborative approach ensured that the pilot was well-supported across multiple dimensions, from governance and infrastructure to research and operations.

Economy

Removing the driver from the autonomous shuttle service is not possible yet, as the role of the driver remains critical from both a security and safety perspective. Drivers are responsible for securing wheelchairs, answering questions from users, providing support, and ensuring passenger confidence during hard braking incidents. Their competence is essential for maintaining high service standards, making it easier for them to focus on user assistance rather than driving the shuttle.

While the business model of removing the driver might become viable in 2-3 years, this depends heavily on overcoming the current shortage of drivers. In the meantime, the focus is on enhancing the skills of the personnel in the shuttle, who are not drivers but provide crucial support services to passengers. Additionally, integrating advanced sensors into the vehicles instead of relying on infrastructure-based solutions can help reduce costs and improve operational efficiency.

Social and Acceptability

The autonomous shuttle service has been generally well-received by the public. About 25% of users are typically car users, while the remainder are primarily pedestrians or cyclists. The primary objective is to prioritize active mobility, encouraging people to leave their cars at home. The shuttle service aims to support this goal by providing a convenient and accessible transportation option for everyone, including people with visual and cognitive impairments, children, and the elderly.

The service has significantly improved accessibility, with a dedicated website allowing users to track the shuttle's location. This feature has been beneficial, although there have been instances where people called in because they couldn’t see the bus. Ensuring that the shuttles meet accessibility standards is crucial, especially for visually impaired users and those with cognitive impairments. Issues such as the distance between the ramp and the pillar and the problem of hard braking, which can be challenging for more vulnerable users, need to be addressed. For example, a service dog of a blind person fell due to a hard brake. Adaptations such as different sounds for vehicle notifications and ramp movements are also important for assisting blind passengers.

While the autonomous shuttle generally feels safe due to its slow speed, hard braking remains an issue, particularly for fragile users. The Navya shuttle currently does not have enough room to accommodate both a wheelchair and a driver, which limits its functionality. Additionally, post-COVID, there is a challenge in regaining users and ensuring the correct target audience is attracted, particularly shifting car users rather than those who already practice active mobility. Despite these challenges, the shuttle service has facilitated access to local amenities for elderly users, enhancing their quality of life.

Over the past five years, there has been no reduction in job positions. The future demand for the service will determine whether additional hires are necessary. During the pilot, nine shuttle operators were employed, with 60% of their working hours dedicated to the shuttle service and 40% at another site, managed by Transdev. There was no need to hire new staff for the pilot, as existing employees were trained for the role. Transdev hired one new person, expecting to add more staff in the future as the demand grows. Training for bus drivers includes obtaining a D license, which involves 140 hours of professional driver education and one week of training specifically for Navya or Easymile shuttles.

Technology

There have been notable improvements in the vehicle's performance, particularly in reducing hard braking incidents. Although these improvements have been significant, hard braking continues to occur occasionally, posing a critical issue, especially if the shuttles were to operate remotely in the future. To address safety concerns, a foldable safety arm was developed by the Linköping pilot team, showcasing innovative solutions tailored to enhance user safety.

However, operational challenges persist, such as the need to regularly cut grass along the shuttle's route. This maintenance is necessary because the shuttle's lidar system, which helps navigate the road, can misinterpret grass on sloped surfaces as obstacles. Additionally, there was a technical problem with one of the shuttles, exacerbated by the bankruptcy of Navya, the vehicle manufacturer, complicating maintenance and support.

Environment and Congestion

It was not possible to definitively measure or state if there was a significant change in environmental conditions due to the pilot. However, the use of electric vehicles does suggest potential positive impacts on noise and pollution, particularly if the service were to scale up. In terms of public space, there were minimal changes. Bus stop signs and colored dots were used to help users understand the shared area, ensuring the shuttle's integration was clear and accessible.

Maintenance of the shuttle route required regular grass cutting to prevent the lidar system from misinterpreting grass as obstacles, especially on sloped roads. Additionally, snow banks posed challenges that needed to be managed to keep the shuttle operational. Importantly, the implementation of the shuttle service did not necessitate the removal of any public spaces, ensuring that the community's existing infrastructure remained largely unaffected.

3.8.5. Trikala

Political, Legal and Governance

The integration of stakeholders was a crucial aspect of the project, involving various sectors including public entities (such as different departments from the municipality and the ministry), private companies (operators and Intelligent Transport Systems - ITS), and non-governmental organizations. An event held in June ensured the presence of diverse stakeholders, reflecting a high level of political consensus and collaboration.

However, several challenges were identified, particularly in the need for legislation and legal permits. The current legal framework requires more flexibility and adaptation to align with the technological advancements being made. Initially, the project benefited from accelerated processes, but for sustained progress, legal aspects must evolve in tandem with technological developments. This alignment is essential to facilitate smoother implementation and broader adoption of autonomous mobility solutions.

Economy

The public transport system has limited resources, and the integration of autonomous vehicles aims to address these challenges by requiring less personnel and providing more operational flexibility. From an economic perspective, the project involved significant capital expenditures and operational expenditures. Running the AV service as a pilot places it somewhat in the middle, but the initial investment (CAPEX) represents a significant budget, especially if not supported by a research project.

The project benefited from high CAPEX investments, including vehicles and infrastructure. To cover these costs, two national funding sources were utilized under the recovery and resilience plan. Looking towards the future, economic sustainability will require developing a broader market with more affordable vehicles to continue operations post-project. Reducing infrastructure costs and securing additional funding will be crucial. Capitalizing on national funding opportunities will also be necessary to advance and sustain the benefits of autonomous mobility solution.

Social and Acceptability

The autonomous vehicle service is ongoing and provides numerous benefits to active populations and individuals with special needs. The pilot area, previously underserved, has greatly benefited from improved accessibility through the AV service. The integration with existing public transport is well-executed, supported by an app that combines AV schedules with other public transport options, making it a seamless experience for users.

This integration has made the service attractive to the local community, and there is a need to accelerate its adoption. The service line crosses the university, specifically targeting students to help boost usage and accelerate the acceptance of AVs. By focusing on this demographic, the service aims to establish a strong user base that can advocate for and demonstrate the advantages of autonomous mobility solutions.

Technology

The technology used in the autonomous vehicle service is mature, with supervision provided from a central control center. While there is data available on accidents involving automated vehicles, there is a lack of comprehensive data on accidents within the entire network. One of the key advantages of this service is the provision of real-time information for users. They are informed exactly when the vehicle will arrive, the route it will take, and the duration of the journey. This is a significant improvement compared to traditional bus systems, where real-time information is often not shared with passengers.

Operating in a real-life environment presents challenges, including navigating real-world obstacles. However, the AV service has been well-designed to handle these situations, providing a reliable and predictable transportation option. The availability of precise, real-time data enhances the overall user experience, making the AV service a compelling alternative to conventional public transport.

Environment and Congestion

The objective of the autonomous vehicle service is to enable a reduction in emissions and noise. Although this reduction has not been quantitatively measured, anecdotal evidence suggests that some users of this route were previously car drivers. This shift from car usage to the autonomous vehicle service is expected to contribute to lower emissions and reduced noise levels in the area. The transition of car drivers to this service underscores its potential environmental benefits, which, although not yet quantified, align with broader sustainability goals.

3.8.6. Gothenburg

Political, Legal and Governance

The Gothenburg pilot for the SHOW project with collaboration from Ericsson was focused on implementing 5G and remote operation technologies. However, due to regulatory constraints, permission to operate without a safety driver has not been granted. The current state of the vehicles is deemed immature for driverless operations. Authorities have indicated that with more advanced vehicles, they may consider allowing operations without a driver. Initially, public transport authorities were interested in the potential of the shuttles, but the immaturity of the technology has tempered their enthusiasm. Continued advancements in vehicle technology are necessary to gain regulatory approval and fully realize the benefits of autonomous operations.

Economy

In the Gothenburg pilot, local public transport tickets allow passengers to use the shuttles without any additional charge. This integration aims to make the service more accessible and appealing to the general public. However, there are economic challenges, including accurately calculating the real cost of the service. Initially, there were few passengers, and the fixed cost of the driver remained constant regardless of ridership. Interestingly, the number of passengers increased during rainy weather, highlighting variability in demand.

The primary goal of the service is to target private car users rather than those who typically walk or cycle. By attracting car users, the service aims to reduce traffic congestion and environmental impact, encouraging a shift towards more sustainable transportation options.

Social and Acceptability

The accessibility of the service has room for improvement. While the service aimed to reduce walking and encourage the use of bicycles, it has not yet fully addressed the needs of disabled individuals. It remains challenging to onboard disabled passengers easily, highlighting an area that requires significant enhancement. The service primarily focuses on elderly users, who have expressed satisfaction with it, though issues with hard braking have caused discomfort, sometimes leading to passengers falling from their seats.

The shuttle service is integrated into the public transport network, with the main users being students and employees commuting to and from the university or nearby park. A key challenge remains increasing the service's attractiveness and accessibility, making it more reliable and faster, and identifying routes that appeal to private car users to encourage a modal shift.

Investing in accessibility features for people with disabilities is crucial. Removing the driver, while a goal, needs to be carefully managed to ensure passengers can receive assistance, such as being seated securely to mitigate the effects of hard braking. This investment will help make the service more inclusive and user-friendly.

