SHared automation Operating models for Worldwide adoption

SHOW

Grant Agreement Number: 875530

D1.2: SHOW Use Cases

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Legal Disclaimer

Executive Summary

The SHOW Use Cases constitute the reference for the design & specification, implementation & demonstration phases of the project and concern all the stakeholders relevant to the SHOW project. This Deliverable utilises the ecosystem, actors, needs and wants of D1.1: *Ecosystem actors' needs, wants & priority and* priorities & user experience exploration tools and concludes in specifying 17 Use Cases for demonstration within the SHOW Project; clustered in 3 UCs families. An effort was made to restrict the number of UC families and list in order not to delude the project's focus, while still covering all proposed UCs at the project proposal and beyond. In this Deliverable a short description of each UC is being presented (Section 2.1.1), in order to provide an overview of the issues that each UC covers, although differences will exist in the way that these issues will be addressed by the different pilot sites linked to each UC. More specifically, in Sections 3.1 and 0 the full analysis of each pilot site is presented, on how they will organize their pilots in order to cover the Use Cases that they will test during the real-life demonstrations. This analysis has been structured to cover the 3 different phases of the pilots, namely the Design phase, the Development\ Implementation phase, and the Business/ Exploitation phase, through the use of a specific consistent issue mechanism (template) that consists of 23 parameters in total, including (indicatively) the description of site specific application of the different UCs in each pilot site and the definition of factors like the operational speed, the traffic context the frequency and timeline of operation, as well as any expected restrictions, key risks and security related concerns, as well as the leading entity(ies) and the key stakeholders clusters involved (for the Design phase). Regarding the Development/Implementation phase, information is provided by each pilot site for the vehicles to be used, the infrastructure, and the operators, as well as a more detailed implementation scenario for each UC. Finally, for the Business/Exploitation phase, description is also included on the specific travellers' cohorts addressed, the pre-existed background of the services and the expected innovation within SHOW, as well as the relevant training and other skills/knowledge requirements for the key stakeholders involved.

Throughout the analysis provided in this Deliverable, the SHOW Use Cases, have been also mapped to the Use Cases and services defined with the SPACE (Shared Personalised Automated Connected vEhicles) project (Section 2.1.3), as well as to the needs and priorities of the stakeholders that consist the project's ecosystem around automated urban mobility (Section 2.3).

As the project is dynamically elaborating and the COVID-19 emergency affects Public Transport operation and planning, it is expected that the mapping of UCs with pilot sites will evolve. Any further changes will be reported to the Pilot Plans/ Pilot reporting deliverables

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2.0	29/11/2020	Revised document after comments from PO	Matina Loukea (CERTH/HIT)

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Abbreviation List

Abbreviation	Definition
AD	Automated Driving
ADS	Automated Driving Systems
AI	Artificial Intelligence
API	Application Programming Interface
AV	Autonomous vehicle
BRT	Bus Rapid Transit
C-ITS	Cooperative Intelligent Transportation System
DRT	Demand Responsive Transport
ETSI	European Conference of Postal and Telecommunications Administrations
HD	High Definition
IoT	Internet of Things
ITS	Intelligent Transportation System
Kph	Kilometres Per Hour
KPI	Key Performance Indicator
LaaS	Logistics-as-a-Service
MaaS	Mobility-as-a-Service
N/A	Non Applicable
OBUs	On-Board Units
PRM	Person with Reduced Mobility
PT	Public Transport
PTO	Public Transport Operator

Abbreviation	Definition
QoS	Quality of Service
RES	Renewable Energy Sources
RoI	Return of Investment
RSU	Road-side Unit
StVO	StrassenVerkehrsOrdnung (Road traffic regulations)
TMC	Traffic Management Centre
UC	Use Case
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
V2X	Vehicle to Everything
VASes	Values Added Services
VRU	Vulnerable Road Users

1 Introduction

1.1 Purpose and structure of the document

The current document, the so-called Deliverable 1.2: SHOW Use Cases, aims to the identification and elaboration of the priority urban automated mobility Use Cases of the project, all meeting stakeholder interest and preliminary acceptance, corresponding also to D1.1 findings. 3 UC families and 17 single UCs have been defined, fully corresponding to and covering as well as elaborating further the ones described in the GA, each one being addressed in at least one pilot site.

1.2 Intended Audience

The SHOW Use Cases constitute the backbone reference document for the whole project development and demonstration activities to follow. To this extend, their description mainly refers internally to the project's participants as it sets the framework and describes the activities of the different Mega and Satellite sites of SHOW that will cover one of more of the UCs, while also they set the functional requirements that will be translated in technical requirements in WP4 System Architecture.

These Use Cases also concern all the stakeholders relevant to the SHOW project (as also defined in D1.1), considering that they respond to the real and perceived needs and wants of the SHOW ecosystem and this is also one of the reason why the project's UCs have been presented and commented during the 1st Pan-European Workshop of SHOW with the participation of more than 50 external experts.

1.3 Interrelations

The interrelations of the Use Case with the other Activities of this and other WPs is shown in the following figure.

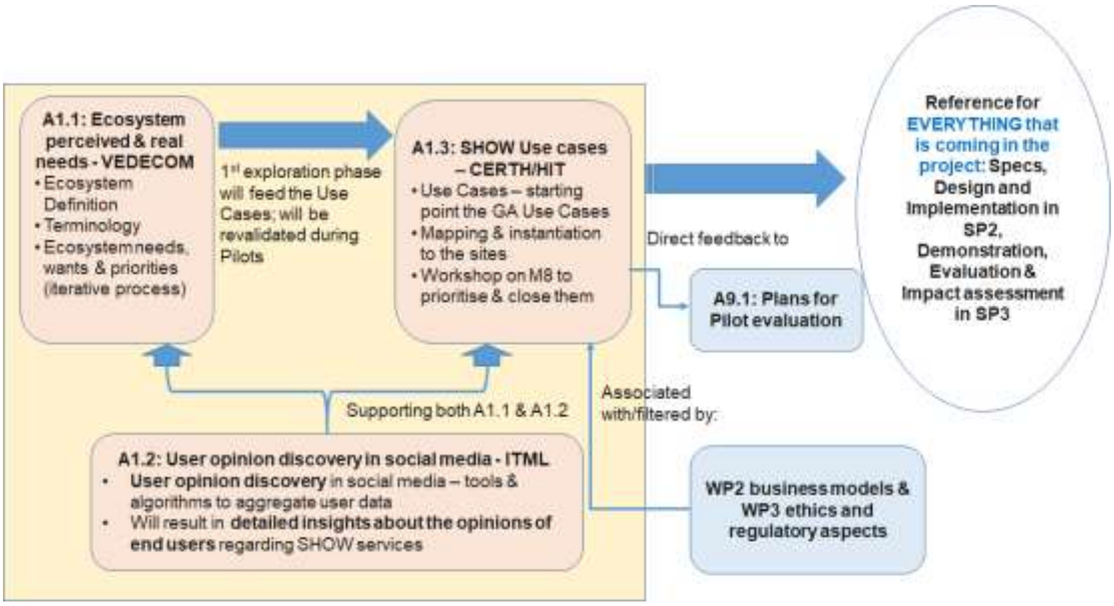


Figure 1: A1.3 SHOW Use Cases interrelations.

2 Methodological Approach

As a starting point to the development of the final SHOW Use Cases were the 7 families of UCs that were already defined in the proposal phase and presented also in the GA, being decomposed in 23 single UCs and which are presented in Table 1 below:

Table 1: Initial clustering of SHOW UCs (as presented in GA)

Family Use Case	Single Use Cases
UC1: Autonomous traffic in real city environment	• **UC1.1**: Under “normal” (higher) speed • **UC1.2**: In complex environments with real curvatures in roundabouts • **UC1.3**: Interfacing non equipped vehicles/ travellers (VRU) • **UC1.4**: In an energy sustainable way • **UC1.5**: For passengers and cargo (including automated cargo delivery at warehouse) • **UC1.6**: Actual integration to City TMC • **UC1.7**: Mixed traffic flows • **UC1.8**: Connection to Operation Centre for tele-operation and remote supervision
UC2: Multi-actor business environments	• **UC2.1:** With different operators • **UC2.2:** With different vehicle types • **UC2.3:** With different infrastructures (5G, G5, IoT, none) • **UC2.4:** All connected in terms of data & business cases
UC3: Seamless autonomous transport chains of Automated PT, DRT, MaaS, LaaS	None
UC4: Mixed passenger/cargo automated transport	• **UC4.1:** Spatial within the same vehicle • **UC4.2:** Spatial with a towed vehicle (platooning) • **UC4.3:** Temporal
UC5: Platooning for efficiency	• **UC5.1:** Urban passenger platooning for higher speed traffic during connectors (city centre to peri urban, at the city ring, etc.) • **UC5.2:** Cargo platooning for efficiency
UC6: Operational services in semi-control environment	• **UC6.1:** Automated service at bus stop • **UC6.2:** Depot management of Automated Buses (servicing, clearing, maintenance)

Family Use Case	Single Use Cases
	• **UC6.3:** Parking applications
UC7: Enhanced services	• **UC7.1:** Self-learning DRT (planning, routing, operation) • **UC7.2:** Added value services based upon big data and AI algorithms (metadata)

During the revision and update of the project's use cases, a clustering of the pre-defined use cases have been made by the participants of the respective Activity (A1.3) , led by CERTH/HIT, in order for them to be more precise and inclusive, reducing to the greatest possible extend any duplications among them. More specifically the main changes that have been made at the initial formulation of the use cases are the following:

- Some of the initially proposed use cases were found having a more **horizontal role** and affecting many or all the UCs, e.g. UC2: Multi-actor business environments that needs to be clarified in the context of each use case. Thus, they have been included in the description of each new UC and not as separate ones.
- Family Use Case 5 of the initially proposed use cases, has been transferred as part of the single use cases of UC1: Automated mobility in cities, due to the fact that urban platooning has not been highly prioritised by the stakeholders in A1.3.
- Family Use Cases 6 and 7 have been merged to one family use case in the new clustering (UC3: Added Value services for Cooperative and Connected Automated mobility in cities), as they are closely interrelated and without excluding any of their sub-UCs.

The final list and description of the SHOW Use Cases is included in Section 2.1, together with their correspondence to the initially proposed use cases (as described in the GA).

In addition, other factors were taken into account during the use cases review and revision, including the results of the project so far, which focus mainly on the needs and priorities of the users and relevant stakeholders. In particular, the approach that has been followed in the Activity for the definition of the project's final use cases is summarised in the following steps:

1. **Starting from the initially proposed Use Cases/ Thematic Areas of the project,** as described in the GA (see Table 1 above).

2. **Mapping to stakeholder needs and priorities** (that have emerged from A1.1 work and presented in D1.1) to them; identifying the gaps and making the necessary adjustments and corrections.

3. Come up with an enhanced list refining once more in relation to other **relevant initiatives Use Cases** (e.g. SPACE) and roadmaps (e.g. ERTRAC) in order to agree with joint efforts and be relevant.

4. **Definition in detail of** the Use Cases – in a **step-wise user-system interaction manner.** – Define also all the conditions, restrictions, success targets from the functional point of view, with the **contribution of all demo sites, OEM's and developers.**

5. **Mapping and instantiation to the demonstration sites.** A first mapping and instantiation was already done from the proposal phase and has constituted the starting point. The updated use cases have been circulated (in multiple iterations) to all demonstration sites requesting and integrating their feedback, towards their finalisation. It should be noted that not all Use Cases are applicable for all demo sites, while even for the same Use Cases, the conditions change among the different sites. The outcomes from this step, regarding the final SHOW Use Cases and is being described in Section 3. In particular for each demonstration site a detailed analysis has been conducted describing the implantation of their UCs, identifying (among others): participating fleet modes, operation speed, traffic and environmental context of operation, specific user cohorts addressed and value chain stakeholders participating, target numbers of passenger/freight operation in demonstrations, real life scenarios, operational and technical dependencies and restrictions, related user experience aspects, training and other skills/knowledge requirements, other "soft" measures connected (i.e. incentives), user acceptance risks to be considered, etc. The template used by the demonstration sites for this analysis can be found in Appendix 1.

6. **Prioritisation of the Use Cases** in a dedicated session during the 1st SHOW Pan-European Workshop that took place at the 18th of September 2020 with the participation of more than **50 stakeholder representatives** covering the whole value chain. The focus has been to present them the SHOW Use Cases and provide them with the opportunity to "weight/rank" them and also give their remarks and feedback for their optimisation. The feedback from this dedicated UCs session and their prioritisation results are described in Section 2.2.

The Use Cases of the project will be revised, if needed, **in an iterative manner** after each demonstration round and changes will be reported to the Pilot Plans/ Pilot reporting deliverables.

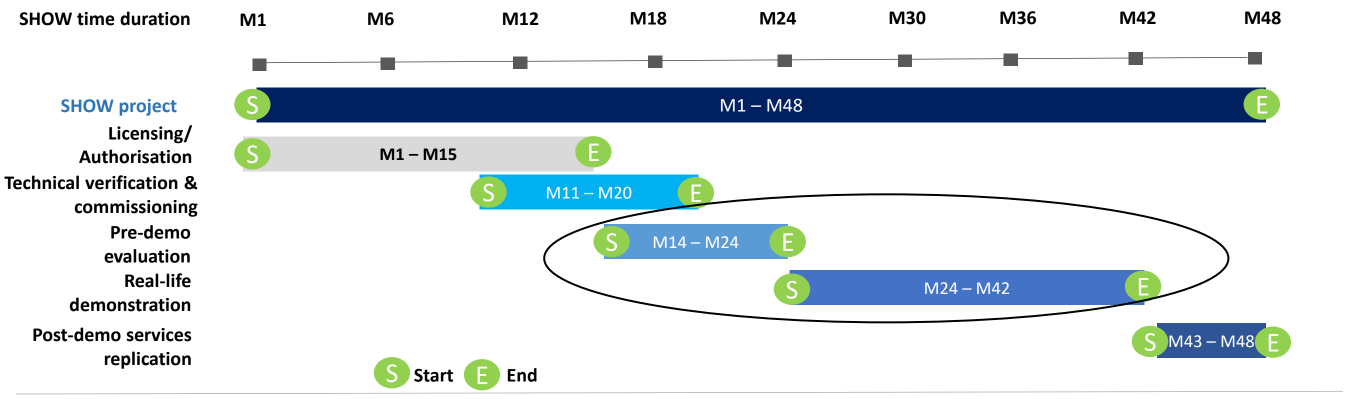


Figure 2: SHOW demonstration plan.

The responsible Partner for all the above tasks is CERTH/HIT. Especially for this part of work, an attempt has been made to involve not only the specific WP and even SP participants, but the whole Consortium, as the Use Cases of the project is one of the most significant elements and outcomes, being also critical for its success.

2.1 Final SHOW Use Cases

2.1.1 Brief description of SHOW Use Cases

The final SHOW Use Cases consist of 3 family Use Cases and 17 single Use Cases, which are being described below.

I. Use Case 1: Automated mobility in cities

UC1.1: Automated passengers/cargo mobility in Cities under normal traffic & environmental conditions

Includes normal speeds, normal/smooth traffic context, no traffic or other environmental complexity. Indicatively: dedicated lane, pre-defined more or less routes, no roundabouts or short curves, no need for self-change of lane, no heavy traffic, no extreme weather conditions (e.g, snowflakes or heavy rain).