Technology

The autonomous shuttles in the project operated slower than other public transport options and vehicles. This was particularly evident in parking lots, where the shuttles' slow speeds caused delays, especially when vehicles were exiting the parking areas. Instances where garbage trucks blocked the way and at bus stops during loading and unloading further contributed to the slow pace.

Navya and Keolis have successfully integrated the shuttles into the public transport system, allowing users to see scheduled times. However, reliability issues have prevented users from fully depending on the service. Initial problems with sensors required a longer testing period, delaying the intended October (2022) tests to February (2023). For the shuttles to be a dependable part of public transport, their reliability must be significantly improved.

The service has experienced minor accidents, such as bumping into other vehicles, resulting in scratches and halting operations for half a day. Additionally, a broken window posed a maintenance issue. Although these incidents did not cause personal injuries, they highlighted the need for enhanced reliability and durability. The real-time information provided was often inaccurate, reflecting a lack of integration and further undermining user confidence.

Environment and Congestion

It is challenging to assess the environmental impact of the autonomous shuttle service, as it is not clear if the shuttle replaced trips that would have otherwise been made by walking or biking. Therefore, while the service aims to reduce car usage and its associated emissions, it is difficult to quantify the actual environmental benefits without further data.

3.8.7. Madrid (Carabanchel)

Political, Legal and Governance

The entire ecosystem in Madrid has shown strong interest in the autonomous shuttle project, with many companies, including startups and large corporations, eager to participate in testing. This strong interest underscores the potential and attractiveness of autonomous mobility solutions.

However, significant challenges remain, particularly regarding political support and regulatory adaptation. Political backing is crucial for driving the project forward and ensuring its success. Current regulations need to be adapted to the realities of CCAM, as they have significantly hindered progress.

Liability issues also pose a challenge, as it is essential to clearly define responsibility in the event of an accident, including insurance aspects. To summarize, the primary challenges lie in the legal aspects and obtaining the necessary permits, which are crucial for the project's advancement.

Economy

The CAPEX and OPEX are not fully clear at the moment. The initial investment is substantial, with an estimated 26% increase required to convert a regular bus into an autonomous one, making it not cost-effective currently. Consequently, the autonomous shuttle service is not yet competitive or profitable.

The potential for reducing public transport costs through an autonomous depot is doubtful, as public transport is largely subsidized, and automation alone may not offset these subsidies. It is possible that the public transport operator might cover more costs without subsidies, but significant financial benefits are not expected in the short term. Comparing autonomous and regular buses, beyond the initial investment, the operational costs should not be significantly higher due to reduced personnel involvement.

A major challenge lies in the purchase of the shuttle or automated vehicle. Operational challenges also arise when relying on third-party companies for operations, such as Navya or EasyMile. Ensuring seamless operations and maintenance while dependent on external providers adds complexity and potential risk to the project's success.

Social and Acceptability

No significant changes were expected in terms of accessibility and quality of service in Madrid, as both are already at a high standard. The profile of users, particularly the elderly, indicates that having a driver available is important. Removing the driver would not necessarily increase the service's attractiveness. The presence of a safety operator on-board is crucial for addressing any issues or accidents that may arise.

One of the main challenges is public acceptance. There is a general reluctance among users to board a bus without a driver, and concerns about sharing space with unknown people. This apprehension is different from the acceptance of autonomous subways, which follow a fixed track and are perceived as more predictable and safer. Overcoming these psychological and social barriers is essential for the successful implementation of autonomous shuttle services in Madrid.

Technology

The autonomous buses in the pilot project demonstrate notable efficiency, capable of performing multiple operations seamlessly. The technology used for supervision, detection, and overall robustness is mature enough and functions well within a semi-controlled environment. The buses are connected to a central control system, allowing real-time information sharing and enhancing operational coordination.

From a technological standpoint, there are no significant challenges. The main concern might be from the operator's perspective, particularly regarding the maintenance of the technology. Ensuring that the system remains operational and effective requires diligent maintenance practices, but overall, the technology's performance and integration have been successful.

Environment and Congestion

The buses used in the pilot project are already electric, so the shift to automation does not have a direct environmental impact. While automation could potentially lead to space savings, this is not a significant indicator at the moment.

The primary challenge lies in the absence of significant changes. With no driver involved, there might be a slight improvement in the utilization of public space, but this impact is minimal.

Overall, the transition to autonomous buses in this context does not present substantial environmental or spatial efficiency changes.

3.8.8. Salzburg

The pilot project encountered several difficulties during its implementation. Initially, the plan was to use Easymile Gen2 vehicles. However, when these vehicles became unavailable, the project shifted to using Navya shuttles. Complications arose when Navya went bankrupt, leading the stakeholders, including the ministry, to start a new national project. This new initiative introduced new vehicles named EVAN. Additionally, a second shuttle, rented for two months and named Heshuttle, was also used; Heshuttle had prior experience with pilots in Hamburg.

The EVAN vehicle was introduced after Heshuttle, but shortly after deployment, there was an accident involving EVAN, necessitating a return to using Heshuttle exclusively for the remaining two months. This series of transitions and the accident posed significant challenges to the continuity and stability of the pilot project.

Political, Legal and Governance

The Salzburg transport authority played a crucial role in integrating the autonomous shuttle service into their app, facilitating seamless user access. The city council was responsible for approving test permits and issuing Letters of Intent (LOI). They were also involved in measuring and mitigating risks, such as granting permission to reduce the speed on the test track for safety purposes and adding extra signage. The Federal Ministry and Climate Tech also contributed by observing and providing support.

One of the major challenges faced was political. The local political landscape presented significant hurdles as the autonomous shuttle project was not prioritized on the agenda. With many different plans addressing urgent problems, there was no dedicated focus or agenda for the implementation of this innovative transport solution.

Economy

The autonomous shuttle service in Salzburg was offered free of charge, making it accessible to all users without any cost barriers.

Social and Acceptability

The autonomous shuttle service in Salzburg provided several benefits for the active population and users with special needs. One of the key advantages was raising awareness and familiarity with automated technology, which helped increase public trust in such innovations. Normally, public transport services run every hour, but with the introduction of the autonomous shuttle, the frequency of service improved, offering a better cycle time. However, it is important to note that the service was not specifically designed to cater to people with special needs.

The service was attractive to the local community, with people showing a willingness to use it. This was reflected in the increased awareness and positive coverage in local newspapers. Although no formal surveys were conducted to measure the exact level of community interest, the anecdotal evidence suggests a high level of acceptance and curiosity about the new technology.

Technology

The autonomous shuttle service was integrated into the public transport app, enhancing the overall connectivity and convenience for users. This integration supported first mile/last mile connectivity, complementing the existing transport system by operating five days a week and using the same stations as other public transport services on public roads, in mixed traffic. The service operated on a fixed route due to technological and topographical challenges. The narrow roads and the current capabilities of autonomous vehicles in peri-urban environments limited the feasibility of an on-demand service.

The technology used in the autonomous shuttle service included mandatory safety operators and high-definition maps that provided detailed information about objects, signage, and lanes. The vehicle relied on its own sensors and internal orientation, without external inputs, except for one use case where CITS (Cooperative Intelligent Transport Systems) infrastructure was used. The EVAN vehicle was equipped with traffic light prioritization, and the entire route was equipped with CITS infrastructure. Real-time operations information was available on the website, and users could see bus arrival and departure times through the public transport app. However, real-time information for the pilot project was not fully implemented, though it is planned for future project.

The maturity of the technology is not yet high enough to fully gain public trust. While the integration with existing transport systems and the provision of real-time information were steps in the right direction, more pilot projects are necessary to prove the benefits of autonomous shuttle services. Economically, the service is still far from being viable. Continuous improvements and more extensive testing are required to enhance technological reliability and public confidence.

Environment and Congestion

There were no significant insights regarding the impact on the environment and congestion from the pilot project. However, it is worth noting that the vehicles used were electric, which inherently contributes to lower emissions compared to traditional combustion engine vehicles.

3.8.9. Karlsruhe

Political, Legal and Governance

The pilot project benefited from strong regulatory support, with laws in place allowing autonomous vehicles on the road. However, obtaining permits from local authorities was still necessary, indicating that there is room for improvement in streamlining the approval process. Germany has taken a pioneering step by being the first country in Europe to implement a comprehensive groundwork law for autonomous vehicles. This legislative framework sets a precedent and provides a solid foundation for further advancements in autonomous vehicle technology and deployment.

Economy

The high cost of implementing autonomous vehicle technology presents significant challenges in establishing a viable business case. The development expenses are considerable, making the pilot run feasible only with the support of the project. Without this backing, the pilot would not have been possible. The biggest challenge remains the price of the technology and the associated infrastructure needed for implementation. These costs make it difficult to scale the project economically and highlight the need for more affordable solutions to make autonomous vehicle services sustainable in the long term.

Social and Acceptability

The autonomous shuttle service aimed to provide a crucial connection between the neighborhood and the station, enhancing local mobility. While the service included a ramp to accommodate users with special needs, it did not specifically address their requirements comprehensively.

The service received positive feedback from the local community, making it an attractive option for regular public transport users. However, there were complaints from other road users about the shuttle's low speed. Notably, the service primarily attracted existing public transport users rather than car users, despite Germany's high rate of car ownership.

In the area where the shuttle operated, there was no regular public transport service, making active modes of transportation the primary alternative. The shuttle filled this gap, offering an important mobility option for residents.

Technology

There is significant room for improvement in the interaction between the autonomous shuttle and other road users, primarily due to its low speed. This slow pace creates problems with bicycles and other vehicles. Increasing the shuttle's speed could make a substantial difference in its effectiveness and integration with traffic.

The FZI shuttles in Karlsruhe operate autonomously without the need for virtual rails. These shuttles run through the Weiherfeld-Dammerstock district and can be called on-demand via a smartphone app to one of the 22 virtual stops available in the area. The shuttles operate in mixed traffic and cannot use segregated lanes. The streets are narrow, and there are few traffic lights in the area due to the relatively light traffic. Improvements are needed in the robustness, speed, and interaction of the shuttles with other traffic participants. The ongoing research aims to further develop the autonomous capabilities and improve user experience based on feedback from real-world operations

Although there were no safety issues, and the shuttle never felt unsafe, there are feasibility concerns regarding other vehicles overtaking the shuttle and the frequent stops. Enhancing these aspects could improve the overall efficiency and acceptance of the service.

Environment and Congestion

The autonomous shuttle service did not result in a measurable modal shift, as users were not primarily car users before using the service. Insights gathered from SHOW surveys and informal conversations with the safety drivers indicated that the majority of users were already utilizing other forms of public transport or active modes of transportation. Therefore, the introduction of the shuttle did not significantly alter existing travel behaviors.

The shuttle operated using electric vehicles, aligning with sustainability goals and reducing environmental impact. However, the lack of a significant shift from car usage limits the broader impact on reducing traffic congestion and emissions.

3.8.10. Monheim

Political, Legal and Governance

The pilot project in Monheim involved several key partners, including the Public Transport Authority (PTA) and the City of Monheim, TÜV (technical safety organization), and the Bezirksregierung (district government). The vehicle manufacturer, Easymile, played a crucial role, along with an app developer (a small to medium-sized enterprise), although the latter was not a critical partner. The Traffic Management Center (TMC) was managed by Bahnen der Stadt Monheim.

The political environment was highly supportive, with strong partnerships and proactive political backing pushing the project forward. However, upcoming political agendas have the potential to disrupt initial plans. Despite this, politics remains the most important driver and enabler for the project.

Greater consideration needs to be given to road maintenance and surrounding infrastructure to ensure smooth operations. Although collaboration among various stakeholders can be time-consuming, it has not presented a major challenge.

Economy

Currently, the automated shuttle service in Monheim is more expensive compared to traditional public transport. Service operators require more frequent breaks than usual bus drivers, needing a pause every 45 minutes, which causes more downtime and higher personnel costs. The initial training for operators takes approximately four days, further increasing costs. As a result, the service relies on higher subsidies to remain operational.

Renting vehicles is more expensive for Monheim than owning and maintaining their own assets. The initial investment included building a dedicated garage and purchasing vehicles, which were funded by the department. New vehicles are leased to manage costs. Economically, the service attracts many tourists, adding a revenue stream, but the initial investment remains very high. Technical supervision infrastructure needs to be developed, initially requiring one supervisor for every two cars, making short- to mid-term costs significantly higher. Long-term costs might stabilize or even decrease as the costs of parts and maintenance reduce.

Innovation is the primary driver for investments in the Public Transport Operator (PTO) services, supported by various levels of government, including local, city, district, and the state of North Rhine-Westphalia. To support the automated service, a significant number of new personnel were hired, with 6-10 new positions created specifically for onboard supervision of automated vehicles. In total, around 50 people were trained, and currently, about 30 operators are required to fulfill the service needs.

However, the current economic model is unsustainable for the next 10 years due to the high costs. The main factor needing change is technological advancement. Vehicles must reach full Level 4 autonomy to justify further investments and reduce operational costs. Only with these advancements can the service become economically viable in the long term.

Social and Acceptability

One of the key challenges in Monheim is raising acceptance of the autonomous shuttle service among local residents. It is crucial to showcase the possibilities and importance of public transport to political decision-makers and potential investors. The service aims to provide a variety of mobility options, primarily benefiting locals such as mothers with young children and older people, who prefer the electric shuttle to walking. Additionally, the service attracts tourists.

Communication with users is primarily handled by onboard supervisors, but Monheim also utilizes the "Bahnen Monheim" public transport application, which includes all timetables and multimodal services. Social challenges include dealing with impatient car drivers and parked cars outside designated zones.

The service has a significant impact on specific user groups, particularly children and older people. Older residents appreciate close contact with the driver, enhancing their sense of security and accessibility. However, the removal of the safety driver might reduce the perceived benefit of the service. Despite this, a recent study indicates that inhabitants would continue to use the service even without an onboard safety driver. The study is expected to be published at the end of January.

The shuttle improves the city's accessibility, especially in the old city part, which is very narrow and inaccessible to conventional bus lines. The shuttle route also includes a "health campus" with many specialized doctors, providing essential mobility for older people who commute to this area for medical services.

Technology

Efforts are underway to identify challenges so that the technology can be further developed by the manufacturer. Despite the maturity of the service, ongoing advancements are vital. In Monheim, where the service has been operational for four years, customer satisfaction remains high.

Regarding technology, progress may seem slow, but improvements from vehicles Gen2 to Gen3 are already noticeable. Looking ahead, several new activities are planned:

- Establishing and training new technical supervision teams.
- Building a "field service" team of technicians capable of assisting vehicles in case of issues.
- Internal adaptations to accommodate future service enhancements.
- Transitioning to vehicles capable of Level 4 autonomy, enabling operations without onboard personnel.
- Implementing remote supervision and technical oversight systems.

The successful pilot program not only provides valuable data but also accelerates technological development. Additionally, efforts to promote the service to the general public, including showcasing it in new areas (as Monheim has done by relocating vehicles to another area), are underway. These initiatives aim to ensure the continued growth and improvement of autonomous shuttle service.

Environment and Congestion

One of the key challenges observed is the presence of delivery services within the city center, leading to road blockages. While the fleet is not yet electrified, transitioning to electric vehicles remains a primary goal for the Public Transport Operator (PTO). However, the PTO is also exploring opportunities for hydrogen buses as part of their sustainable transportation strategy.

Another primary objective is to transform the city center into a more public transport and pedestrian-friendly environment. This entails reducing reliance on cars and minimizing the need for parking spaces. Currently, the autonomous shuttles operate within the existing road infrastructure, with some adjustments made such as the removal of parking spaces that hinder automation.

The long-term vision includes allocating more space to public transport as its usage increases. This aligns with the broader goal of promoting sustainable modes of transportation and reducing the environmental impact of urban mobility.

3.8.11. Les Mureaux

Political, Legal and Governance

In the region, there's a concerted effort to strengthen collaboration among the aeronautical, technological, and automotive industries, all of which have a significant presence. Key partners involved in this endeavor include subcontractors responsible for platform and vehicle technology provision (such as Easymile), the Ariane Group (private site owner), and the Public Transport Authority (PTA) along with the city and district governments, particularly in managing public road usage.

Initially, running the service on private roads proves to be more feasible compared to public roads due to regulatory constraints. Currently, public road operations mandate one-to-one supervision. However, successful piloting addresses stakeholder needs, notably:

Département des Yvelines: Demonstrating the technical and operational feasibility of offering similar services on open roads in the future.

Ariane Group: Providing a service to their employees with a focus on availability and reliability, enhancing the value proposition for the site and its workforce.

This collaborative approach underscores the importance of industry partnerships in advancing autonomous transportation solutions and underscores the potential benefits for both private enterprises and public stakeholders alike.

Economy

Investment for the project, totaling approximately €5 million, is split evenly between the Department and the project partners.

In terms of service expansion, new private sites would be required to finance a "finished" service. Existing sites, like Airbus Toulouse, could see vehicle replacements once the technology matures sufficiently. Private sites contribute 95% of the funds, with the Public Transport Authority (PTA) providing the remainder.

Profitability hinges on efficient operation, with one operator managing at least five shuttles to offset various costs (e.g., data, maintenance, personnel).

The PTA deems the service cost-effective if it significantly undercuts electric vehicle alternatives, particularly for first-last-mile solutions.

Supervisors' training and deployment present additional cost considerations, with a ratio of one supervisor per three vehicles deemed unfeasible. A minimum of six vehicles would optimize cost-effectiveness.

Cost optimization strategies involve centralized control rooms and on-site personnel to streamline supervision expenses.

The decreasing price of essential technologies like LIDARs contributes to the overall viability of the business case, making autonomous transport solutions more economically feasible over time.

By strategically managing costs and leveraging advancements in technology, the project aims to enhance its financial sustainability while expanding its service offerings to meet growing demands.

Social and Acceptability

The autonomous shuttle service addresses the region's need for improved last-mile connectivity, particularly to and from the train station, where existing provisions may be suboptimal.

However, challenges persist with user incivility, largely attributed to perceived shortcomings in service quality. Despite technological improvements, such as enhanced safety features, user behaviors such as overtaking the shuttle remain prevalent.

Nevertheless, the general acceptance of the service remains positive. Users appreciate the convenience and accessibility offered by the autonomous shuttles, contributing to overall satisfaction with the service.

Efforts to mitigate user incivility and further enhance service quality are essential to ensure the continued success and widespread adoption of autonomous shuttle solutions in the region.