It may concern cargo (cargo delivery at warehouse or similar) or passengers mobility.

Modes addressed: PT, DRT, MaaS, LaaS.

UC1.2: Automated passengers/cargo mobility in Cities under complex traffic & environmental conditions

Includes normal speeds, complex traffic or environmental context (e.g., curvatures in roundabouts, etc.), when any of the above (UC1.1) restrictions is applied (e.g., heavy traffic, extreme weather conditions, etc.).

It may concern cargo (cargo delivery at warehouse or similar) or passengers mobility.

Modes addressed: PT, DRT, MaaS, LaaS.

It considers as UC1.1 still dedicated or restricted AV lanes.

UC1.3: Interfacing non automated vehicles and travellers (including VRUs)

According to the Drive2theFuture project, to achieve a VRU redefinition towards Autonomous Vehicles (AV) per transport mode and AV level it is essential to take stock of current definitions and underlying concepts. As for now, VRU can be defined (as):

- Non-motorised road users, such as pedestrians and cyclists as well as motor-cyclists and persons with disabilities or reduced mobility and orientation (European Union, 2010).
- Road users who are most at risk for serious injury or fatality when they are involved in a motor-vehicle related collision (US DOT FHWA, 2019).
- With regard to the amount of protection in traffic (e.g. pedestrians and cyclists) or by the amount of task capability (e.g. the young and the elderly) (SWOV, 2012).
- A term applied to those most at risk in traffic. Thus, vulnerable road users are mainly those unprotected by an outside shield (OECD, 1998).
- Road user who is present in a crash involving vehicles which do not have a protective shell (Avenoso, 2005).

Most definitions include pedestrians and cyclists, children and adolescents as well as motorised two wheelers as they have less protection and/or have physical disadvantages compared to the average road user. Other definitions also include seniors, mobility impaired persons, scooter riders, skateboarders and segway riders.

Within this UC the interaction between the AV and any of the above VRU types will be demonstrated and analysed for all modes addressed. This will include issues of safety and security of VRUs (e.g. children, elderly, persons with disabilities) also as AV passengers.

UC1.4: Energy sustainable automated passengers/cargo mobility in Cities

Solutions (e.g., inductive dynamic or static charging, RES based charging, etc.) that make the service sustainable, i.e. able to cover the same service with the electric AV. (area, frequency, cost) as with the conventional one.

Modes addressed: PT as a minimum. Potentially extendable to: DRT, MaaS, LaaS.

UC1.5: Actual integration to city TMC

Integration of the AV (or fleet) operation/ supervision centre to a TMC (of the city or other); together with the overall traffic supervision.

Modes addressed: PT as a minimum. Potentially extendable to: DRT, MaaS, LaaS.

UC1.6: Mixed traffic flows

AVs and non AVs mixed in the same traffic flows (extension of UC1.3).

Modes addressed: PT as a minimum. Potentially extendable to: DRT, MaaS, LaaS.

UC1.7: Connection to Operation Centre for tele-operation and remote supervision

Remote supervision and teleoperation of AV (or AV fleets) by a control centre. This control centre may be integrated into the TMC (of UC1.5) or be autonomously operating.

Modes addressed: All

UC1.8: Platooning for higher speed connectors in people transport

AV L4/5 has and is expected to have speed limitations today and in the short to mid-term future. The operating speeds are appropriate for dense urban circulation and too slow for longer connection to peri-urban/rural areas or from hub to hub (i.e. from a University to a hospital clinic area where AVs perform in local transport). For this reason this UC focuses upon urban platoons of more than one AVs; where the leading vehicle has a driver that allows the platoon to run on higher speeds between AV L4/5 operating zones and then collect or dispatch AV L4/5 vehicles from such areas to perform the transport between them.

Modes addressed: MaaS as a minimum particularly extendable to DRT, PT.

UC1.9: Cargo platooning for efficiency

“Efficiency” can be measured in different aspects – platooning is usually associated with lower fuel / energy consumption in highway scenarios due to reduced air drag at higher vehicle speeds. But efficiency in an urban scenario could mean consuming less space on roads. Again, the above speed limitations make such a UC promising.

Modes addressed: LaaS.

UC1.10: Seamless autonomous transport chains of Automated PT, DRT, MaaS, LaaS

Automated travel through multiple means; e.g., a traveller using an automated metro line, then boarding an automated bus, using DRT or MaaS for the last mile.

Modes addressed: All

II. Use Case 2: Automated mixed mobility in cities

This family includes UCs on how to use the same AV to transport passenger and goods either at the same time (spatial mobility) or at different routes/ times (temporal mobility, in order to enhance efficiency of use of AV fleet and reduce their idle times, as well as the required operators investment in vehicles.

UC2.1: Automated mixed spatial mobility

Mixed mobility of cargo/passengers at the same time within the same vehicle, but at different parts of the vehicle or with towed vehicle. Separation and security of cargo compartments, as well as access to it and combined passenger/cargo loading/unloading will be demonstrated.

Modes addressed: DRT, PT

UC2.2: Automated mixed temporal mobility

Same vehicle used at different times for passenger and cargo transfer (e.g., in the morning for traveling people and in the night for goods supply to shops).

Modes addressed: DRT

III. Use Case 3: Added Value services for Cooperative and Connected Automated mobility in cities

This UC concerns all services that support and enhance the AV fleet usage functionality of the operator and the passengers.

UC3.1: Self-learning Demand Response Passengers/Cargo mobility

Planning, routing, operation self-learning services for passengers and/or cargo; based upon AI enabled algorithms that optimise DRT operations (e.g., using historical and real time dynamic service data).

Modes addressed: Mainly DRT, potentially all.

UC3.2: Big data/AI based added value services for Passengers/ Cargo mobility

AI enabled smart services for passengers or goods; adapting the service to the customer needs and preferences.

Modes addressed: Mainly MaaS/ LaaS, potentially DRT.

UC3.3: Automated parking applications

AVs self-parking functions.

Modes addressed: All

UC3.4: Automated services at bus stops

Automatically handling bus stop approach, leaving and then merging again with traffic.

Modes addressed: PT

UC3.5: Depot management of automated buses

Automated servicing, clearing, maintenance of AVs and their fleets at depot areas.

Modes addressed: All

Due to the urgency and the impact caused by the COVID-19 crisis outbreak in both the research and the transportation areas, an additional UC has been suggested by the SHOW Consortium, relevant to this and with focus on public transport. The integration of this UC to the SHOW pilots is under investigation and any relevant progress will be reported to the Pilot Plans / Pilot reporting deliverables.

2.1.2 SHOW Use Cases correspondence to the GA Use Cases

In Table 2 below the mapping and transformation of the initially proposed Use Cases in the SHOW GA to final project's Cases is presented, in order to provide a clear overview.

Table 2: Mapping of SHOW Use Cases to former (GA) Use cases

SHOW GA Use Cases	New SHOW Use Cases
UC1: Autonomous traffic in real city environment	**UC1: Automated mobility in cities**
UC1.1: Under “normal” (higher) speed	UC1.1: Automated passengers/cargo mobility in Cities under normal traffic & environmental conditions
UC1.2: In complex environments with real curvatures in roundabouts	UC1.2: Automated passengers/cargo mobility in Cities under complex traffic & environmental conditions
UC1.3: Interfacing non equipped vehicles/ travellers (VRU)	UC1.3: Interfacing non automated vehicles and travellers (including VRUs)
UC1.4: In an energy sustainable way	UC1.4: Energy sustainable automated passengers/cargo mobility in Cities

SHOW GA Use Cases	**New SHOW Use Cases**
UC1.5: For passengers and cargo (including automated cargo delivery at warehouse)	Integrated in other UCs (e.g, UC1.1, UC1.2)
UC1.6: Actual integration to City TMC	UC1.5: Actual integration to city TMC
UC1.7: Mixed traffic flows	UC1.6: Mixed traffic flows
UC1.8: Connection to Operation Centre for tele-operation and remote supervision	UC1.7: Connection to Operation Centre for tele-operation and remote supervision
UC2: Multi-actor business environments	No stand-alone UC but features that need to be defined in the context of each Use Case (in each pilot site). Regarding the former GA UC2.3, the description of the technological communication channels (e.g., V2V, V2I) has been also transferred to the infrastructure description of each site, (see Section 3 under the infrastructure description of the Development\ Implementation Section of each site). However, this information will be elaborated and further analysed in the relevant SHOW Architecture System report, and in the individual architecture of the different sites and the relevant technical reports.
UC2.1: With different operators	
UC2.2: With different vehicle types	
UC2.3: With different infrastructures (5G, G5, IoT, none);	
UC2.4: All connected in terms of data & business cases	
UC3: Seamless autonomous transport chains of Automated PT, DRT, MaaS, LaaS	UC1.10: Seamless autonomous transport chains of Automated PT, DRT, MaaS, LaaS
UC4: Mixed passenger/cargo automated transport	**UC2: Automated mixed mobility in cities**
UC4.1: Spatial within the same vehicle	UC2.1: Automated mixed spatial mobility
UC4.2: Spatial with a towed vehicle (platooning)	
UC4.3: Temporal	UC2.2: Automated mixed temporal mobility
UC5: Platooning for efficiency	Transferred as sub-Use Cases of UC1
UC5.1: Urban passenger platooning for higher speed traffic during connectors (city centre to peri-urban, at the city ring, etc.);	UC1.8: Platooning for higher speed connectors in people transport
UC5.2: Cargo platooning for efficiency	UC1.9: Cargo platooning for efficiency
UC6: Operational services in semi-control environment & UC7: Enhanced services	GA UC6 & UC7 have been merged to →

SHOW GA Use Cases	New SHOW Use Cases
	UC3: Added Value services for Cooperative and Connected Automated mobility in cities
UC6.1: Automated service at bus stop	UC3.4: Automated services at bus stops
UC6.2: Depot management of Automated Buses (servicing, clearing, maintenance)	UC3.5: Depot management of automated buses
UC6.3: Parking applications	UC3.3: Automated parking applications
UC7.1: Self-learning DRT (planning, routing, operation);	UC3.1: Self-learning Demand Response Passengers/Cargo mobility
UC7.2: Added value services based upon big data and AI algorithms (metadata)	UC3.2: Big data/AI based added value services for Passengers/ Cargo mobility

2.1.3 SPACE correspondence to SHOW Use Cases and Pilot sites

The SPACE (**S**hared **P**ersonalised **A**utomated **C**onnected v**E**hicles) project (https://space.uitp.org/), which is an UITP initiative, centres on the notion that one of the latest developments in mobility, the arrival of automated vehicles (AVs) represents a unique opportunity for a fundamental change in urban mobility that could result in healthier, more competitive and greener cities. This will only happen if AVs are used as shared vehicles that are integrated into an effective public transport network. By employing AVs as shared vehicles, such as shuttle buses or in car or ride-sharing schemes, AVs could drastically reduce car ownership, regain essential urban space, and result in better mobility for all. This is further described in the UITP policy brief "Autonomous Vehicles: a potential game changer for urban mobility"[1].

As shown in the Table 3 below, SHOW Pilot site services cover in good balance all current and future operational environments identified within SPACE:

Table 3: SHOW Pilot demonstrators meeting SPACE priority Use Cases.

SPACE Use Case - Services	Indicative liaison to SHOW UCs
1. First/last mile feeder to PT station - Feeder service, fixed route, operational times in parallel to high capacity PT, on-demand or fixed stops (rush hour), shared use.	UCs1.1, 1.2, 1.3 & 1.6, 1.8, 1.9, 1.10, 3.2,
2. Area based service and feeder to PT station - Proximity service, area–based, dynamic routing, on-demand stops, shared use.	UCs1.1, 1.2, 1.3. 1.6, 1.10, 3.1

[1] https://www.uitp.org/publications/autonomous-vehicles-a-potential-game-changer-for-urban-mobility/

SPACE Use Case - Services	Indicative liaison to SHOW UCs
3. Premium shared point -to-point service - On-demand point-to-point service: dynamic routing, shared use, extended operational times.	UCs1.5, 1.6 1.7, 1.8, 2.1, 2.2, 3.1, 3.2
4. Shared point-to-point service - On-demand point-to-point service where/when demand is low: dynamic routing, shared use, extended operational times.	UCs1.5, 1.6 1.7, 1.8, 2.1, 2.2, 3.1, 3.2
5. Local bus service - Replacement of local PT in small cities, on-demand shared fleet-based service, dynamic routing, 24h operation.	UCs1.1, 1.2, 1.3, 1.5, 1.6, 1.7, 1.10
6. Special service (campus, business park, hospital) - Feeder to PT stations and additional service on private grounds, shared use, scheduled service during morning and afternoon peak - otherwise on-demand. Possibility of hybrid vehicle use carrying correspondence and small parcels.	UCs1.1, 1.2, 1.3, 1.5, 1.6, 1.7, , 2.1, 2.2, 3.1, 3.2
7. Bus Rapid Transit (BRT) - high frequency fixed route, fixed stops, separated lane, shared use.	UCs1.1, 1.2, 1.3. 1.5, 1.6, 1.7
8. School bus - Door-to-point service, fixed route with fixed operational time.	UC3.4
9. **Premium - Robo-taxis -** Point-to-point on demand premium service; for private use and sequential sharing.	UCs1.1, 1.2. 1.5, 1.6, 1,7, 1.8, 3.1, 3.2
10.Car-sharing - On-demand sequentially shared private service, reserved for a period of time, dynamic routing, extended operational times.	UCs1.1, 1.2, 1.3, 1.5, 1,6, 1.8, 1.10
11.Depot - Automated and optimised fleet management in the bus depot (parking and charging management).	UC3.5
12.Intercity travel - Long distance fixed route connection between villages/ cities on highways.	UCs1.1, 1.2, 1.3, 1.4, 1,6, 1.8, 1.9, 1.10, 3.1, 3.2
13.Pop-Up Shuttle transport - Temporary service with fixed route, operational only for some days/weeks during exhibitions, large events, concerts, etc.	UCs2.2. 3,2

2.2 Outcomes from the SHOW Use Cases interactive session

As mentioned above in during the 1st SHOW Pan-European Workshop (https://show-project.eu/2020/10/01/show-successfully-holds-the-first-pan-european-workshop-how-to-make-ccam-in-cities-a-reality/) that took place at the 18th of September 2020 with the title "How to make CCAM in Cities a reality?", a dedicated interactive session was included that concerned the presentation to the audience of the SHOW Use Cases, as well as the provision of their feedback through a voting/ commenting process that included both discussion but also the use of a visualization tool (https://www.mentimeter.com/).

Figure 3: SHOW first pan-European Workshop "How to make CCAM in Cities a reality?"

More than 50 external to the project participants joined the SHOW Use Cases interactive session throughout its duration covering 5 different stakeholders' clusters, with the majority of them representing the sector of Research & Academia, as depicted in Figure 4 below.