Technology

Transdev operates a shuttle service within a private site, utilizing three vehicles to provide optimal connectivity to future stations. However, several challenges affect the service's efficiency and potential future viability.

There are plans to transition towards an on-demand model in the near future, acknowledging the need for adaptability and responsiveness to user demand.

Compared to e-scooters, the shuttle service faces challenges in speed, potentially making it less attractive to users seeking faster modes of transportation.

Vehicle availability remains inconsistent, with all three vehicles rarely operational simultaneously. Achieving consistent and reliable service delivery is crucial for maintaining user satisfaction and trust, necessitating advancements in vehicle reliability and operational standards.

Future viability hinges on technological advancements, particularly in vehicle maturity and communication systems. Addressing issues such as data consumption and communication delays will be essential to ensure the service's long-term success.

Innovation in service delivery and a proactive approach to addressing operational challenges will be vital for ensuring the shuttle service remains competitive and relevant in the evolving transportation landscape.

Environment and Congestion

The primary benefits derived from the autonomous shuttle service predominantly revolve around environmental considerations, particularly in facilitating modal shifts towards more sustainable transportation options.

Regulatory mandates stipulate that a significant portion of the vehicle fleet must transition to electric or hydrogen-powered alternatives. Specifically, 50% of the vehicles replaced must adhere to these zero-emission standards, reflecting a commitment to reducing carbon emissions and fostering eco-friendly transportation solutions.

There is a clear trajectory towards the electrification of the transportation sector, with a notable emphasis on zero-emission buses. Presently, there are approximately 3000 electric vehicles in operation, representing a substantial investment in sustainable mobility initiatives. Moving forward, the trend indicates a continuation of this electrification drive, with a mandate for replacing vehicles with electric counterparts comprising 50% of the overall fleet renewal strategy. This underscores a broader commitment to enhancing environmental sustainability and reducing the carbon footprint associated with public transportation operations.

3.9. Impacts regarding SMEs

3.9.1. Business Models for SMEs

There are several categories of SMEs and startups participating in the SHOW project, each specializing in different fields of activities:

- Operators of autonomous vehicles: SURAAA and Remoted Oy,
- Providers of autonomous shuttles: Easymile and Beti,
- Providers of integrated services including logistics: CTLup
- Providers of IT solutions and software: ARTIN, and CTLUP.

Our objective is to align each SME with the most suitable and beneficial SHOW Business Model. Based on their feedback and evaluations, here's the analysis:

For operators of autonomous vehicles:

According to feedback from these SMEs, the following SHOW Business Models are perceived as highly beneficial:

- BM1 – Autonomous PT in combination with additional on-demand service
- BM6 – Robotaxi services for short distance trips
- BM7 – Sustainable living areas with autonomous public transportation
- BM8 – First/Last mile autonomous transportation to mobility HUBs

For providers of autonomous shuttles

All Business Models that are based on shuttles would be relevant for them, namely:

- BM1 – Autonomous PT in combination with additional on-demand service
- BM4 – Combined MaaS and LaaS

- BM5 – Peri-urban automated transportation and C-ITS connectivity
- BM6 – Robotaxi services for short distance trips
- BM7 – Sustainable living areas with autonomous public transportation
- BM8 – First/Last mile autonomous transportation to mobility HUBs
- BM10 – Interoperable IoT platforms for automated mobility

Providers of integrated services including logistics

The most beneficial Business Model identified for providers of automated droids is, BM4 – Combined MaaS and LaaS, which includes a significant component focused on providing logistic services.

For providers of IT solutions

All BM seems to be relevant for the providers of technology. However, the BM10 – Interoperable IoT platforms for automated mobility is particularly beneficial, since it aims at expanding the field of view and finally ODD of the vehicle by combining in-vehicle sensors and additional perception provided by infrastructure (road-side units, traffic lights, smart devices, infra cameras, etc.)

3.9.2. Market conditions and main barriers

Feedback from the majority of SMEs involved in the projects indicates that they encounter significant barriers to development, particularly in the legal and technological domains.

Legal Barriers: A major hurdle cited by SMEs is the need for harmonized legislation. The lack of consistent legal frameworks across regions complicates operations and makes it challenging to attract investment.

Technological Barriers: Providers and operators of Autonomous Vehicles (AVs) encounter substantial technological challenges. These include enhancing the accuracy of detecting Vulnerable Road Users (VRUs) and achieving higher operational speeds. Developing high-performance sensors and the entire vehicle infrastructure is costly, and SMEs often rely on the availability and affordability of sensor technologies in the market. For instance, Navya's bankruptcy highlights the financial strain of in-house development of automated shuttles.

Currently, all providers of automated shuttles are striving to introduce next-generation vehicles with improved performance capabilities. Achieving this goal necessitates robust support from regulatory bodies and access to public and European funding opportunities.

In summary, addressing these legal and technological barriers is crucial for the sustainable growth and success of SMEs involved in automated mobility projects. Harmonizing legislation and fostering technological innovation with adequate financial support are essential steps toward overcoming these challenges.

3.10. Synthesis on viability conditions of SHOW business models

As defined in section 2.1.2, a business model is considered viable when it is sustainable in terms of both value and technology. Below, we summarize the conditions necessary for achieving economic and technological viability.

3.10.1. Economic viability

Economic viability remains elusive at the current scale of the pilot service. Achieving this goal necessitates reducing vehicle costs, including hardware expenses, sensors, licenses, and Application Programming Interfaces (APIs). Additionally, personnel costs remain high due to the crucial role staff play in ensuring security and safety, particularly due to the added costs of training drivers. Consequently, government funding is essential today, and these pilots operate solely thanks to the SHOW project. Attaining Level 4 autonomy and eliminating the need for a driver is crucial for achieving economic sustainability. The study of [35] estimated that automation will reduce wage costs by 60%. With the cost savings brought by remote supervision, autonomous shuttles have the potential to improve the flexibility and the accessibility of public transport [36]. The difference between remote and on-board supervision is also location specific as higher income countries would benefit more from remote supervision [37].

According to the site's experts, scaled deployment, with at least five vehicles manageable by a single remote control, is crucial to reach economic viability. In Les Mureaux, Transdev tested a single remote supervisor to oversee a fleet of three automated shuttles and proved that safety could be ensured. They argue that one supervisor for three vehicles is not economically viable and cannot cover all operating costs (e.g., data, maintenance, etc.). A recent study of [38] explored the number of supervisors required to ensure safety while considering different penetration rates of cooperative and non-cooperative automated cars (i.e., replacing personal cars). They found that one remote supervisor could operate 52 vehicles. Nevertheless, they ignored the cognitive capability (e.g. situation awareness, fatigue, etc.) of the human supervisor to manage many vehicles [39]. Coming back to the economic viability, there is currently no evidence about the real costs of the envisioned service, and more generally about the minimum number of vehicles that should be supervised to be viable.

3.10.2. Technological viability

Several technological improvements have been observed throughout the SHOW project: almost no major incidents or critical situations occurred, some of the vehicles were designed to address the needs of people with reduced mobility, in vast majority of cases, real-time information was shared with passengers, and a booking platform was developed, among other advancements.

Nevertheless, the automation of vehicles is still facing major technological challenges to be viable. The maximum speed of shuttles allowing to detect obstacles and to react in emergency is considerably under 30km/h, which makes biking or riding e-scooters even more attractive as a last-mile solution. In addition, shuttles should analyse their environment smarter to avoid erroneous detections. Improving the performance and accuracy of sensors is crucial to increase the service speed and with that the quality of service. Current developments of the new vehicle generation (Gen3) aim to overcome these challenges, by reaching higher speeds while being more reactive.

Regarding the supervision technology, there is also room for progress: control of doors and ramps, communication with on-board passengers, cybersecurity issues as well as latency issues, etc. The integration of automated vehicles into a global transportation system will in addition generate more complexities, since the two layers of supervision should cooperate: the supervision of the unit vehicle, performed by the service provider, and the supervision of the fleet of all shared vehicles, including other automated cars and buses, performed by the PTO.

3.10.3. Other viability conditions

3.10.3.1. Political and legal conditions

Establishing a good relationship with the municipality, local government, and federal authorities is a key for the successful validation of business models for autonomous vehicle projects. A great support of public authorities is observed in all pilot sites. However, the regulation should be more aligned with CCAM technology development. In particular, the process for obtaining automated vehicles testing permits needs to be improved and shortened. Supervision without an operator on board is prohibited at the majority of SHOW sites. Vehicle speed on public roads is limited to 20 km/h (25 km/h in Greece), which does not allow for a realistic evaluation of the service and affects the pre-acceptance stage. Lastly, insurance aspects remain unclear, specifically who is liable in the event of an accident.

3.10.3.2. Social conditions

The acceptance of the service usage is high at the majority of sites, particularly among individuals with disabilities, for whom the low speed of the shuttles is not a discomfort but rather an attractive feature. The service is also generally appealing to local communities. Additionally, the reservation platform enhances the usability of the service. On the other hand, sharing a vehicle with strangers without an operator on board can be a barrier to service usage. Overall, the results are positive and should be accelerated through the expansion of pilot programs.

3.10.4. Summary of viability conditions

In summary, realizing the viability of the SHOW Business Models demands the deployment of a service that attains commercial-level performance, rivalling the efficiency of current mobility services, primarily sourced by public authorities at local, regional and/ or national levels, and seamlessly integrates into a comprehensive multimodal landscape.

Table 62 Conditions of viability

Viability	Conditions	Comment
Economic viability	Decrease of vehicles costs (sensors, LIDARs, hardware, etc.)	However, more advanced sensors and LIDARs are required to reach better performances.
	Remove the on-board safety operator and to reach level 4	The role of on-board operator is crucial to ensure security and safety, and to enhance the trust.
	One supervisor for at least five vehicles	The cognitive capabilities and technical/vocational skillset of the human supervisor to be evaluated. The minimum number of vehicles to be observed needs to be validated.
Technology viability	Higher speeds and lower reaction time.	More advanced and accurate sensors required. Trust and latency aspects to be eliminated.
	Supervision with additional components to control the main features of the vehicle	Technology development and additional partnerships required
	Cooperation between different layers of supervision	Technology development and additional partnerships required
Other viability aspects	Regulation should be aligned with technology development and aligned also across Europe.	
	Increase of speed to improve the acceptance of the service.	Still, lower speed remains attractive for disabled and elderly people

4 Comparison with the Chinese experience

As part of the Twinning Activities of the SHOW project, exchanges and experience sharing were conducted with Beijing Jiaotong University (BJTU).

This collaborative work sought to articulate a comprehensive growth vision for AVs under different continental/ national and local strategies planned or implemented by actors. This included an exploration of experimented and/or implemented business models, along with the identification of opportunities and challenges encountered during their development—spanning policies, technological maturity, operational processes, costs, and beyond.

This section summarizes the key lessons learned from the Chinese experience.

4.1. Business models description and analysis

Through the SHOW project, eight business/ operating models have been developed. Additionally, one more business model not derived from a SHOW demonstration have been identified, namely BM10 – Interoperable IoT platforms for automated mobility (refer to section 3.1).

In China, eight business models are also identified. Their proposition values are described in the following table:

Table 63 Business models description in China

Business/ Operating Models	**Service Description**
BM1 – Robotaxi	This business model refers to autonomous taxis, which are vehicles that provide rental services based on autonomous driving technology, with the speed up to 50 km/h. Robotaxi represents one of the largest market spaces for autonomous driving scenarios and is a comprehensive test of autonomous driving capabilities.
BM2 – Robobus	This business model refers to low-speed autonomous buses (including fixed-route buses and short-distance shuttles). Unlike Robotaxi, the purpose of Robobus is not to replace drivers or reduce operating costs but to reshape and improve urban traffic microcirculation systems, thereby effectively solving congestion problems.
BM3 – Trunk logistics	This business model refers to the logistics process involving transportation, collection, storage, and delivery facilitated by assisted autonomous driving. Trunk logistics primarily relies on L3 and L4 autonomous heavy-duty trucks as transportation tools, capable of achieving point-to-point freight transport with driving speeds reaching 80-120 km/h.
BM4 – Last-Mile Delivery	This business model refers to assisting the logistics industry in improving the efficiency and quality of logistics and solving the "last mile" delivery work, characterized by high frequency and small-batch deliveries. The operational scenarios are relatively closed.
BM5 – Port Scenario	The application of autonomous driving in port scenarios can effectively address problems associated with traditional port transportation, such as high work intensity, high risk, long-term labor shortages, and excessive costs, significantly reducing labor costs and enhancing safety. Ports are typical closed and low-speed environments, low vehicle interference, and an easy-to-improve foundation, making them one of the typical scenarios for the commercial application of autonomous driving.

Business/ Operating Models	Service Description
BM6 – Mining Area Scenario	Autonomous driving in mining operations can utilize technical support to reduce overall costs and improve the comprehensive operational benefits of mining. Currently, almost all autonomous driving scenarios focus on open-pit mining, providing experience in dynamic operations and timeframes applicable to other autonomous driving scenarios.
BM7 – Sanitation Scenario	This involves using autonomous sanitation vehicles to replace traditional driver-operated sanitation vehicles. Autonomous sanitation is one of the fastest-growing scenarios for autonomous driving, capable of performing tasks such as road cleaning, watering, and disinfection on open roads, streets, and in enclosed areas like parks and school campuses.
BM8 – Agricultural scenario	In agricultural scenarios, we primarily discuss drone-based crop protection and autonomous agricultural machinery. The essence of autonomous agricultural machinery is not only to replace the driver in operating the machinery but also to perform agricultural tasks effectively in place of the driver.

4.2. Development policies and transferability of AV-based business models

Status of Research projects and policies in Europe

In Europe, several tests and pilots were conducted during the last decade (more than 350 pilots), half or more of them own-funded from Member States, and the others funded by Europe. They addressed different use cases: connectivity, vulnerable road users, freight, chauffeur, remote control, parking, platooning, last-mile delivery, etc. In addition, according to the CCAM Knowledge-Base, about 70% of these pilots were on public roads, 10% on test tracks and corridors and less than 5% on private and close sites. Most of pilots were also based on passenger cars and shuttles. The deployments of Cooperative Intelligent Transport Systems (C-ITS) in Europe reveal a growing adoption of these technologies across various countries, each implementing pilot projects on key infrastructures. These deployments cover a wide range of geographical areas, including cross-border highway corridors, strategic urban centers, and critical interurban roads. Countries such as Austria, Belgium, France, the Czech Republic, and Greece have installed Road-Side Units (RSUs) and implemented hybrid communication technologies, combining ITS-G5 standards and LTE cellular communication to ensure maximum interoperability and safety. For instance, in Spain, deployments under the DGT 3.0 project cover over 12,270 km, while the Czech Republic has implemented hybrid systems across more than 360 km of highways. In France, over 580 intelligent RSU are tested to collect data and to increase the reliability of the transportation network. In Finland and Sweden, the NordicWay 3 projects demonstrate strong Nordic collaboration to harmonize C-ITS standards using technologies adapted to both urban and interurban environments. These initiatives clearly show a commitment towards more connected and automated mobility, aiming to improve road safety and facilitate effective cross-border interoperability.

Regarding the regulation, European regulations use the United Nations Economic Commission of Europe (UNECE) regulation requirements as a basis to develop the legal EU framework for automated vehicles. In addition, the testing and deployment of CCAM must align with European clean transport objectives. For example, CCAM solutions on the road will need to comply with new CO_2 emission standards for both light-duty and heavy-duty vehicles, and additional charging points will be mandated under the latest regulations governing alternative fuel infrastructure. At national level, each country has its specific regulatory framework for automated driving (AD).

Status of Research projects and policies in China

As of now, China has established 17 national-level intelligent connected vehicle testing zones, opened over 32,000 kilometers of test roads, issued more than 7,700 test licenses, and recorded over 120 million kilometers of test mileage. Over 8,700 intelligent roadside units (RSUs) have been deployed nationwide, and several regions have initiated the construction of cloud-based control platforms. On the local level, 51 cities have introduced autonomous driving pilot demonstration policies. Regions like Shenzhen, Shanghai, Jiangsu, and Hangzhou have enacted local legislation related to autonomous driving, continually expanding application scenarios. For instance, Beijing is actively promoting new application scenarios such as Daxing Airport based on the Demonstration Zone 3.0. Wuhan supports nearly 500 driverless vehicles in regular pilot services across 12 administrative districts. In terms of application scenarios, autonomous driving mobility service providers have launched passenger test operations in numerous cities, including Beijing, Shanghai, Guangzhou, Shenzhen, Chongqing, Wuhan, Changsha, Chengdu, Hefei, Yangquan, and Wuzhen. In the area of trunk logistics, autonomous driving technology can address the shortage of over 10 million truck drivers in China. Regarding unmanned mining trucks and logistics in closed environments, such as campuses and parks, autonomous vehicles have started to be utilized effectively. The express logistics industry has initiated pilot programs for unmanned delivery vehicles across 10 provinces nationwide. A single unmanned vehicle can carry approximately 600 packages per trip, with a fully charged tested range of about 120 kilometers. In the context of closed environments, more than 700 unmanned vehicles have been deployed in over 400 universities nationwide to facilitate unmanned delivery services.

In the recent three years, China has actively promoted the development of the autonomous driving industry through a series of policies and pilot projects, accelerating the application and standardization of intelligent connected vehicles. The formulation of autonomous driving laws and regulations continues the approach of "central government setting the framework, and local governments implementing the pilot projects." Based on local pilot projects, it assists in promoting the formulation of national-level laws and regulations in the future. After the national-level autonomous driving commercialization policies are issued, local governments will implement them accordingly. A total of 14 policies have been issued by departments such as the State Council, the Ministry of Transport, the Ministry of Industry and Information Technology, the Ministry of Science and Technology, the Ministry of Public Security, and the Ministry of Natural Resources. These policies cover areas such as safety management of intelligent driving, infrastructure construction, technical pilots, industry standards, and market access, aiming to accelerate innovation and the implementation of autonomous driving technology, thereby enhancing the intelligence level of transportation. The policies also emphasize green transportation development goals, promoting the application of intelligent connected vehicles in urban logistics, public transportation, and other fields. Meanwhile, local governments are also vigorously supporting the testing and application of related technologies, striving to build a safe, efficient, and environmentally friendly intelligent transportation system. The newly released guidelines clarify the configuration requirements for vehicles and safety operators, detailing who is eligible to apply for autonomous vehicle road access, how autonomous vehicles can get on the road, and how accident responsibilities are divided. Notably, for taxis with full autonomous driving capabilities, remote safety operators can be used during operations in designated areas, with local approval, achieving a truly "driverless" experience inside the vehicle.