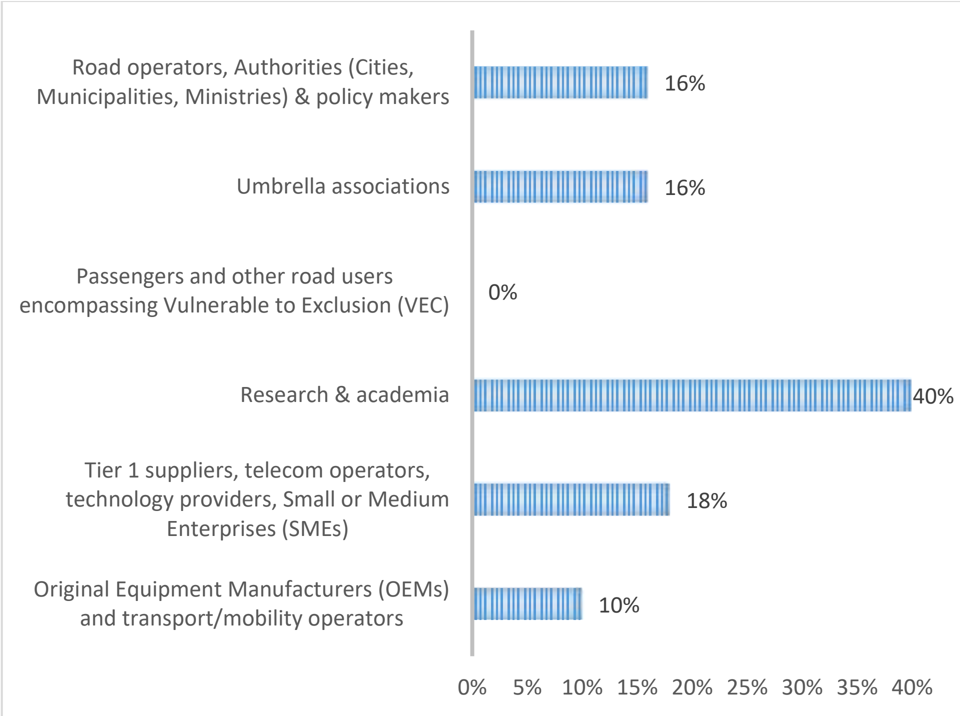


Figure 4: Stakeholders' clusters of the SHOW UCs interactive session participants.

During this session a list of criteria was provided to the participants, related and describing the introduction of AVs in public transport in general. The participants were asked to rank those criteria according to their importance (ranking from not important at all up to very important).

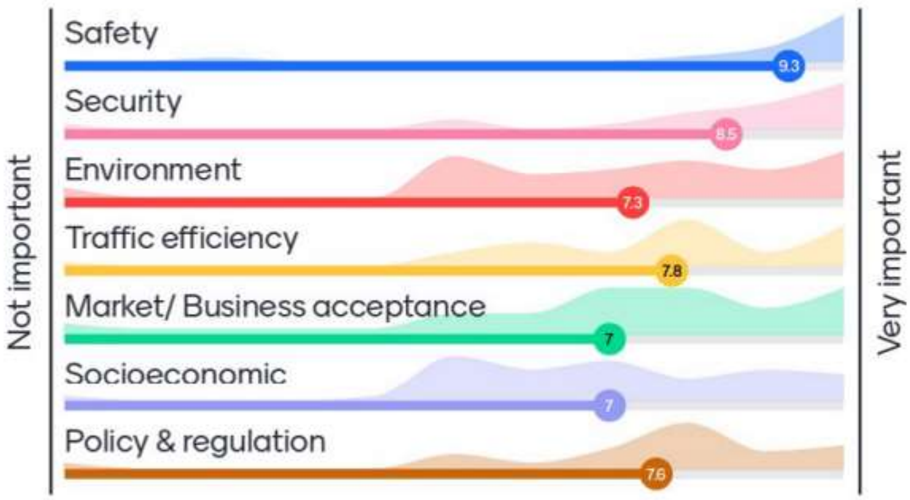


Figure 5: Importance of criteria regarding AVs in public transportation (from 0 to 10).

As depicted in Figure 5, **safety and security** have been ranked by the participants at the first two places as the most important criteria, followed by **traffic efficiency** and **policy regulation** (with minor differences between them), **environment** coming at the 5th place and **market/ business acceptance** together with **socioeconomic** issues ranking last.

In the next step of the session, the participants were asked to assess how those criteria/ parameters believe that they will be affected by each one of the SHOW family use cases.

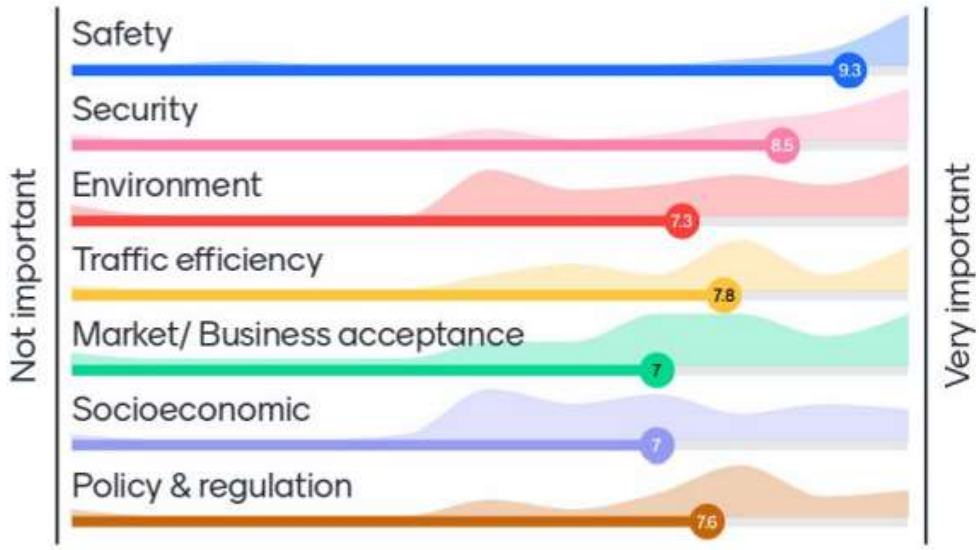


Figure 6: Criteria prioritisation for UC1 cluster (from 0 to 10).

The realisation of family UC1: “Automated mobility in cities” (including the single UCs that fall under it) focuses on both automated passengers and cargo mobility in cities under normal and complex traffic and environmental conditions, including also the interaction of AVs with non-automated vehicles and VRUs, integration to TMC and with features of tele-operation and remote supervision, as well as cargo platooning and seamless autonomous transport chains of automated PT, DRT, MaaS, LaaS. According to the feedback provided by the workshop participants, the realisation of this UC is expected to have a very important impact on safety of the AVs operation and integration to the urban traffic environment, as well as to its security and traffic efficiency (in diminishing order). The aspects expected to be affected the least are the market & business acceptance and socioeconomic issues.

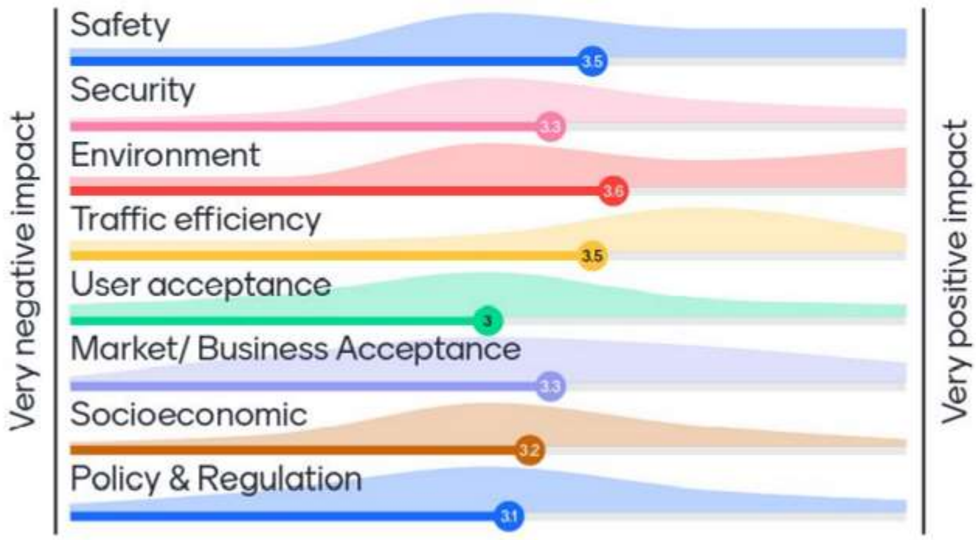


Figure 7: Criteria prioritisation for UC2 cluster (from 0 to 10).

According to Figure 7, the implementation of UC2 that consists of the mixed spatial and/ or temporal mobility of cargo and passengers, is expected to have a bigger influence in the environment, followed by the aspects of safety and traffic efficiency. The factor that is expected to be affected the least (with minor variance though) is the user acceptance of the AVs in the urban environment.

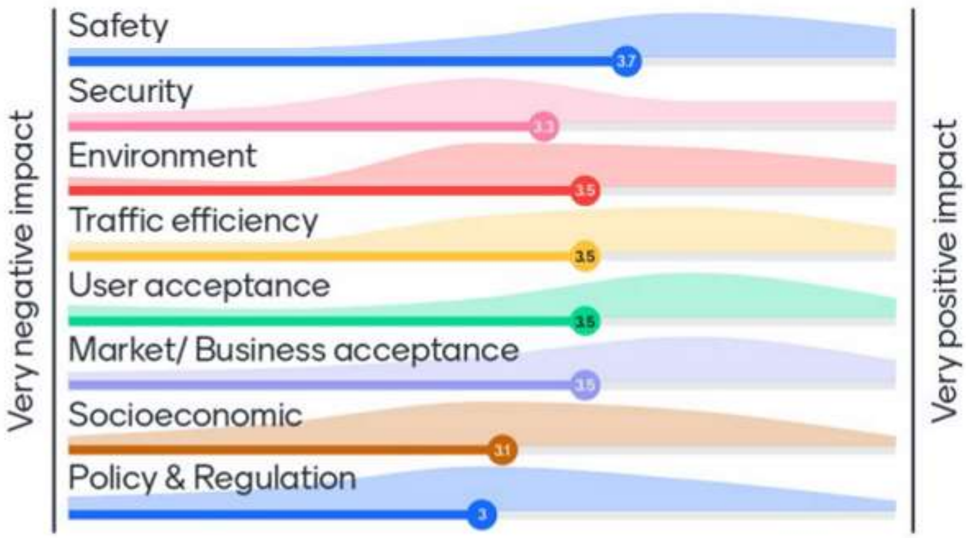
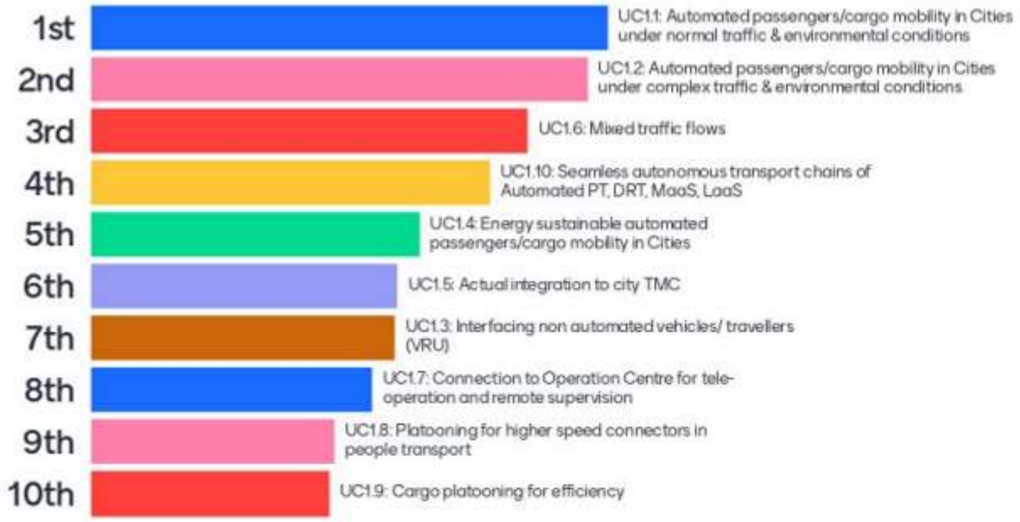


Figure 8: Criteria prioritisation for UC3 cluster (from 0 to 10).

Moving on to UC3 that includes added value services, such as self-learning services, Big Data , automated parking applications and services at bus stops, as well as depot management of automated buses, the experts foresee again that these services are going to affect firstly safety, followed by environment, traffic efficiency, user acceptance and market/ business acceptance (with the exact same ranking). Issues related top policy & regulation are expected by the workshop participants to be affected the least (see Figure 8).

After the completion of this part of the UCs interactive session, the participants were also asked to prioritise the single UCs of each family UC and also provide their feedback about them.

Regarding the first UC “Automated mobility in cities”, the sub-UC of the Automated passengers/cargo mobility under normal traffic and environmental conditions (UC1.1) has been identified as the most important one, followed by the one covering the complex traffic and environmental conditions (UC1.2), while the UC1.6 concerning the AVs and non AVs mixed in the same traffic flows has ranked third (see Figure 9). The UC that covers the cardo platooning aspect (UC1.9) has ranked as the least important.



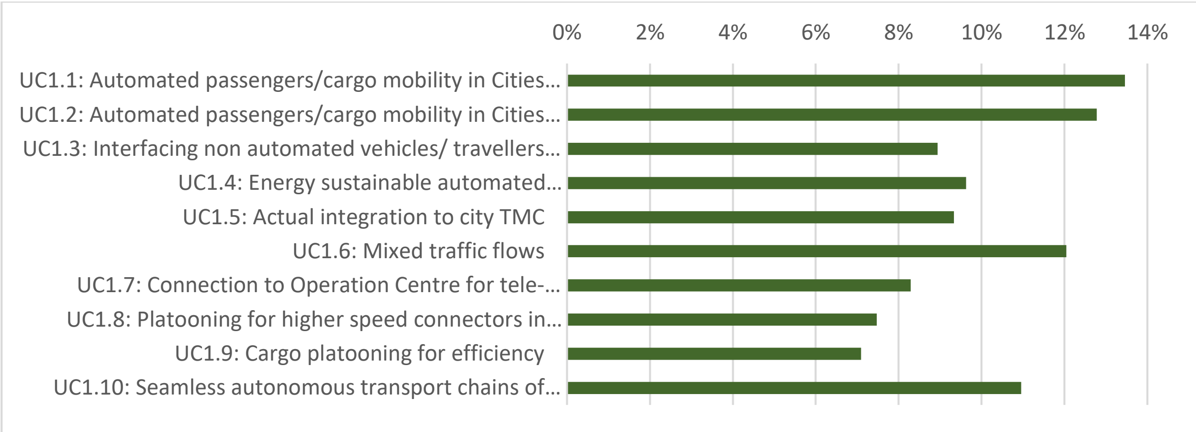


Figure 9: Ranking and rates of single Use Cases of UC1 cluster.

The remarks provided by the participants for these UCs, focused mainly to the fact that a fully connected, interoperable infrastructure with strong platforms and partners are required to make the UCs and business models viable. Moreover, it has been pointed out that the coexistence of non-automated and automated vehicles will be tricky for long time and legal aspects and liability will be something very sensible, while also that the teleoperation and remote monitoring related issues are also crucial and need attention. Finally, regarding UC1.0: Seamless autonomous transport chains of Automated PT, DRT, MaaS, LaaS.