Transferability assessment

Europe: A SWOT analysis has been applied to all SHOW business models in *D2.5: Scalability and transferability of business / operating models* to assess the challenges and opportunities regarding their transferability. The results of this analysis underscored the strengths, weaknesses, opportunities, and threats associated with transferring AV BMs: (i) Strengths: Successful integration of SMEs, startups, and PTOs without undermining existing operations, and prioritization of innovative approaches; (ii) Weaknesses: High initial investments and technological limitations can hinder transferability; (iii) Opportunities: Expanding into new markets, leveraging technological advancements, and forming strategic partnerships present significant growth potential; (iv)Threats: Regulatory hurdles, public resistance, and competition from established transport modes pose challenges to transferability.

China: A SWOT analysis has been applied to all Chinese business models to assess the challenges and opportunities regarding their transferability. (i) Strengths: As technology continues to mature, the intelligent layout of vehicle-end, road-end, and cloud-end systems is continuously improving. A series of policies, regulations, standards, and action plans related to autonomous driving have been intensively released, providing a clear and precise development path that accelerates the commercialization process of autonomous driving. (ii) Weaknesses: Autonomous driving mobility services must combine physical assets with intelligent services, leading to a significant cost floor that is difficult to break through, especially concerning initial investments and technical maintenance. A major criterion for determining whether autonomous driving can quickly scale is the speed and cost of scenario replication. Only technology that can be rapidly and inexpensively replicated to similar scenarios has the potential for scalability. Excessive customization requirements from the scenario side, or the need for a large operational team, are obstacles to scalable replication. (iii) Opportunities: The opportunities for autonomous driving technology lie in forming strategic collaborations, integrating technology solutions, and partnering with governments and industry participants. Achieving mass production and developing innovative products will be key factors for companies to establish a strong market position and achieve sustainable growth. (iv)Threats: Data security, Public acceptance, Technological barriers, Regulatory hurdles.

4.3. Enablers and challenges for the development of AV-based business models

The enablers and challenges for the development of SHOW business models are presented above and summarized in Table 62. In this section, we focus on the Chinese experience and lessons.

4.3.1. Economic challenges and enablers

In China, the unit service cost of Robotaxis remains significantly higher than that of comparable ride-hailing cars. It is expected that with technological breakthroughs, optimization of pre-installation plans, and large-scale operations, the cost curve will improve significantly in the coming years. At present, the cost of a Robotaxi is around 88,000 Euro. The commercialization profitability tipping point for fully autonomous vehicles will be when the cost drops below 50,000 Euro. On one hand, as autonomous driving technology solutions improve and the core hardware supply chain matures, the vehicle manufacturing cost is expected to decrease by more than 50% compared to the current pre-installed models. On the other hand, labor costs account for 50% of the operating costs of taxis. The key to optimizing operational costs is to transition safety operators from in-vehicle to remote monitoring, and continuously reduce the human-to-vehicle ratio, thereby significantly lowering safety and maintenance costs. The continuous optimization of various cost elements, such as vehicle technology costs, operational service costs, energy costs, and regulatory costs, will support Robotaxis in achieving higher operational efficiency and economic benefits.

4.3.2. Technological enablers and challenges

Currently, China's autonomous driving technology has made significant progress in specific scenarios. Through hardware and vehicle architecture upgrades, the performance of autonomous systems in complex scenarios has been greatly enhanced, especially in applications such as highways and urban roads, where most complex long-tail scenario problems have been addressed. Additionally, companies have accumulated large amounts of multi-dimensional data to form a data loop, providing strong support for autonomous driving technology. The maturity of high-definition maps and vehicle-to-everything (V2X) technology also supports the improvement of system positioning accuracy and information exchange capabilities. These technological advancements have laid a solid foundation for the application of autonomous driving in China.

However, autonomous driving still faces numerous challenges at the technical level. Firstly, core technologies such as perception, decision-making, and control require further breakthroughs, particularly in improving precision recognition and decision-making capabilities in non-standardized environments. Secondly, the safety of autonomous driving systems needs to be strengthened to cope with complex traffic situations and unexpected events. The challenges of algorithm robustness and data training persist, especially when dealing with extreme weather and complex road conditions. Although most long-tail issues have been resolved in some scenarios, system stability and adaptability still need to be enhanced under more complex conditions. These technical bottlenecks must be overcome to achieve the full commercialization of autonomous driving technology.

4.3.3. Other enablers and challenges

4.3.3.1. Political and legal

In recent years, China has introduced numerous policies and guidelines to regulate and address the long-standing policy gaps concerning the market entry, mass production, and commercialization standards for advanced autonomous driving models. However, policies related to specific scenarios still need further improvement. For example, with the rising demand for delivery services such as food delivery and supermarket shopping, unmanned delivery vehicles have emerged and become a focal point in the autonomous driving industry. However, the characteristic of unmanned delivery vehicles lacking a driver's seat does not conform to the current motor vehicle standards system, resulting in policy and legal gaps in areas such as vehicle registration, driving, right-of-way, accident handling, and traffic violation processing.

4.3.3.2. Social

In recent years, public acceptance of autonomous driving technology in China has significantly increased, particularly in terms of safety perception, where there is considerable tolerance. A 2022 survey revealed that over 80% of respondents believe autonomous driving is safer than human driving, and nearly 87% think that autonomous driving technology is likely to or has already surpassed the driving skills of most human drivers. This trust in the safety of autonomous driving is particularly evident in Wuhan, a city where the technology has been a focus of deployment. A 2023 survey found that more than 90% of Wuhan respondents believe autonomous driving is safer than human driving.

Moreover, as autonomous driving technology gradually moves towards commercialization in certain cities in China, real user experiences have further boosted public acceptance. The commercial pilot of autonomous mobility services has recorded over 430,000 orders, with stable operations and consistently positive user feedback. Many users around the pilot areas have already adopted autonomous driving as a regular means of transportation. Currently, there are over 6,000 market entities involved in the autonomous driving industry chain in China. Overall, public acceptance of autonomous driving technology is steadily increasing, laying a solid foundation for broader commercialization in the future.

4.4. Summary

As a summary, to reach the viability of AV-based business models in China, it's crucial to deploy an AV-based service that achieves commercial-level performance, rivals the efficiency of current mobility services—primarily provided by public authorities at various levels—and integrates seamlessly into a comprehensive multimodal transport system.

The summary of viability conditions is presented in Table 64.

Table 64 Conditions of Business models' viability in China

Viability	Conditions	Comment
Economic	Improve an independent and controllable technological innovation system for intelligent vehicles.	Breakthroughs in key core technologies, enhancement of testing and evaluation methods, and demonstration operations and validation in key scenarios such as terminals, ports, and mining areas.
Technology	Limitations in perception capabilities and the lack of a unified technical route have resulted in different approaches, in the perception and decision-making layers.	There are limitations in perception capabilities, such as LIDAR being susceptible to environmental conditions and cameras performing poorly in adverse weather. Additionally, advancing autonomous driving to higher levels requires a significant increase in the computing power of onboard chips.
Supporting Infrastructure	Coordinated development.	It requires the combined efforts of enterprises, industries, research institutions, and government agencies to create a unified approach.
Other aspect	Improving the relevant legal and regulatory framework.	Clarifying the liability of intelligent connected vehicles in traffic accidents, and enhancing data security and personal privacy protection are also essential issues that must be addressed for the long-term development of the industry.

5 Conclusions

This document presented the results of the validation of SHOW business/ operating models. A comprehensive methodology is proposed and applied. It is based on six steps, breaking down each business/ operating model in several assumptions, which are then assessed one by one, and results in a global evaluation of the business / operating model. This methodology is combining two approaches (strategic management approach and engineering approach). It also relies on several areas since each business / operating model is validated from the perspective of different stakeholders.

In order to propose a methodology that is suitable for cross-evaluation among different cities and mobility services, a scoring model is established. It classifies each assumption according to its objectives and proposes accordingly their weights for each business / operating model. The scoring relies then on interviews, surveys, vehicles' data collection, simulation, cost-benefit analysis, and combines their results to provide scores for each SHOW business/ operating model. In parallel, two-rounds of interviews are conducted with pilot sites to understand main barriers and enablers to reach the viability. The combination of the scoring model and the interviews constitutes the core of the business/ operating model validation methodology that had been developed within the project SHOW.

The validation of business/ operating models using this hybrid methodology provides several insights and recommendations.

Firstly, it should be outlined that each business/ operating model has at least one of the four following goals: (1) to improve accessibility and community vitality, (2) to reduce costs compared to existing mobility solutions, (3) to reduce the externalities of private cars, in terms of pollution, CO_2 emissions, congestion, etc. and (4) to develop and validate a more advanced technology, that enables to provide in turn a better quality of service. The validation of the business model should take into account its strategic/ business goal, which extends beyond financial metrics typically examined in traditional studies of new businesses.

Secondly, the validation of all business models yielded high scores for all business/ operating models. In particular, it is found that:

- **To increase the accessibility, equity and community vitality**: The Business Models that are recommended are *BM1 - Autonomous PT in combination with additional on-demand services*, *BM3 - Advanced MaaS in urban environments, BM5 - Peri-urban automated transportation and C-ITS connectivity,* and *BM7 - Sustainable living areas with autonomous public transportation.*
- **To accelerate the business ecosystem development**: All the Business Models are relevant.
- **To reduce the environmental impacts:** The Business Models that have the highest scores are *BM3 - Advanced MaaS in urban environments, BM7 - Sustainable living areas with autonomous public transportation, BM8 - First/Last mile autonomous transportation to mobility hubs* and *BM10 - Interoperable IoT platforms for automated mobility.* However, accurately measuring progress towards this goal has proven challenging due to the limited deployment fleet, necessitating further detailed studies to assess environmental impacts effectively.
- **To provide better service quality because of the automation:** All the Business Models are relevant. Highest scores are observed for *BM2 - Autonomous Bus Depots, BM4 - Combined MaaS* and *LaaS and BM8 - First/Last mile autonomous transportation to mobility hubs.*

All the SHOW Business Models are particularly appealing and promise reduced operating costs, limited environmental impact through their use of electric vehicles, and significant contributions to the creation and development of a business ecosystem. Moreover, they hold substantial potential to enhance the quality of public transportation services. However, the low speeds create discomfort for passengers and present a barrier to widespread adoption in daily use.

Thirdly, the analysis of willingness to pay showed consistent values across users from various sites and countries for autonomous shuttles and robotaxis with ridesharing, ranging between 0.5 and 2 euros. Additionally, it revealed that users are willing to pay a premium to use privately operated robotaxis (without sharing their rides), averaging an additional 0.5 euro.

The analysis of SMEs revealed a wide range of business models they could potentially integrate, all of which hold substantial potential benefits. However, overcoming legal barriers and further maturing the technology are essential steps for their growth.

The viability has been explored from different perspectives according to a PESTEL approach against economic, technological, social, legal aspects, etc. It is found that to reach the viability, costs of vehicles must decrease substantially. Furthermore, one supervisor should manage the operation of at least five vehicles to improve the economic viability. Technological challenges to increase safety and speed but also eliminate trust and latency issues (especially for remote supervision) still must be addressed, through improving the accuracy of sensors and the features of supervisors. Political backing is crucial to drive the project forward and ensure its success. The current regulations need to be adapted to the realities of CCAM.

Finally, the collaboration with the Beijing Jiaotong University (BJTU) aimed to deepen the understanding of the multifaceted landscape surrounding AVs, offering insights derived from real-world demonstrations and national initiatives. The business models of Europe and China were identified and compared: categorized by value propositions in Europe (SHOW – WP2) and by activity sector in China. This joint effort revealed that AV-based business models in both regions face similar economic and technological challenges to achieve viability and transferability.

Annex 1 – Definition of assumptions for BM stakeholders

The assumptions of the ten business models are detailed in D2.3 - First Version of Validated Business/Operating Models and are reiterated below.

BM1 – Autonomous PT in combination with additional on-demand services

The assumptions for BM1 are generated based on the Proposition value canvas and the Business model canvas described respectively in Table 1 and Table 2 of *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites*.

This business model is based on 17 assumptions as presented below:

H1: We believe that we could generate a fully integrated (physically and digitally) autonomous PT and on-demand operation (APT-ODS).

H2: We believe that we could generate an automated shuttle bus fixed line at peak time that connects the different facilities around the campus area and reduce travel times.

H3: We believe that we could generate an on-demand services at off peak times that reduce travel times.

H4: We believe that we could generate an integrated operation (APT-ODS) that serves students, commuters and personnel within the service area.

H5: We believe that through integrated operation (APT-ODS) we can reduce the waiting time of service users at peak time.

H6: We believe that through integrated operation we can increase service frequency.

H7: We believe that through integrated operation (APT-ODS) we can provide comfortable and at-standard seating capacity to service users.

H8: We believe that through integrated operation (APT-ODS) we can provide cheap and flexible service to users.

H9: We believe that through integrated operation (APT-ODS) we could guarantee standing and seating capacity to users if using pre-booking services.

H10: We believe that users can use USB charging while commuting.

H11: We believe that through integrated operation we could provide real-time information about traffic volume in the area and riders for the shuttle

H12: We believe that by introducing integrated APT-ODS we can build a sustainable urban environment in the area: by reducing emissions

H13: We believe that by introducing integrated APT-ODS we can build a sustainable urban environment in the area: by reducing noise

H14: We believe that by introducing integrated APT-ODS we can build a sustainable urban environment in the area: by increasing safety

H15: We believe that by introducing integrated APT-ODS we can eliminate existing mobility gaps in the area.

H16: We believe that by introducing integrated APT-ODS we can reduce private car usage in the area

H17: We believe that by introducing integrated APT-ODS we can provide a better cost-effective operation compared to private cars.

BM2 – Autonomous Bus Depots

The assumptions for BM2 are generated based on the Proposition value canvas and the Business model canvas described respectively in Table 3 and Table 4 of *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites*.

This business model is based on 14 assumptions as presented below:

H1: We believe that through an autonomous bus depot OPEX costs will decrease significantly.

H2: We believe that through an autonomous bus depot there will be associated space savings.

H3: We believe that through an autonomous bus depot the safety within the depot will increase.

H4: We believe that through an autonomous bus depot we will reach lower levels of idle times and increase vehicle usage, increase productivity/speed of depot operations.

H5: We believe that PTOs and city and regional authorities will be interested in the implementation of an autonomous bus depot**.**

H6: We believe that through an autonomous bus depot we will contribute to a PT ticket price reduction in the near future, which suppose a benefit from social side.

H7: We believe that through an autonomous bus depot we will increase services (frequency and variety) as more vehicles will be available and drivers will have extra hours too**.**

H8: We believe that PTOs and city and regional authorities will contribute to the cost reduction we can deliver via an autonomous bus depot.

H9: We believe that homologation and authorization for an autonomous bus depot should not be extremely lengthy and complicated (controlled environment).

H10: We believe that through an autonomous bus depot we will contribute to reducing tedious labor and job satisfaction (also contributing with new jobs in control tower for instance).

H11: We believe that through autonomous bus depot operations will be easier to handle and coordinate.

H12: We believe that an autonomous bus depot will not be severely conditioned for functioning due to weather issues.

H13: We believe that initial investment & maintenance costs for an autonomous bus depot will be higher than a regular one, but the increase will not be drastic.

H14: We believe that improved connectivity in the area (i.e. 5G) will allow teleoperation of the buses.

BM3 – Advanced MaaS in urban environments

The BM3 relies on 13 assumptions, based on Table 5 and Table 6 of *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites*. These assumptions are:

H1: We believe that we could generate a mobility as a service (MaaS) operation integrated with existing conventional services.

H2: We believe that we could generate an autonomous mobility service for population ranging from urban areas to rural areas.

H3: We believe that we could generate a mobility service for different trip purposes including commuting, shopping, groceries leisure and tourism.

H4: We believe that we can provide a real-Time information about traffic volume in the area and riders for the shuttle (with application).

H5: We believe that a real-time information about traffic volume in the area and riders for the shuttle can provide added value to the passengers.

H6: We believe that we could generate a pre-booking application for ticketing and seat selection.

H7: We believe that by introducing MaaS services we could reduce private car usage in urban areas and decrease level of congestion.

H8: We believe that by introducing MaaS services we could achieve sustainability in urban cities by providing less noise.

H9: We believe that by introducing MaaS services we could achieve sustainability in urban cities by providing less emission.

H10: We believe that by introducing MaaS services we could achieve sustainability in urban cities by providing more safety.

H11: We believe that by introducing MaaS services we could achieve sustainability in urban cities by providing more space and more comfortable services to passengers.

H12: We believe that by introducing MaaS services we could have control over fleet operation and monitoring of network status.

H13: We believe that by introducing MaaS services we could reduce delays.

BM4 – Combined MaaS and LaaS

Based on Table 7 and Table 8 of *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites*, the assumptions of BM4 are generated:

H1: We believe that we could generate autonomous services connected through all available mobility services including train, metro, bus (conventional and autonomous shuttle), bike and private vehicles (include taxi).

H2: We believe that we could generate autonomous services connected through all available logistic services.

H3: We believe that we could generate sequential services; mobility for passengers and logistics for goods.

H4: We believe that mobility services are for population for visiting or living in the testing area.

H5: We believe that users can access to service information at stations and website; through on-site intelligent signs and totem for passengers (use of ITS, 5G networks).

H6: We believe that the sequential MaaS and LaaS service model can provide less congestion.

H7: We believe that the sequential MaaS and LaaS service model can provide less noise.

H8: We believe that the sequential MaaS and LaaS service model can provide less emission.

H9: We believe that the sequential MaaS and LaaS service model can provide more safety.

H10: We believe that we can provide an integrated ticketing system among autonomous and existing public transport modes.

H11: We believe that mobility service will be used mainly by existing public transport users.

H12: We believe that mobility service will attract almost all private car users by transforming area into a private car free zone (Reduction of private car usage in urban areas).

H13: We believe that we could generate autonomous services that can provide cost effectiveness in comparison to the private car.

H14: We believe that autonomous services can attract more users and increase revenue by optimising transit time.

H15: We believe that with autonomous mobility services more reliable service can be provided between train stations and business hubs (i.e. commercial area, hospitals, campus, …).

H16: We believe that with autonomous mobility services can increase the comfort of reduced mobility passengers.