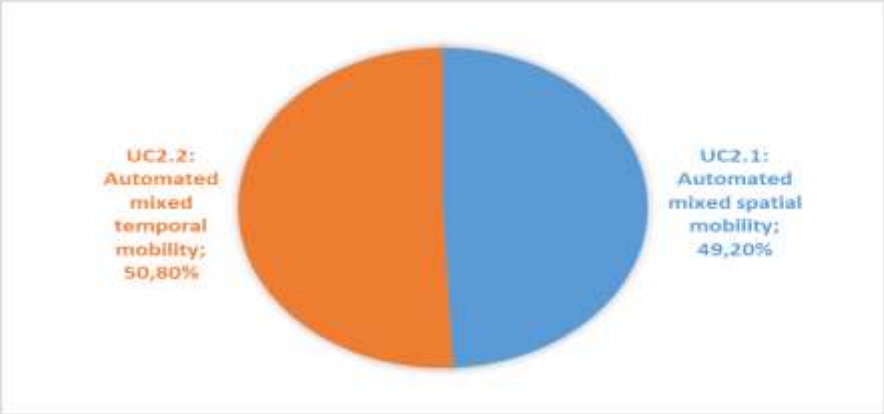
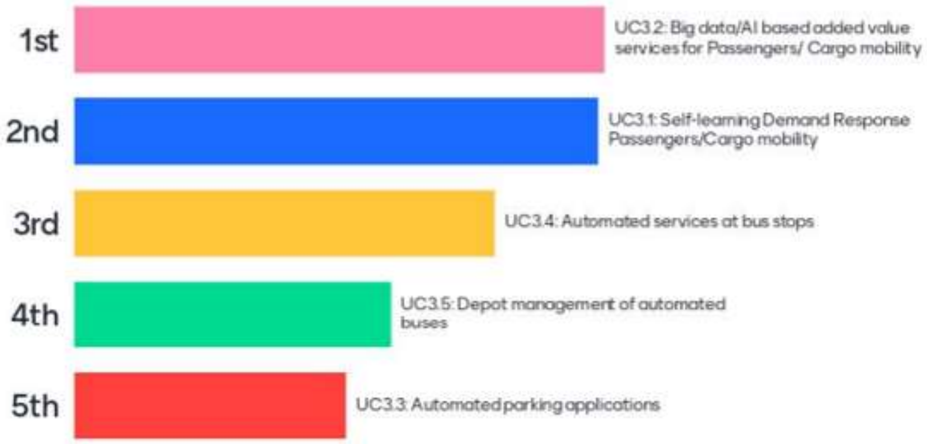


Figure 10: Ranking and rates of single Use Cases of UC2 cluster.

As depicted in Figure 10, regarding the family UC2: Automated mixed mobility in cities, the mixed temporal mobility has been ranked as slightly more important than the spatial one. It has been also mentioned by the participants that we have to additionally consider what economic value AVs bring and not only technical or safety consideration, as well as pre-existing systems (a subway is 1000% more efficient than an AV shuttle in a dense area).



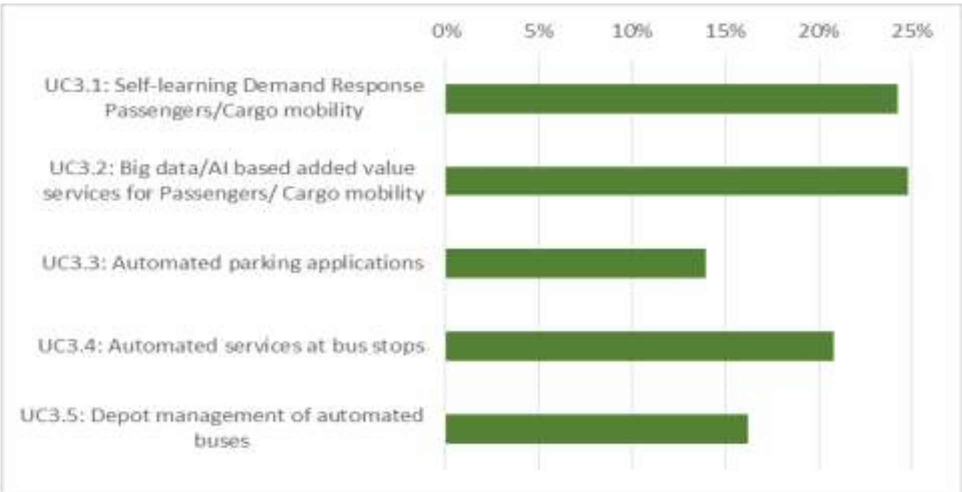


Figure 11: Ranking and rates of single Use Cases of UC3 cluster

Finally, in Figure 11 the ranking of UCs concerning the Added Value services for Cooperative and Connected Automated mobility in cities (UC3) is presented, where the most important UC has been identified the one referring to the Big Data and AI based added value services, while the one regarding Self-learning demand response services follows with minor difference. The least important UC from his family has been considered to be the one concerning the Automated parking applications.

In this part, the remarks of the participants focused mainly to the importance of accessibility to all, mentioning also that in cases where special user groups with reduced mobility are addressed, DRT is extremely important, as a good service for the "last mile" problem and areas where only a smaller group/ individuals travel Automated services must help to reduce barriers and access to mobility services and to increase them (socioeconomic aspects).

Based on the above, it was decided to realise all identified by SHOW stakeholders UCs but providing the highest priority to UC1 cluster followed by UC3 and then UC2 (with minor differences to UC3). The hierarchy of the UCs clusters has been resulted by the hierarchy of the criteria importance per cluster UC (as depicted in Figure 6, Figure 7 and Figure 8 above) in accordance to the overall hierarchy of the importance of the criteria themselves, taking for example the fact that the safety and security criteria have been ranked as the 2 most important in the criteria overall ranking, while these criteria are also ranked as the most important in the UC1 cluster ranking.

As an extension to this ranking, an overall prioritisation has been also made to all single UCs, according to the individual ranking that has been conducted by the stakeholders during the dedicated Workshop session. More specifically, the single UCs have been clustered again in 3 categories, corresponding also to the clustering used for the ecosystem needs, wants and priorities in D1.1: a) **essential**, referring to the UCs addressing vital issues for the development of CCAM and its integration to the urban mobility and have to be taken into account immediately by relevant technology providers, legislation, etc. b) **secondary**, referring to the UCs addressing issues that are considered important and have to be taken into account at a secondary stage by relevant technology providers, legislation, etc. and c) **additional**, referring to the UCs addressing issues that are good to have and have to be taken into account at some point by relevant technology providers, legislation, etc., once the essential and secondary ones have been covered. However, it needs to be clarified that all the identified UCs will be addressed by the SHOW pilot sites, regardless their priority level (as depicted in Table 11 below).

The UCs ranked above the average in each of the family UCs 1 and 3 ranking have been included in the Essential UCs addressing issues UCs cluster. Moreover, the ones above the median value have been considered as Secondary and those blow the median value as Additional. Regarding the UC2 family, which has been ranked in the 3rd place of the overall ranking of family UCs, the single UC with a rate above average was considered as a Secondary UC, while the one below average was considered an additional UC. In Table 4 below the clustering on the single UCs in the 3 categories is included.

Table 4: Prioritisation of SHOW single UCs

Essential	• UC1.1: Automated passengers/cargo mobility in Cities under normal traffic & environmental conditions. • UC1.2: Automated passengers/cargo mobility in Cities under complex traffic & environmental conditions.

	• UC1.6: Mixed traffic flows. • UC1.10: Seamless autonomous transport chains of Automated PT, DRT, MaaS, LaaS. • UC3.1: Self-learning Demand Response Passengers/Cargo mobility. • UC3.2: Big data/AI based added value services for Passengers/ Cargo mobility.
Secondary	• UC1.3: Interfacing non automated vehicles/ travellers (VRU). • UC1.4: Energy sustainable automated passengers/cargo mobility in Cities. • UC1.5: Actual integration to city TMC. • UC2.2: Automated mixed temporal mobility. • UC3.4: Automated services at bus stops.
Additional	• UC1.7: Connection to Operation Centre for tele-operation and remote supervision. • UC1.8: Platooning for higher speed connectors in people transport. • UC1.9: Cargo platooning for efficiency. • UC2.1: Automated mixed spatial mobility. • UC3.3: Automated parking applications. • UC3.5: Depot management of automated buses.

2.3 Mapping of user needs and priorities and SHOW Use Cases

SHOW WP1: "Ecosystem view and SHOW Use Cases" aims primarily at investigating and elaborating the shared Cooperative, Connected & Automated Mobility (CCAM) involved stakeholders' needs and priorities in an iterative manner throughout the whole course of the project. Within A1.1 the ecosystem of the project around automated urban mobility has been defined and includes all the internal (i.e., SHOW partners) and external (e.g., municipalities, users) stakeholders to SHOW project. The proposed stakeholders' categories are listed below:

- Original Equipment Manufacturers (OEMs) and transport/mobility operators.
- Tier 1 suppliers, telecom operators, technology providers, Small or Medium Enterprises (SMEs).
- Research & academia.
- Passengers and other road users encompassing Vulnerable to Exclusion (VEC).
- Umbrella associations.
- Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers.

The ecosystem stakeholders' wants, needs and priorities are investigated through a series of mechanisms, the most important of which being the desktop research already conducted (reported in D1.1) and the user acceptance survey planned to take place iteratively in the context of the pre-demo and demo activities of the project.

With the desktop research realised so far for the identification of the needs and priorities per relevant stakeholder group, shared and cooperative automation in Public Transport (PT) in urban context has been investigated and as much as possible has been associated to private vehicle transport, DRT and MaaS. Both passenger and freight transport have been addressed. All the key findings have also fed the SHOW Use Cases in order to ensure that they truly respond to the users' demand. The tables presented below include the mapping of the gaps, needs and priorities of the different stakeholders' types and the different areas to the SHOW UCs.

2.3.1 *Stakeholders' needs for* Automation in Public Transport

Table 5: Mapping of stakeholder needs in PT and SHOW UCs

Needs	Priorities	Relevant SHOW UC(s)
Passengers and other road users encompassing VECs		
• Frequent service. • Safety/ security assurance. • Accessibility for all (including VECs). • Needs for fast transport. • Ensuring hygiene	• Safety - need of constant contact to security personnel. • Proof of traffic safety level. • Efficient transportation time. • Ensuring hygiene	UCs 1.1, 1.2, 1.3, 1.6, 1.8, 1.10, 3.1, 3.2
• User-friendly app. • Smooth driving style, no harsh brakes or impatient driving.	• Optimised UI and info mobility service. • Smooth driving profile.	UCs 1.1, 1.2, 1.3, 1.4.
• Clear announcements on board. • Comfortable interior of vehicles.	• Environmentally friendly commute.	UCs 1.3, 1.10
OEMs, Road/Mobility operators		
• Cooperate with authorities. • Decrease system cost.	• Pricing framework. • Environmental sustainability. • Healthy use.	UCs 1.8, 1.9, 3.5
• Vehicles travelling in higher speed-closer to normal.	• Sufficient operations speed.	UCs 1.2, 1.3, 1.4, 1.6, 1.7, 1.8, 1.9, 1.10, 3.1
Tier 1 suppliers, telecom operators, technology providers and services company		
• Sufficient enabling infrastructure.	• Develop highly automated systems to deploy AVs so as to assure user security. • AVs to operate with multiple on-board and infrastructure enabling schemes; being interoperable.	UCs 1.2, 1.3, 1.6
• Cooperate with manufacturers-Deploy fleets of vehicles.	• Alter transportation time with productive, personal time.	UC 1.7
• Data to develop VASes.	• Gathering anonymised data for exploitation.	UCs 3.1, 3.2
Authorities (Cities, Municipalities, Ministries), policy makers, municipality agency and road operators		
• Environmental Sustainability	• Universal, legal framework. • Public-private cooperation schemes.	UC 1.10

Needs	Priorities	Relevant SHOW UC(s)
• Review current legislation, road rules to comply with AVs.		
• Organise public awareness campaigns	• Revise concept of operation for all (pedestrians, cyclists, commercial vehicles, heavy vehicles, etc.)	All UCs
Research and academia		
• Safe, accessible, reliable transport • Secure data privacy	• Integration of all different AVs (private vehicles, shuttles, cargo) in city traffic. • Avoid cyber-attacks in fully automated vehicles.	UCs 1.3, 1.6
• Optimal services within a single Architecture.	• Algorithms for optimal operation pf AV fleets.	UCs 3.1, 3.2

2.3.2 *Stakeholders' needs for Automation in Private Vehicles*

Table 6: Mapping of stakeholder needs in private vehicles and SHOW UCs

Needs	Priorities	Relevant SHOW UC(s)
Passengers and other road users encompassing VECs		
• User friendly HMI. • Driver to be able to take control of the vehicle.	• Safety • Willingness to pay	Training actions of WP15
• Appropriate training schemes.	• Environmental sustainability	UC 1.3 and training actions of WP15
OEMs, Road/Mobility operators		
• Environmentally sustainable use under all circumstances (weather, traffic).	• Safety functions under all weather conditions. • Integration into TMC.	UCs 1.2, 1.5
• Better sensors and enabling technologies.	• Testing of relevant solutions under controlled environments.	UCs 1.2, 1.6, 1.8
Tier 1 suppliers, telecom operators, technology providers and services company		
• Assist interoperability with other automated modes of transport in mixed traffic.	• Develop systems for AVs to operate in complex city environments.	UCs 1.2, 1.6, 1.7

Needs	Priorities	Relevant SHOW UC(s)
• Use traffic cameras at intersections to detect VRUs and communicate with the AVs.		
• Improved sensor and algorithms for enabling UCs.	• Use IoT and smart algorithms to develop urban platooning	UCs 1.2, 1.6, 3.3, 3.5
Authorities (Cities, Municipalities, Ministries), policy makers, municipality agency and road operators		
• Appropriate legislative framework. • Road infrastructure, enabling communication infrastructure.	• Safety-who is responsible. • Legislative Framework. • Insurance framework.	All UCs
• Operation centres (development, staffing, operation legal framework).	• Operational centres framework.	UCs 1.5, 1.7
Research and academia		
• Encourage user acceptance. • Promote safe use. • Promote accessibility for all users.	• Improve safety through lower accident probability and severity. • Data privacy.	All UCs

2.3.3 *Stakeholders' needs for Automation in MaaS*

Table 7: Mapping of stakeholder needs in MaaS and SHOW UCs

Needs	Priorities	Relevant SHOW UC(s)
Passengers and other road users encompassing VECs & Umbrella associations/Non-profit organisations		
• Easy to use and friendly systems and apps reducing congestion, while enhancing environmental and economic sustainability, also guaranteeing (quantifiably and qualifiedly) the safety and security parameters.	• Safety and security on board. • Protection against cyberattacks and hacking, in compliance with GDPR and data confidentiality.	UC1.10 (especially UC1 cluster)
• Accessibility (for VEC, VRU, PRM etc.) and proof or evidence of vehicle control any time, either on board or remotely for psychological.	• Long term operational excellence, environmental and economic sustainability with upgraded, additional or added value services, complementary to the currently existing ones.	All UCs
OEMs, Road/Mobility operators & Tier 1 suppliers, telecom operators, technology providers and services company		

Needs	Priorities	Relevant SHOW UC(s)
• Legal framework and inter partner agreements to broadly open market opportunities.	• Safety and security, development of HMIs, establishment of business models and collaboration schemes in market.	UC 1.5
• Increased interoperability, integration, environmental and economic sustainability.	• Technological evolution and excellence.	UCs 1.2, 1.3, 1.6, 1.8, 1.9
Authorities (Cities, Municipalities, Ministries), policy makers, municipality agency and road operators		
• Road, system and telecommunication infrastructures and networks based on a well-established framework and structured in line with a holistic development plan.	• Safety and security, business and collaboration schemes determining the responsibility share amongst involved stakeholders and legislative framework on integration procedures.	UC1.10 (also WP17)
• Holistic approach solutions through integrated initiatives from private domain.	• Operational excellence, business models and exploitation plans.	UCs 1.5, 1.7
Research and academia		
• Projects funding to provide evidence on efficiency, safety and security of vehicles, systems and services, encouraging user acceptance and promoting accessibility for all.	• Safety and security, operational excellence and data privacy.	All UCs
• Inter-partner agreements and interconnection with other stakeholders (especially private domain) and the market for the capitalization of research results. • A stable and adapted framework from the part of public authorities towards the exploitation of innovative research results and findings.	• Speed up the integration of fully autonomous mobility solutions in real conditions within the urban and peri-urban network.	

2.3.4 *Stakeholders' needs for Automation in DRT*

Table 8: Mapping of stakeholder needs in DRT and SHOW UCs

Needs	Priorities	Relevant SHOW UC(s)
Passengers and other road users encompassing VECs		
• Reduced travel time.	• Safety. • Accessibility for all.	UCs1.10, 3.1, 3.2

Needs	Priorities	Relevant SHOW UC(s)
	• Good integration to PT/ MaaS.	
• User-friendly app.		
Authorities (Cities, Municipalities, Ministries), policy makers, municipality agency and road operators		
• Increase safety.	• Update traffic management operations through cooperation with industry and road operators.	All UCs
• Offer first/last mile services.	• Increased use of AV services to connect terminal (e.g., airports, ports, train terminals) with city centres).	UCs1.10, 3.1, 3.2
Research and academia		
• Low-cost high quality services.	• Accessibility for all. • Reduction of environmental footprint.	UCs1.10, 3.1, 3.2
• Better service definition.	• Promotion of personalised modes of transport. • Development of user-friendly apps.	

2.3.5 *Stakeholders' needs for Automation in Freight* Transport

Table 9: Mapping of stakeholder needs in freight transport and SHOW UCs

Needs	Priorities	Relevant SHOW UC(s)
Passengers and other road users encompassing VECs & Umbrella associations/Non-profit organisations		
• Easy to use and friendly systems and apps. • Evidence on the efficiency of autonomous mobility solutions. • Transfer of control between the vehicle and driver / operator and vice versa. • Behaviour control of vehicles in relation to other road users. • Clarification of the impact on societal values.	• Provision of evidence of AVs' integration and efficiency in real traffic conditions (interrelation with conventional traffic, systems and services), also evaluating access degree in real conditions in urban environment. • Safety and security on board and protection against cyber-attacks and hacking, in compliance with GDPR data confidentiality. • Investigation of potential ways of interconnection and integration.	All UCs
OEMs, Road/Mobility operators & Tier 1 suppliers, telecom operators, technology providers and services company		

Needs	Priorities	Relevant SHOW UC(s)
• Operational interoperability • Establishment of legal framework in order to allow for development of technological solutions. • Development of business models and partner agreements. • Environmental and economic sustainability and connectivity	• Development of inter-partner agreements and collaboration with authorities and other stakeholders towards operational excellence, simplicity and interoperability of the systems towards seamless mobility on transport networks. • Safety and security. • Technological evolution and excellence.	UCs1.9, 2.1. 2.2, 3.1, 3.2
Authorities (Cities, Municipalities, Ministries), policy makers, municipality agency and road operators		
• Road, system and telecommunication infrastructures and networks with operational interoperability and accessibility. • Holistic approach solutions through integrated initiatives from private domain.	• Establishment of legislative framework on integration procedures and creation of business and collaboration schemes, towards the development of long-term autonomous mobility solutions with environmental and economic sustainability.	All UCs
• Operational excellence of monitoring and controlling systems and mixed schemes with passengers and cargo delivery by common automated vehicle fleet, under vehicle sharing concepts.	• Safety and security, operational excellence and avoidance of deficiencies, failures, malfunction, accidents and inefficiencies	UCs1.5, 1.7.
Research and academia		
• Projects funding to provide evidence on efficiency, safety and security of vehicles, systems and services, encouraging user acceptance and promoting accessibility for all.	• Safety and security, operational excellence and data privacy. • Speed up the integration of fully autonomous mobility solutions in real conditions within the urban and peri-urban transportation network Speed up the integration of fully autonomous mobility solutions in real conditions within the urban and peri-urban transportation network. • Environmental, business, economic and operational sustainability. • Collaboration schemes development and adoption of resource and energy efficient	All UCs

Needs	Priorities	Relevant SHOW UC(s)
	ways of automated driven solutions' management. • Provision of justification acting as auxiliary DSS. • Time and cost savings for all involved stakeholders and mainly end users.	
• Inter-partner agreements.	• Business agreements.	

2.4 Mapping of SHOW KPIs to SHOW Use Cases

In Table 10 below the mapping between the current SHOW KPIs and the project's UC is also presented. The KPIs mentioned below are still under elaboration and will be finalised on M22. Any changes between the final KPIs and the SHOW UCs will be also reported in the respective Deliverable (D9.3).

Table 10: Mapping of current SHOW KPIs and UCs

Description of KPI	Relevant SHOW UC(s)
Safety	
Road accidents: Total number of injury accidents (i.e. accidents with at least one person slightly injured) in a specific area.	• All UCs • From WP10 on Simulations and any conflicts reported during the pilots.
Conflicts: Total number of conflicts encountered per 100 million kilometres.	• All UCs • From WP10 on Simulations and any conflicts reported during the pilots.
Conflicts with VRUs: Total number of traffic conflicts instances that include pedestrians or cyclists.	• UC1.3 (partly) • From WP10 on Simulations and any conflicts reported during the pilots.
Time headway: Time difference between the time the front of a vehicle arrives at a point on the road and the time the front of the following vehicle arrives at the same point.	UCs1.1, 1.2, 1.3, 1.6, 1.10
Reaction time: The time it takes for the operator of a vehicle to respond to a stimulus on the road (e.g. an obstacle).	UCs1.1, 1.2, 1.3, 1.6, 1.10
Safety enhancement: % of expected safety enhancement**.**	• All UCs • From WP10 on Simulations
Traffic efficiency	
Average speed of pilot vehicles.	UCs1.1, 1.2, 1.5, 1.6, 1.8, 1.9, 1.10, 3.1, 3.2.
Acceleration variance: Variance of pilot vehicle acceleration.	UCs1.1, 1.2, 1.3, 1.6, 1.10
Number of hard brake events per kilometres	
Non-scheduled number of stops per kilometre	
Scheduled number of stops per kilometre	
Service reliability: Punctuality for vehicles and passengers	UCs1.5, 1.7
Kilometres travelled with travellers in pilots	UCs1.1, 1.2, 1.3, 1.6, 1.10
Kilometres travelled without travellers in pilots	UCs1.1, 1.2, 1.3, 1.6, 1.10
Average speed per vehicle type	UCs1.3, 1.5
Average vehicle (travel time) delay	
Number of vehicle stops per kilometre for all vehicle types	UCs1.1, 1.2, 1.3, 1.6, 1.10
Number of hard braking events in traffic	UCs1.1, 1.2, 1.3, 1.6, 1.10
Total vehicle delays in an intersection	UCs1.3, 1.5
Total travel time in network per vehicle type	UC1.5
Modal split: The share of each mode choice (in number of trips or distance travelled)	
Total mileage: Total number of kilometres travelled in a network, per mode of transport and/or trip purpose	
Travel time delay over the entire network	

Description of KPI	Relevant SHOW UC(s)
Average vehicle speed in a network	
Number of trips: Number of trips in the network, per mode and/or trip purpose	
Traffic	
Percentage increase in single vehicle km travelled	UC1.5
Percentage increase in average vehicle occupancy	
Percentage of PT quality of service enhancement	
Energy	
Energy use per kilometre of a vehicle	UCs1.4, 1.5
Environment	
Emissions of a vehicle (CO_2, PM, NOx)	UC1.5
Concentrations of pollutants (e.g. NOx) along roads	
noise levels along roads	
Percentage reduction in CO_2 and air polluted emissions	
Percentage reduction in noise level	
Percentage reduction in energy consumption compared to existing conventional alternatives	UCs1.4, 1.5
Percentage reduction in energy consumption compared to non-use of SHOW energy management services	
Societal	
Amount of travel: Person kilometres of travel per year in an area.	UC1.5
Shared mobility rate: Percentage of trips made sharing a vehicle with other.	UCs1.5, 3.1, 3.2
Vehicle utilisation rate: Percentage of time a vehicle is in motion (not parked)	UCs1.7, 3.1, 3.2
Number of passengers: Number of people transported throughout the project per automated vehicle/service type.	All UCs
Number of cargo: Number of cargo transported throughout the project per automated vehicle/service type.	All UCs (freight related)
Person km travelled: Person km travelled by special groups of citizens (elderly, PRMs, children) per type of AV/service type.	UC1.3
Ratio of average load to total vehicle freight capacity.	
Percentage of vehicle-km run empty.	All UCs (freight related)
Operative cost of the travelled km.	
Revenue from the service	All UCs
Equity	
Inequality in transport: To which degree are transport services used by socially disadvantaged and vulnerable groups, including people with disabilities.	UC1.3
Employability	
Job loss: Percentage of jobs that have a high probability of being replaced by computer automation within the next two decades	WP15 (A15.4 on Training activities)
Job gain: Number of jobs created by the implementation of computer automation, and other systems (sensors, cameras etc.) used in autonomous vehicles within the next two decades	WP15 (A15.4 on Training activities)
User perception/acceptance/trust	
User perception of travel quality	All UCs
User perception of travel reliability	
User feeling of trust in the autonomous vehicle	

Description of KPI	Relevant SHOW UC(s)
User feeling of safety during travel	
User perception of travel comfort	
Traveller acceptance rating	
Perceived usefulness	
User experience	
Share of kms driven within the ODD when the driver decides to use automation	UCs1.5, 1.7
Willingness to pay/ share	
User willing to pay for the new mobility service	All UCs
User willing to share a ride in CAVs	
Project's success	
Number of SHOW UCs successfully deployed and tested in pilots	All UCs
Realisation of each UC under the pre-defined in \operational and functional requirements	
Number of novel business models created and tested	
Number of SMEs that will use the SHOW services marketplace to develop services (during project's duration)	
Number of MoUs for services sustainability created between various stakeholders at SHOW or new follower cities	
Number of business models adopted that promote strategic partnering opportunities for local synergies	
Number of SHOW deployed fleets remaining at service after project end	
Number of AV fleets planned to be deployed within 3 years after the project by SHOW sites and liaised followers (with relevant funding secured	
Number of alternative infrastructure schemes to support deployment	
Business	
Number of external collaborations	All UCs
Willingness to invest	

3 Full descritpion of SHOW Use Cases per Pilot Site

SHOW includes five Mega Sites, with good geographical balance (Sweden in North Europe, Germany, France, Austria in Central Europe and Spain in South Europe). Mega Pilots relate to a City or an agglomeration of them (within the same country), that collectively satisfy the majority of SHOW UCs and cover all vehicle types, traffic environments (urban, peri-urban, corridors) of varying population and traffic density as well as all key traveller groups. Each Mega Site represents a different scenario of automated and sustainable urban centres of tomorrow, with business models, socioeconomic conditions and cultural issues that are relevant to the specific state. The very big differences between readiness Level, public acceptance, stakeholders' maturity, infrastructure availability, legal framework and political priority and support across Europe make it necessary to run in parallel several Mega Sites, to take into account all these aspects.

It also includes six Satellite Sites, each with a unique characteristic, focusing upon specific SHOW UC's and being complementary to the Mega Site, in terms of UC's, applied technologies, traffic environments and geographical coverage, again covering all EU areas (Finland and Denmark in North Europe, Netherlands in Central Europe, Italy and Greece in South Europe, Czech Republic in Eastern Europe). Relevant sites focus on different UCs of SHOW (Table 11 below) but have also complementary characteristics in terms of technologies, user clusters or business models in relation to the mega sites; such as representation of small cities with automated transport legacy (Trikala in Greece), EU13 states (Brno in Czech Republic) and AV services in special areas/ traffic environments (Copenhagen).

In Sections 3.1 and 0 below the full analysis of each site is presented, on how they will organize their pilots in order to cover the Use Cases that they will test during the real-life demonstrations. The analysis implemented has been divided in three sections, according to the respective template provided, relevant to the different phases of the process, namely:

- the Design phase, where information has been provided about the ecosystem and the main stakeholders involved, the traffic and operation context, as well as the relevant concerns and the expected risks and restrictions to be addressed to each pilot site and for each UC.
- the Development\ Implementation phase, where information has been provided regarding the step-wise implementation scenarios, as well as the respective vehicles and infrastructure and the included entities for the pilots realisation.
- the Business/ Exploitation phase where information has been provided on the existing background of each pilot site and the expected innovation to be offered by SHOW, the needs & priorities to be covered of the involved stakeholders as well as provisional business plans and operating models.

The SHOW Use Cases, after their finalisation, will be also communicated to the project's follower sites (the existing and the future ones), in order for them to map their plans with these UCs; thus testing their transferability and enhancing their multiplication.

Table 11: Mapping of pilot sites to SHOW Use Cases

	UC 1.1	UC 1.2	UC 1.3	UC 1.4	UC 1.5	UC 1.6	UC 1.7	UC 1.8	UC 1.9	UC 1.10	UC 2.1	UC 2.2	UC 3.1	UC 3.2	UC 3.3	UC 3.4	UC 3.5
Mega Demonstration Sites																	
Rouen Pilot site	×	×	×	×	×	×	×			×			×			×	
Rennes Pilot site	×		×	×						×		×					
Linköping Pilot site	×		×			×	×						×	×		×	
Kista Pilot site	×	×	×			×	×									×	
Madrid Pilot site	×	×	×			×	×	×		×					×		×
Graz Pilot site		×	×													×	
Salzburg Pilot site		×	×		×	×							×				
Karlsruhe Pilot site	×	×	×			×	×		×		×	×					
Aachen Pilot site	×			×		×				×							
Braunschweig Pilot site	×					×		×									
Satellite Demonstration Sites																	
Turin Satellite site		×	×		×		×			×							
Trikala Satellite site	×	×	×		×	×	×	×		×							
Tampere Satellite site	×	×		×			×						×				
Brainport Satellite site	×		×					×									
Brno Satellite site	×	×	×			×	×										
Copenhagen Satellite site	×	×	×	×	×	×	×						×	×		×	

3.1 Mega Pilots

3.1.1 The French twin Mega Pilot

The French twin Mega pilot site consists of 2 sites, one in Rennes and one in Rouen.