BM5 – Peri-urban automated transportation and C-ITS connectivity

Based on Table 9 and Table 10 of *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites*, the assumptions of BM5 are generated:

H1: We believe that the peri-urban on-demand service could connect the sub-urban area with the well-established transit network.

H2: We believe that the established regional transit network could be benefiting from C-ITS cooperative traffic management features such as in-vehicle speed limits, emergency electronic braking light, road works warnings, weather conditions and intersection safety.

H3: Business environment: We believe that we can implement on-demand passenger transport for commuting, leisure, tourism and business reasons for the population at peri-urban areas.

H4: Business environment: We believe that we can implement an on-demand passenger transport for PT users with additional mobility needs.

H5: We believe that with the implementation of an on-demand service higher flexibility is given to the residents.

H6: We believe that with the implementation of an on-demand service higher frequencies could be achieved.

H7: We believe that with the electric buses used for the on-demand service sustainability can be boosted, through reduction of noise.

H8: We believe that with the electric buses used for the on-demand service sustainability can be boosted, through reduction of emissions.

H9: We believe that with the electric buses used for the on-demand service sustainability can be boosted, through providing more safety.

H10: We believe that with the on-demand service the challenges of a hilly area (especially for elder people) can be tackled.

H11: We believe that with the implementation of the on-demand service the walking distances in peri-urban areas can be reduced to 1 – 2 km to the next PT line with higher frequencies.

H12: We believe that by introducing an on-demand service we can reduce private car usage in the peri-urban area.

H13: We believe that by introducing an on-demand service we can provide a better cost-effective operation compared to private cars.

BM6 – Robotaxi services for short distance trips

The assumptions for BM6 are generated based on the Business model canvas and the Proposition value canvas described respectively in Table 11 and Table 12 of *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites*.

H1: We believe that with the implementation of the robotaxi service the transportation efficiency can be increased.

H2: We believe that the robotaxi service will be attractive.

H3: We believe that we can implement a robotaxi service for different patterns including commuting, leisure, and shopping.

H4: We believe that the integration of the robotaxi service is especially valuable for PT users with additional mobility needs (Busses are often complicated to enter for people with these needs).

H5: We believe that with the implementation of the robotaxi service waiting times can be reduced.

H6: We believe that with the implementation of robotaxis the usage of public modes will increase.

H7: We believe that the implementation of robotaxis will increase the comfort in public modes, in particular concerning the maximum load section.

H8: We believe that we could synchronize robotaxis operations given demand and real-time state of public modes.

H9: We believe that robotaxis passengers will be satisfied.

BM7 – Sustainable living areas with autonomous public transportation

Based on Table 13 and Table 14 of *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites*, the assumptions of BM7 are generated:

H1: We believe that fewer parents will drive their children to school by car, which will increase the accessibility for paratransit and other critical road users.

H2: We believe that fewer relatives will drive their car for visits at the elderly home and increasing accessibility for relatives in rush hour.

H3: We believe that children, elderly and users with special needs will have an increased transport offer through providing a first and last mile solution.

H4: We believe that general users will have an increased transport offer through providing a first and last mile solution.

H5: We believe users will accept this solution – regardless of vehicles' low speeds.

H6: We believe that the AV shuttle will contribute to increase the quality of life in the area.

H7: We believe that efficient autonomous first and last mile solutions will increase land and facility value and increase ability for employers to retain and attract new employees.

BM8 – First/Last mile autonomous transportation to mobility hubs

Based on Table 15 and Table 16 of *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites*, the assumptions of BM8 are generated:

H1: To create a connected and automated passenger transport service between station-to-station and stations-to-university and stations-to-shopping mall.

H2: To create a connected and automated passenger transport service between different organizations as shopping mall-to-university, shopping mall-to-business district, and business district -to-university.

H3: To create a connected and automated cargo transport service between shopping mall-to-stations.

H4: To serve for the passengers as students, workers, visitors, and shoppers.

H5: To provide the information about the transportation (such as arrival/departure time, shuttle location, estimated travel time, etc.) by using a digital platform such as an application and/or website (5G connection).

H6: The deployment of connected and automated vehicle will reduce the congestion around mobility HUBs thanks to dedicated lines or some promotions.

H7: The deployment of connected and automated vehicle will reduce the travel time to mobility HUBs thanks to dedicated lines or some promotions.

H8: To reduce parking-area-use and illegal parking, the connected automated shuttle would avoid any time-loss for parking.

H9: To be preferred, the automated shuttle service would provide a cheaper service to the users by saving travel and waiting time.

H10: The users may reach the free Wi-Fi and USB Charging stations on the automated shuttle

H11: To provide a promotion, the public transport tickets and subscriptions would be accepted for automated shuttle service without any additional payment required.

H12: To reduce the time-loss that caused by parking and congestion, the connected automated shuttle would serve as comfortable as private transport.

H13: To be more reliable, the connected and automated service would be supported by providing current location of the vehicle (5G connection).

H14: To increase the accessibility of the connected automated shuttle, IoT and 5G digital assistance systems would be provided for users who need assistance.

BM9 – Integrated automated and electric shuttle busses for large scale events

The assumptions of BM9 are generated based on Table 17 and Table 18 of *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites*:

H1: We believe that the automotive industry will be interested in testing AV-based services during large events.

H2: We believe that automated services deployed for large scale events will be used by event visitors and inhabitants as well.

H3: We believe that testing automated services during large events will involve the automotive industry, event associations, ITS providers, infrastructure providers and SMEs.

H4: We believe that testing automated services during large-scale events will challenge the limits of the service in terms of capacity and service performances.

H5: We believe that service automation will be safe for visitors of the event.

H6: We believe that providing an automated service during large scale events will promote the technology and create a great image to show around the world.

H7: We believe that testing and sponsoring automated services during large scale events will be costly and only big corporations would be able to pay.

H8: We believe that using autonomous services during the event will improve the experience of visitors and their satisfaction.

BM10 – Interoperable IoT platforms for automated mobility

The assumptions of BM9 are generated based on Table 19 and Table 20 of *D2.2: Proposed business / operating models & mapping to UCs and Pilot sites*:

H1: We believe that IoT interoperability for connected and automated driving will increase safety.

H2: We believe that IoT interoperability for connected and automated driving will provide more comfort for driving.

H3: We believe that the possibility of interconnecting surrounding sensors (e.g. cameras, traffic light radars, road sensors) in addition to on-board sensors (e.g., LiDAR, radar, cameras) will add detection robustness.

H4: We believe that the possibility of interconnecting surrounding sensors will reduce implementation costs.

H5: We believe that the possibility of interconnecting surrounding sensors will enable pushing the SAE (Society of Automotive Engineers) level of driving automation to full automation.

H6: We believe that the possibility of interconnecting surrounding sensors will enhance the traffic flow, therefore also reducing emissions and noise.

H7: We believe that IoT interoperability for connected and automated driving will enhance the possibility for new players to join the market and contribute with new data-driven business models.

H8: We believe that to stay profitable OEMs will have to enter digital ecosystems (joint acquisition of HERE from Daimler, Audi and BMW; alignment of BMW with Intel/ Mobileye).

H9: We believe that IoT interoperability for connected and automated driving will allow for higher speed (due to higher safety and higher detection rate).

Annex 2 – Case example for scoring a Business Model goal

The objective of this Annex is to show an example of calculation.

Consider the BM1 – Autonomous PT in combination with additional on-demand services.

To score the Goal 4 – Technology and associated service quality, all the assumptions should be scored.

The scoring for all the assumptions of the Goal are presented into the following table:

Table 65 – Example of scoring for BM1 – Goal 4 (no specific site)

Assumptions	Indicator range	Site data / interviews	Value
H14: We believe that by introducing integrated APT-ODS we can build a sustainable urban environment in the area: by increasing safety.	1 - ((Conflicts + road accidents + HBE) / Kms travelled)	Dynamic data	0,97
H1: We believe that we could generate a fully integrated (physically and digitally) autonomous PT and on-demand operation (APT-ODS).	1: Physically and Digitally integrated 0.5: Physically Or Digitally integrated 0: No integration	Physically integrated (linked to PT) and digitally integrated (on-real time information integration and on-demand transport)	1
H11: We believe that through integrated operation we could provide real-time information about traffic volume in the area and riders for the shuttle.	1: Real-time information available 0: No real time information	Real time information available for shuttle and bus	1
H2: We believe that we could generate an automated shuttle bus fixed line at peak time that connects the different facilities around the campus area and reduce travel times.	Ratio: average speed / maximum speed	Average speed = 3,91 Maximum Speed = 22	0,17
H7: We believe that through integrated operation (APT-ODS) we can provide comfortable and at-standard seating capacity to service users.	Ratio of satisfied users	Satisfaction survey: 89%	0,89
H8: We believe that through integrated operation (APT-ODS) we can provide cheap and flexible service to users.	1: free service 0.5: Public transit integration / cost = PT ticket cost 0: more expensive than PT	Free service	1

The score of the Goal 4 is the sum of all scores, weighted by the maximum possible score.

The following table presents the calculation of the final score for Goal 4:

Table 66 Example of calculating the final score for Goal 4 – BM1 (no specific site)

Sum of all scores	5,04
Maximum possible score	9
Final Score = **Sum of all scores / Maximum score**	**0,56**

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