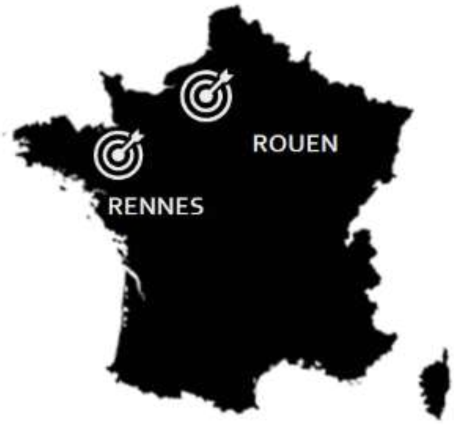


Figure 12: The French twin mega pilot site

From the SHOW Consortium, VEDECOM is responsible for the organisation of the whole mega site, while in each of the cities the following partners are involved:

- Rouen Metropolis: Transdev Autonomous Transport System;
- Rennes Metropolis: ID4CAR, CHU Rennes, Keolis Rennes.

3.1.1.1 Rennes Pilot site

In the Rennes pilot site the following SHOW Use Cases are going to be covered: UC1.1; UC1.3; UC1.4; UC1.10; UC2.2.

The UCs 1.1 and 2.2 are going to be tested in parallel, consisting 2 phases of the same service.

<u>Design Section</u>

1. **Site specific application of the Use Case:**
   i. **Site specific title of the Use Case:**

- **For Use Cases 1.1 & 2.2:** Providing a safe, acceptable and efficient mixed transport service for all the CHU users.
- **For Use Case 1.3:** Improving the interface between the shuttles and the vulnerable users in the CHU (including passengers with motor, visual ad cognitive problems, etc.) for overall safety.
- **For Use Case 1.4:** Developing a management system for combining the needs of charging and the requirement of the service via optimisation tools.
- **For Use Case 1.10:** Integrating the automated shuttle service into the automated transport offer in Rennes (metro).

   ii. **Leading entity:** CHU KEOLIS

2. **Ecosystem key stakeholders clusters involved:**
   - ✓ OEM’s and transport/mobility operators
   - ✓ Tier 1 suppliers, telecom operators, technology providers, SME’s

- ✓ Passengers and other road users encompassing VEC
- ✓ Umbrella associations
- ✓ Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers

For UCs 1.3 and 1.4 stakeholders' clusters of OEM's and transport/mobility operators and of Tier 1 suppliers, telecom operators, technology providers, SME's are applicable.

3. **Operational speed**: Up to 20 km/h

4. **Traffic context**:

- Dedicated and mixed lanes
- Low density of traffic (CHU hospital site)

5. **Frequency and timeline of operation**: Every day service 7h00 – 21h00, frequency to be adapted according to the needs of the hospital services during the tests.

6. **Restrictions & dependencies:**

- For Use Case 1.10: Capacity of integration in the MaaS system which is under development in Rennes.
- Regarding the other UCs, no specific restriction has been defined, except from these imposed by COVID 19 outburst or other sanitary and epidemic concerns, due to the fact this is a hospital site.

7. **Key risks identified:**

- **For Use Cases 1.1 & 2.2**
  - **User acceptance**: the users are special and vulnerable groups, as it is an hospital (e.g. ill or with a disability, etc.); their user acceptance may differ for the "average" group.
  - **Operational risks**: the number of users and the management of peak hours will be a major point to deal with.
  - **Behavioural risks**: the understanding of the functioning of the shuttle and services, the progress to increase the comfort and adaptation of shuttles' design to the needs of users (especially those with cognitive problems).
  - **Business risks**: Business mode and RoI for the operator, joint business model to find between KEOLIS and CHU / Rennes administration.
- **For Use Case 1.3**
  - Low risk as the shuttle is operating in slow speed.
- **For Use Case 1.4**
  - Incompatibility between the time necessary to charge the shuttle/need for dense services at some high peak hours.
  - Business model if more shuttles are needed.
- **For Use Case 1.10**
  - Business model and RoI for the operator, joint business model to find between KEOLIS and CHU / Rennes administration

8. **Security concerns:**

- Cybersecurity (for all UCs)
- Interaction with most vulnerable users (UCs 1.1, 2.2, 1.3)

- Data protection of users (health data may be collected) (All UCs)

Development\ Implementation Section

1. **Storyboard for the site specific use case:**

- **For Use Cases 1.1 & 2.2**

The use case will be to offer mobility for all types of passengers on the CHU site (patient, doctors, visitors) and evaluate which segment is the most appropriate for use of automated shuttles under which conditions.

The shuttles will also transport light material when there are no passengers to move (at night), the security and safety requirements for this material transport will be analysed and new services and equipment will be developed (GRUAU third party).

Actors: shuttle and its driver; PT operator KEOLIS, passengers, ESI group (SC) for acceptability, GRUAU.

- **For Use Case 1.3**

This use case aims to study the interaction of the shuttle with vulnerable users on the CHU campus and the interaction with high other speed vehicles, such as ambulances.

Actors: shuttle and its driver; PT operator KEOLIS, remote operator NAVYA EASYMILE.

- **For Use Case 1.4**

The main scenario will be to develop a tool for CHU, to manage the planning for charging the shuttles, the time needed and its compatibility with the density of the service and the number of shuttles. The tests will allow to estimate the number of users per hour of the day and needs of freight transport for the night. According to these numbers, the number and frequency of shuttles will be refined and a charging time table will be issued. It will define the necessary number of shuttles according to hours and the final needs for service.

Actors: shuttle and its driver; PT operator KEOLIS, CHU Rennes Metropole, electricity provider EDF/ENEDIS, SME for fleet/charge management tools.

- **For Use Case 1.10**

The Use Case will be focused on the integration of the service in the CHU in the ticketing system and the KORRIGO mobility card, as well as in the parking's ticketing system as part of the parking fees. The CHU shuttle service will be integrated into the STAR metropolitan information system and in the CHU information system.

Actors: PT operator KEOLIS, CHU, Rennes Metropole, Region (for KORRIGO).

2. **Demonstrators:** 3 NAVYA shuttles and 3 EASYMILE shuttles

3. **Vehicle types included:** Shuttles

4. **Involved vehicle brands:** NAVYA & EASYMILE

5. **Involved fleet operators:** KEOLIS

6. **Physical Infrastructure required:**

There is no TMC covering the specific area to interface. IoT nodes are expected to be satisfied; though the shuttles will mainly operate autonomously.

7. **Relevant WP(s)/Activity(ies) of GA:** WP1 and WP7

8. **Entities involved in implementation:**

   i. **Internal entities to the Consortium:** NAVYA, EASYMILE, KEOLIS CHU ID4CAR GRUAU (3rd party) MOBHILIS (3rd party) ESI (subcontractor)

   ii. **External entities to the Consortium:** Rennes Metropole

9. **Entities involved in testing & demonstration:**

   i. **Internal entities to the Consortium:** NAVYA, EASYMILE, KEOLIS CHU ID4CAR GRUAU (3rd party) MOBHILIS (3rd party) ESI (subcontractor)

   ii. **External entities to the Consortium:** Rennes Metropole

Business\ Exploitation Section

1. **Specific travellers' cohorts addressed:** Patients of CHU, visitors, doctors and medical personnel.

2. **Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable):** During night hours and related to non-medical goods.

3. **Starting point/background & Innovation in SHOW:** No experimentation in CHU of all automated transport is made so far; the innovation will be in relevant services and adaptation of the interior design and operation of shuttles.

4. **Training and other skills/knowledge requirements for key stakeholders involved:** None planned.

5. **Incentives associated:** Free access during the project

6. **Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):**

To be defined at a later stage.

3.1.1.2 Rouen Pilot site

In the Rouen pilot site the following SHOW Use Cases are going to be covered: UC1.1; UC1.2; UC1.3; UC1.4; UC1.5; UC1.6; UC1.7; UC1.10; UC3.1; UC3.4.

Design Section

1. **Site specific application of the Use Case:**

   i. **Site specific title of the Use Case:**

   - UC 1.1: Automated passengers mobility in Cities under normal traffic & environmental conditions.

- UC 1.2: Automated passengers mobility in Cities under complex traffic & environmental conditions.
- UC 1.3: Interfacing non automated vehicles/ travellers (VRU).
- UC 1.4: Energy sustainable automated passengers/cargo mobility in Cities.
- UC 1.5: Actual integration to city Public Transport Control Centre.
- UC 1.6: Mixed traffic flows.
- UC 1.7: Connection to Operation Centre for remote supervision
- UC 1.10: Seamless autonomous transport chains of Automated PT, DRT, MaaS
- UC 3.1: Self-learning Demand Response Passengers mobility
- UC 3.4: Big data/AI based added value services for Passengers mobility

- **Leading entity:** Transdev Group Innovation, subsidiary of Transdev Group

2. Ecosystem key stakeholders clusters involved:

- ✓ OEM's and transport/mobility operators
- ✓ Tier 1 suppliers, telecom operators, technology providers, SME's
- ✓ Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers
- ✓ Insurance companies

Figure 13: Involved stakeholders in the Rouen site
(www.RouenNormandyAutonomousLab.com)

3. Operational speed:

- **Shuttle i-Cristal**: Up to 30 km/h
- **Robo-taxi Renault Zoe**: Up to 30 km/h

Advanced tests will be performed on private tests trucks with higher speeds up to 50km/h.

4. Traffic context:

Different environments are present in the Rouen demo site: suburban and city-centre.

- A regular bus line enforced with i-Cristal autonomous shuttles;
- An on-demand Transport service in dense urban heart of Rouen in Renault ZOE;
- A private test track area and circuit for advanced tests**.**

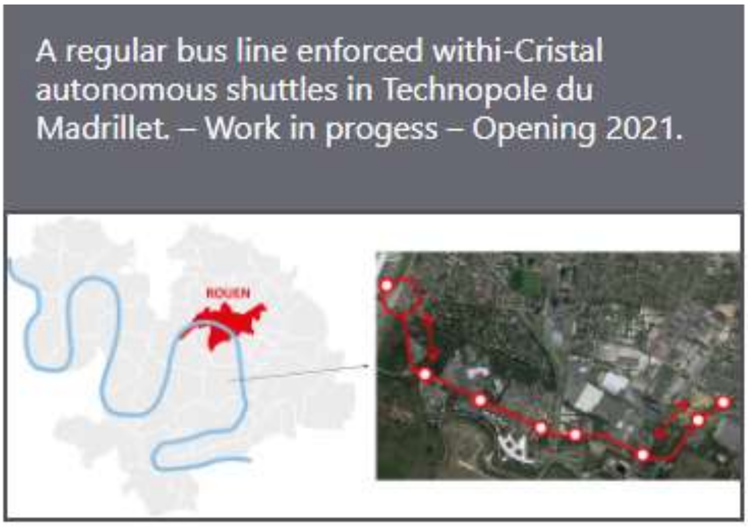


Figure 14: Rouen - bus line service with automated shuttle

Figure 15: Example of situation in Rouen – Madrillet area (simple traffic scenario - UC1.1)

Figure 16: Example of situation in Rouen - Madrillet area (complex traffic scenario - UC1.2)

Figure 17: Example of situation in Rouen - Madrillet area (mixed lanes traffic scenario - UC1.6 and interface with VRUs – UC1.3)

Figure 18: Rouen - Robotaxi service

Figure 19: Example of situation in Rouen - city centre

5. **Frequency and timeline of operation:**

- The services will be tested in predefined periods up to 7 hours/day, 5 days /week, through:
  - Automated shuttle complementing existing classic buses on a bus line, and
  - On demand robotaxi.

6. **Restrictions & dependencies:**

- Range of electric vehicles;
- Supervisor's and Driver's rest periods based on regulations;
- COVID-related limitations;
- Legal permits;
- Technology barriers / complexity of the environment.

7. **Key risks identified:**

- Legal permits
- Technical barriers / Complexity of the environment.

8. **Security concerns:**

We are putting all our efforts in developing a safe & secure system while trying to prevent any conflicts.

Development\ Implementation Section

1. **Storyboard for the site specific use case:**

There are two area to be covered from the scenario point of view: the technological and the service aspects:

From a technical point of view, the focus is on the ability of the vehicle to travel in automated mode from an origin to a destination while servicing several point/stops
From a service point of view, in this project we have:

- A regular bus line serviced by i-Cristal autonomous shuttles;
- An on-demand transport service in the dense urban heart of Rouen, serviced by Renault ZOE.

2. **Demonstrators:**

- All vehicles are Level 4 SAE;
- We are still in a transition phase where a safety driver will be inside the vehicle, but the goal is to achieve a high level of reliability in order to be able to operate without a safety driver (reaching eventually L5), beyond the project duration.

3. **Vehicle types included:**

- **i-Cristal shuttles**

- **Robotaxi Renault Zoe**

4. **Involved vehicle brands:**
   - Lohr
   - Renault

5. **Involved fleet operators:**
   - Transdev Group (+ TCAR + Transdev Group Innovation)

6. **Physical Infrastructure required:**

The service will be integrated into the PT operator TMC by Rouen.

Figure 20: Rouen Control Room for Public Transport

The main goal of this Control Room is to ensure a high quality of the public transport services for passengers by:

- Real-time monitoring of network status
- Management of operational hazards/incidents
- Sending instructions to drivers/vehicles

In the left part of the photo you can distinguish 2 separate work posts (red, yellow) dedicated to the Autonomous Transport System (L4 SAE) and the other 3 work posts dedicated to the “traditional” public transport: buses, BRT (L2 SAE), metro/tramway, intervention team.

Remote supervision will be experimented but not remote control.
The digital infrastructure required:

- Traffic Light Controller (TLC)
- On-Board Unit (OBU)
- Road-side Unit (RSU)

More than that, on the roadside unit we have extended perception.

Figure 21: Digital infrastructure in Rouen site

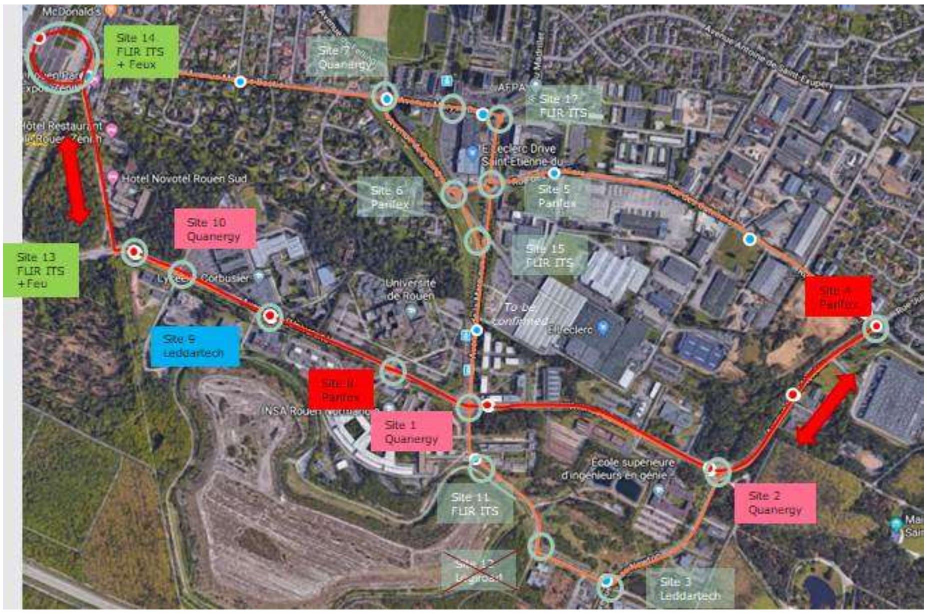


Figure 22: Rouen - digital infrastructure sites - Only the L#27bis (red trajectory) will be experimented during the SHOW Project

During the project:

- All historical V2X sites are maintained.
- 8 V2X sites are mandatory to operate L27bis, 2 of them being linked with traffic lights controllers.
- Sensors calibration campaign has started and will be validated before the shuttle arrives on site.

7. **Relevant WP(s)/Activity(ies) of GA:**

- WP1: Ecosystem views & SHOW Use Cases
- WP2 Business / Operating models
- WP3: Ethical and Legal Issues
- WP4 System architecture and tools
- WP5 Big Data Collection, processing and analytics
- WP6 Services Marketplace
- WP7: Automated vehicles functions

8. **Entities involved in implementation:**

   i. **Internal entities to the Consortium:** Transdev Group with its subsidiaries Transdev Autonomous Transport Systems + Transdev Rouen.

   ii. **External entities to the Consortium:** Renault Groupe.

9. **Entities involved in testing & demonstration:**

   i. **Internal entities to the Consortium:** Transdev Group with its subsidiaries Transdev Autonomous Transport Systems + Transdev Rouen.

   ii. **External entities to the Consortium:** Renault Groupe.

Business\ Exploitation Section

1. **Specific travellers cohorts addressed:** Commuters, tourists, residents, scholars, vulnerable road users and persons with disabilities (wheelchair users can board on the automated shuttle).

2. **Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable):** No freight transportation in the demo site of Rouen.

3. **Other KPI's and success targets addressed:**

There are different categories of KPI to be monitored:

- KPIs related to the service of passenger transport: independent to the fact that the vehicle is automated or not.
- KPIs related to technological aspects: in this case, mostly related to the AVs technologies.

4. **Starting point/background & Innovation in SHOW:**

Rouen has already deployed the first on-demand transport service using autonomous vehicles on open roads in Europe, with the Rouen Normandy Autonomous Lab project[2], in various suburban locations. Rouen Normandy Autonomous Lab has allowed Rouen Normandy Metropolis and its partners (Normandy Region, Caisse des Dépôts, Transdev, Renault, Matmut and FEDER / Europe) to gain a valuable experience and know-how from those on-going field operations. This innovative sustainable transportation service showcases innovative capabilities developed between key actors of tomorrow's mobility.

Rouen Normandy Autonomous Lab started in 2017 and now follows its next step within SHOW. This new phase consists of the experimentation of 3 autonomous and electric mobility services by Transdev and Renault, as Collective Public Transport on the territory of the Rouen Normandy Metropolis, committed to the development of intelligent mobility for all, with autonomous shuttles in urban and peri-urban areas to complement and/or then replace a bus line; on-demand, electric, autonomous and shared cars to serve Rouen city centre, with fixed stops.

5. **Training and other skills/knowledge requirements for key stakeholders involved:**

- Transdev Rouen is our Field Team
- Transdev Versailles is our R&D team

List of all the planned trainings:

- Safety Operator Training: Transdev Rouen trainers teaching Transdev Rouen bus drivers:
  - Start the vehicle and its systems;
  - Check the systems current state;
  - Drive manually an autonomous vehicle;
  - Handle the safety regarding the vehicle environment;
  - Maintenance Level 0.

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[2] https://www.rouennormandyautonomouslab.com/

- Safety Operator Trainer Training: Transdev Versailles teaching Transdev Rouen trainers:
    - Safety Operator Training;
    - Advanced autonomous driving functions;
    - Advanced open road safety training.
- Supervision Operator Training: Transdev Rouen trainers teaching Transdev Rouen control center operators:
    - Start the supervision system;
    - Maintain the supervision system;
    - Manage vehicles' safety remotely from the control center;
    - Manage non driving functions remotely;
    - Manage operational timetables and vehicle path.
- Supervision Operator Trainer Training: Transdev Versailles teaching Transdev Rouen trainers:
    - Supervision Operator Training + Advanced supervision functions.
- Infrastructure maintenance Training: Transdev Versailles teaching Transdev Rouen electrical lab employees:
    - Sensors calibration theory;
    - System electric diagram.
- On-site test engineers: STA internal training:
    - How to facilitate the explanations of problems found during tests to the R&D teams.

6. **Incentives associated:** None specific.

7. **Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):**

At this stage we are still in the phase where we are massively investing in the technologies in order to achieve the minimum required level that allows us to create a real service. The decision makers should understand that the gap between experimentation and real service is big and we still need massive financial support.

3.1.2 The German Mega Pilot

Some changes have occurred within the German Mega pilot, since the Manheim site has not been able to find vehicle manufacturer for the 5 shuttles that are required for this demo site, due also to COVID-19 imposed restrictions. To this extend, rnv has expressed the wish to leave the SHOW Consortium. In order for the Manheim site's requirements to be covered, it has been replaced by the Braunschweig site (led by DLR), while also the number of vehicles and use-cases will be increased in Karlsruhe through additional application and trips[3].

3.1.2.1 The Karlsruhe Pilot site

In the pilot site of Karlsruhe the following SHOW Use Cases are going to be covered: UC1.1; UC1.2; UC1.3; UC1.6; UC1.7; UC1.9; UC2.1; UC2.2

[3] Provisionally, pending amendment.

Design Section

1. **Site specific application of the Use Case:**
   i. **Site specific title of the Use Case:**

- **For Use case 1.1**: Restricted area Markensen Kaserne.
- **For Use case 1.2:** Driving in (peri-) urban areas.
- **For Use Case 1.**3: Co-existence with VRUs on the street.
- **For Use case 1.6:** Driving in (peri-) urban areas with mixed traffic flow.
- **For Use case 1.7:** Demonstration of Connection to Operation Centre for remote supervision and decision aid in restricted or in (peri-) urban areas.
- **For Use case 1.9:** Demonstration of Cargo platooning in restricted or in (peri) urban areas.
- **For Use case 2.1:** Demonstration of automated mixed spatial mobility in restricted or in (peri-) urban areas.
- **For Use case 2.2:** Demonstration of automated mixed temporal mobility in restricted or in (peri-) urban areas.

   ii. **Leading entity:** FZI

2. **Ecosystem key stakeholders clusters involved:**
   - ✓ Research & academia (UCs1.1, 1.2, 1.6, 1.7, 1.9, 2.1, 2.2)
   - ✓ Passengers and other road users. encompassing VEC (UCs1.2, 1.6, 1.7, 1.9, 2.1, 2.2).
   - ✓ Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers (UCs1.2, 1.6, 1.7, 1.9, 2.1, 2.2).
   - ✓ Insurance companies (UCs1.1, 1.2, 1.6, 1.7, 1.9, 2.1, 2.2).

3. **Operational speed:** Up to 20 km/h (Shuttle)/30 km/h (Car)

4. **Traffic context**:
   - **For Use Case 1.1:** Peri-urban and no dedicated lanes.
   - **For Use Cases 1.2, 1.3, 1.6:** The autonomous vehicles are going to drive in suburban and urban areas with mixed lanes and a medium traffic density.
   - **For Use cases 1.7, 1.9, 2.1, 2.2:** Regarding the test location the autonomous vehicles are going to drive in suburban and urban areas with mixed lanes and a medium traffic density or in restricted controllable areas.

5. **Frequency and timeline of operation**: No regular service, on-demand and according to Pilot needs.

6. **Restrictions & dependencies:**
   - **For Use Case 1.1:** No public transport and controllable, restrictable environment.
   - **For Use Cases 1.2, 1.3, 1.6, 1.7, 1.9, 2.1, 2.2:** The autonomous vehicles will only drive in daylight and not in challenging weather conditions like heavy rain, storms or snow.

7. **Key risks identified:**
   - **For Use Case 1.1:** Since the environment is controllable and restrictable there is a minimum of risk.

- **For Use Cases 1.2, 1.6, 1.7, 1.9, 2.1 2.2:** The main risks arise through other traffic participants, especially VRUs.

8. **Security concerns:** For all not expected threats there is always a safety driver on board.

Development\ Implementation Section

1. **Storyboard for the site specific use case:**

- **For Use Case 1.1:**

The passenger arrives at the restricted area in order to visit a specific building. Since the area is restricted, visitors are not allowed to drive inside with their own car. Therefore, a shuttle service to the specific target building is provided.

- **For Use Cases 1.2 & 1.3:**

The driving area belongs to a residential area. By offering autonomous rides to local Points of Interests, like bus stops or tram stations interest and trust in autonomous vehicles shall be created. Especially the concept of the last mile shall be deployed.

- **For Use Case 1.6:**

As above but without dedicated lanes; in mixed traffic.

- **For Use Case 1.7:**

For the Demonstration of Connection to Operation Centre for tele-operation and remote supervision the autonomous vehicles will provide the possibility for a tele operator to supervise it. He has the possibility to look into the current state of the vehicle and can support the vehicle in his decision process. So there is no direct control of the driving shaft, it is only possible through the planning process which is running on the vehicle. This will take place in both the restricted area mentioned in UC1.1 and the residential area mentioned in UC1.2.

- **For Use Case 1.9:**

To demonstrate the efficiency of cargo platooning the autonomous vehicles will automatically follow each other in a defined distance. The platooning may take place in either the restricted area mentioned in UC1.1 or the residential area mentioned in UC1.2.

- **For Use Case 2.1:**

To demonstrate the automated mixed spatial mobility the autonomous vehicles will transport cargo and passenger at the same time within the same vehicle. This may take place in either the restricted area mentioned in UC1.1 or the residential area mentioned in UC1.2.

- **For Use Case 2.2:**

To demonstrate the automated mixed temporal mobility the autonomous vehicles will transport cargo and passenger at different time within the same vehicle. This may take place in either the restricted area mentioned in UC1.1 or the residential area mentioned in UC1.2.

2. **Demonstrators:**

- EasyMile Shuttle EZ10 Gen2: DL3/4
- Audi Q5 (UCs 1.2 & 1.6)

3. **Vehicle types included:** Shuttles and car

4. **Involved vehicle brands:** EasyMile, Audi

5. **Involved fleet operators:** FZI, VBK,

6. **Physical Infrastructure required:**

There will be no dedicated integration to the local TMC. The supervision centre will operate autonomously though there is no direct teleoperation of the vehicle.

C-ITS will be also employed.

7. **Relevant WP(s)/Activity(ies) of GA:** WP11 and WP12

8. **Entities involved in implementation:**
   i. **Internal entities to the Consortium:** FZI

   ii. **External entities to the Consortium:** None

9. **Entities involved in testing & demonstration:**
   i. **Internal entities to the Consortium:** FZI

   ii. **External entities to the Consortium:** VBK, KVV

Business\ Exploitation Section

1. **Specific travellers cohorts addressed:**
   - **For Use Case 1.1**: Visitors to the restricted area
   - **For Use Cases 1.2, 1.6**: Local residents, commuters
   - **For Use Cases 1.7, 1.9, 2.1, 2.2:** Local residents, commuters, University staff

2. **Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable):**

The cargo has to be packaged and has to be fixed within the shuttle so there is no danger for passengers. The packages have to be transported within the shuttle and are not allowed to overhang. If the shuttle is needed as a whole for transportation this will be communicated over the booking system.

3. **Starting point/background & Innovation in SHOW:** Service did not exist before.

4. **Training and other skills/knowledge requirements for key stakeholders involved:** Training for manual and automated driving mode of the FZI shuttles.

5. **Incentives associated**: All services will be free of charge.

6. **Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):**

The cargo has to be packaged and has to be fixed within the shuttle so there is no danger for passengers. The packages have to be transported within the shuttle and are not allowed to overhang. If the shuttle is needed as a whole for transportation this will be communicated over the booking system.

3.1.2.2 The Aachen Pilot site

In the pilot site of Aachen the following SHOW Use Cases are going to be covered: UC1.1; UC1.4; UC1.6; UC1.10.

As during the demo we will also operate 2 non-automated vehicles and our use case is based on automation and is executed / located at a bus stop there is a relation to the use case UC3.4 - Automated services at bus stops.

Design Section

1. **Site specific application of the Use Case:**
   i. **Site specific title of the Use Case:**

   - **For Use Case 1.4:** Predictive / collaborative driving manoeuvres based on V2V communication at bus stops (flowing traffic merge-out and merge-in), to reduce energy consumption through longitudinal control of multiple vehicles to avoid stationary traffic.
   - **For Use Cases 1.1, 1.6 & 1.10:** Ring feeder as on-demand service in a campus environment, based on automated people mover vehicles interfacing PT and interfacing to connected intelligent DRT/MaaS applications in Aachen (Mobility Broker and other DRT systems).
     - UC1.1 is defining the general scenario / boundary conditions. UC1.6 is included due to interfacing with regular public transport. UC3.4 is included due to the fact that bus stops are integral components of the provided mobility service. With this in mind, the UC1.10 is the core use case.

   ii. **Leading entity:** FEV / e.GO MOOVE (UCs 1.4, 1.6, 3.4) and ASEAG / Stadt Aachen / e.GO MOOVE (UCs 1.1, 1.6, 1.10, 3.4).

2. **Ecosystem key stakeholders clusters involved:**
   - ✓ OEM’s and transport/mobility operators
   - ✓ Tier 1 suppliers, telecom operators, technology providers, SME’s (only for UC1.4)
   - ✓ Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers

3. **Operational speed**: Up to 30 km/h.

4. **Traffic context**:
   - **For all Use Cases:**

The test site CAMPUS MELATEN NORD is a peri-urban environment located close to the borders of both Netherlands and Belgium, easily accessible and fully connected to public transport. The Campus Melaten primarily hosts RWTH institutes. The road network consists of mixed lanes for both PT and regular traffic. There are bicycle lanes on all roads separated from the road through lane markings as defined in the StVO. The traffic density is low to medium, consisting of PT, industrial and private vehicles, pedestrians and bicycles.

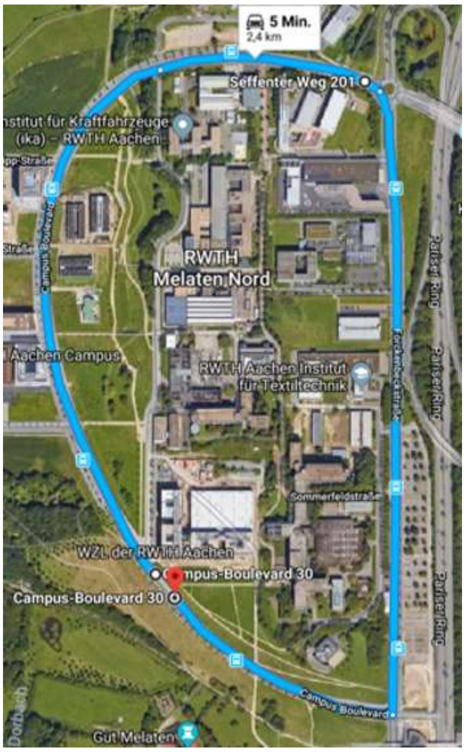


Figure 23: Test site details (source: Google Maps)

Figure 24: Typical test site bus stop

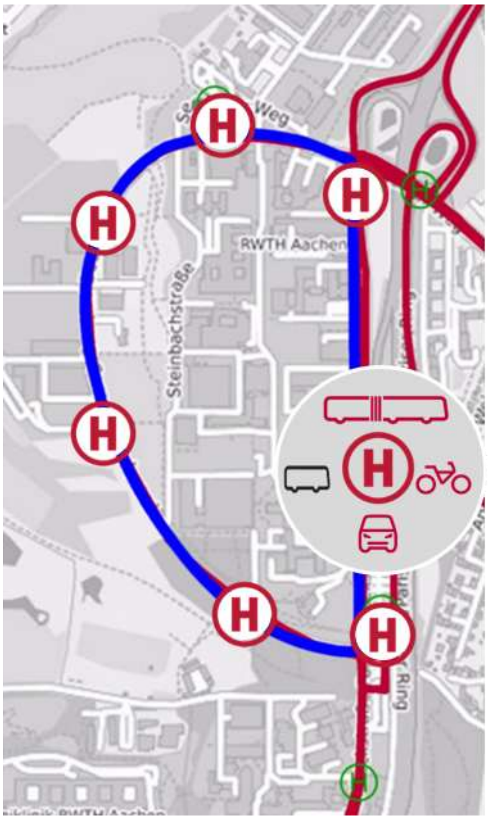


Figure 25: Test site PT details (source ASEAG)

5. **Frequency and timeline of operation:**

- **For Use Case 1.4:**

Manoeuvre will be executed once as baseline with manual driving and without energy saving functionality. Then there will be an iterative execution with automation and energy saving functionality, depending on development and release status of the software stack and on testing / demonstration time slots. Although the People Mover may be active frequently, the other involved entities (FEV vehicles) will only be active during the use case testing and demonstration performance.

- **For Use Cases 1.1, 1.6, 1.10**

During the pilot phase in Aachen, two People Mover vehicles will be operated for a certain duration partially in regular PT mode, partially in DRT (Demand Responsive Transport) mode.

6. **Restrictions & dependencies:**

- **For Use Case 1.4:**

The environmental restrictions depend on the capabilities of the automated vehicles that are going to be used. These vehicles and the AD Systems (Automated Driving Systems, ADS) are still under development. Currently, the ADS operates under moderate environmental conditions. There is a dependency on continuous V2V connectivity.

The communication hardware will be commercially available and off-the-shelf. It is not possible to develop the hardware. There is no lateral control of the FEV vehicles. The driving lane is not wide enough to pass the People Mover at safe distance without accessing the opposing lane. Oncoming traffic is not taken into account. The opposing lane is No-Go Area for safety reasons and due to the absence of lateral control.

Figure 26: Manoeuvre Restrictions

- **For Use Cases 1.1, 1.6, 1.10**

The environmental restrictions depend on the capabilities of the automated vehicles that are going to be used. These vehicles and the AD Systems are still under development. Currently, the ADS operates under moderate environmental conditions.

7. **Key risks identified:**

- **For Use Case 1.4:**

a) **Operational Risks**:

i. Crossing Pedestrians in front of People Mover during bus stop departure

Figure 27: Crossing Pedestrians during Bus Stop Departure

1. Dangerous situation -> Manoeuvre will be aborted
2. People Mover Safety Driver waits until the critical area is free from pedestrians to reinitiate ADS
3. FEV-Follow waits

ii. Crossing Pedestrians in front of FEV Follow during Bus stop Departure

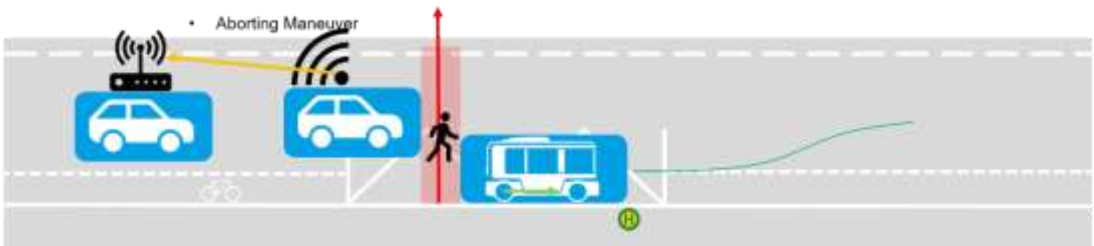


Figure 28: Crossing Pedestrians during Bus Stop Departure

1. People Mover can safely depart from bus stop.

2. FEV-Follow has to wait, until critical area is free of pedestrians and communicates manoeuvre pause to following vehicles.
3. Bicycle on bicycle lane during People Mover Pull-over.

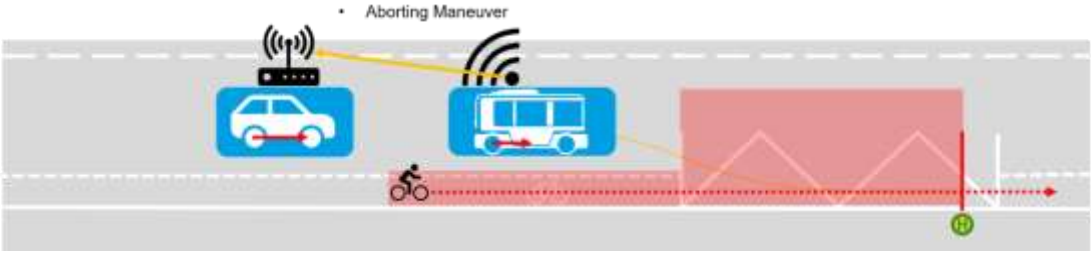


Figure 29: Bicycle on bicycle lane during Bus Stop Pull-Over

1. Dangerous situation -> Manoeuvre will be aborted.
2. People Mover Safety Driver aborts manoeuvre and waits until the critical situation is dissolved to reinitiate ADS.
3. FEV-Follow aborts manoeuvre and waits until the critical situation is dissolved.

b) <u>Acceptance / Operational Risks:</u>

i. Impatient, unaffiliated traffic participants during Bus Stop Departure

Figure 30: Impatient traffic participants during Bus Stop Departure

1. Following, unaffiliated traffic passes FEV-Follow and People Mover
2. Dangerous situation -> Manoeuvre will be paused.
3. People Mover Safety Driver waits until the critical situation is dissolved to reinitiate ADS.
4. FEV-Follow waits until the critical situation is dissolved.

- **For Use Cases 1.1, 1.6, 1.10**

a) <u>Operational Risks:</u>
- All possible Risks of driving a vehicle on public roads.

b) <u>Acceptance Risks:</u>
- Traffic participants react impatiently, if L4 People Mover behaves too passively.
- Passengers deny service due to lack of trust towards autonomous systems.

c) **Business Risks:**

- Passengers deny service due to lack of trust towards autonomous systems.

8. Security concerns:

- **For Use Case 1.4:**
  - The vehicles are permanently under surveillance of authorized persons (Safety Drivers).
  - The communication is done via 4G/5G communication. C-ITS standards will be followed.

- **For Use Cases 1.1, 1.6, 1.10**
  - The vehicles are permanently under surveillance of authorized persons.
  - Mobility App communication is done via Mobile Phone Communication, according security standards are fulfilled and according risks apply.
  - RBL communication is secured according to standards for RBL communication security.

Development\ Implementation Section

1. Storyboard for the site specific use case:

- **For Use Case 1.4:**
  → Participants:

1. e.GO People Mover SAE L4 with communication device.

Figure 31: People Mover

2. FEV Passenger Vehicle SAE L0/L3/L4 with communication device.

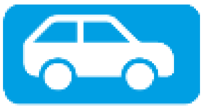


Figure 32: FEV Follow

3. Driver (People Mover Safety Driver)
4. Drivers (FEV Vehicles)
5. Passenger(s) (People Mover passengers)

→ Starting position for Bus-stop Pull-over Manoeuvre:

- People Mover is driving at v_m

Figure 33: Starting position

- FEV-Follow is driving at $v_f = v_m$ at constant safety distance.

→ **Bus Stop Service Intention Communication before Bus Stop Pull-over Manoeuvre**

- People Mover intents to serve an upcoming bus stop and communicates this intention together with the planned deceleration or velocity profile to the other vehicles of the formed vehicle group earlier than the service manoeuvre is actually performed.

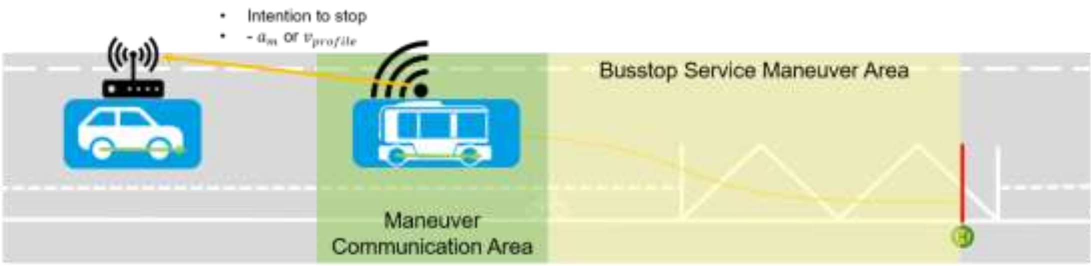


Figure 34: Bus Stop Service Intention Communication

→ **Bus Stop Pull-over Manoeuvre Initiation**

- People Mover initiates bus stop manoeuvre
- FEV-Follow optimizes his velocity w.r.t. the upcoming stop of the People Mover, a safe distance and energy efficiency.

Figure 35: Bus Stop Pull-over Manoeuvre Initiation

→ **Bus Stop Service Manoeuvre**

- People Mover performs bus stop service.
- Passengers depart and enter the shuttle.

→ **Bus Stop Departure Intention Communication before Bus Stop Departure Manoeuvre**
- People Mover finishes the bus stop service and communicates the intention to depart including the planned acceleration or the planned velocity profile to other vehicles of the formed vehicle group.

Figure 36: Bus Stop Departure Intention Communication

→ **Bus Stop Departure Manoeuvre Initiation**
- The People Mover initiates the bus stop departure manoeuvre
- FEV-Follow optimizes his velocity w.r.t. the departure of the People Mover and w.r.t energy efficiency.

Figure 37: Bus Stop Departure Manoeuvre Initiation

PLEASE NOTE: The story board is subject to continuous refinement / evolvement throughout the SHOW project. The story board presented here is a snapshot dated Sep. 10th 2020, the story board is subject to change.

- **For Use Cases 1.1, 1.6, 1.10**

→ **Service Roads:**

1. Campus-Boulevard
2. Forckenbeckstrasse
3. Steinbachstrasse

→ **Fixed Bus Stops:**

1. Campus Melaten
2. Floriansdorf
3. Forckenbeckstrasse
4. Maria-Lipp-Strasse
5. Rabentalweg

6. Stiewistrasse
7. Wilfried-Koenig-Strasse

→ **Pilot Application Domains:**

1. Integrated MaaS during service peak times

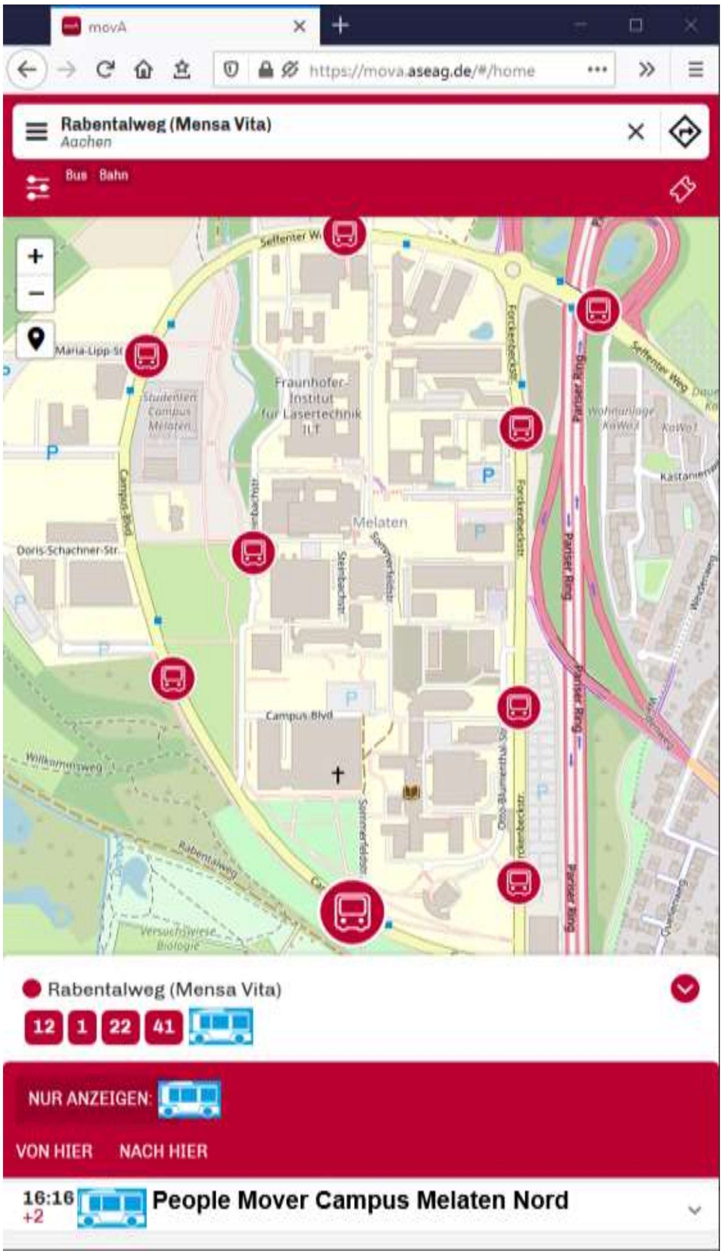


Figure 38: ASEAG movA web portal symbolic picture

- The People Mover is integrated into the ASEAG MaaS platform movA via an ASEAG RBL unit and serves the bus stops along the route on Campus Melaten as part of the regular ÖPNV net.
- The Campus Melaten bus stops are also served by regular ÖPNV lines and serve as hubs for exchanging passengers between regular ÖPNV lines and Campus Melaten People Movers.
- The People Mover serves the bus stops according to a regular time table clockwise along the Campus-Boulevard and the Forckenbeckstrasse.
    - Entering a bus stop, if:

        - a stop is triggered by an on-board passenger
        - or if potential passengers are waiting at the bus stop
    - Performing a stop with passenger exchange.
    - Departing from the bus stop, after the passengers are served.

1. DRT outside of main service time

- Due to low passenger amounts outside of main serving times, the PT is reduced to an on demand service at the fixed bus stops.
- Service time is unprofitable for ÖPNV, People Mover complements the service.
- The People Movers are integrated into the ASEAG Mobility App movA as on-demand service at the Campus Melaten area.
- In operation, the People Mover responds to calls via the ASEAG Mobility App movA
- Example storyboard for on-demand service:
    - Starting point: A passenger with ASEAG Mobility App movA on his smartphone and up to 2 People Mover with ASEAG Mobility App movA connection are located at the Campus Melaten Nord.

Figure 39: On Demand service starting point

    - A passenger calls the People Mover via the ASEAG Mobility App movA.
        - The ASEAG Mobility App Client communicates with the ASEAG Mobility App Server and provides the current location of the passenger as well as the destination location.

Figure 40: On Demand service

- The ASEAG Mobility App Server identifies the bus stop, that is closest to the passenger as pick up location, as well as the bus stop, that is closest to the destination location as drop-off location.
- The ASEAG Mobility App Server identifies the People Mover closest to the pickup location among the registered and active People Movers.
- The ASEAG Mobility App Server calls the identified People Mover and communicates the pickup location as well as the drop-off location.

Figure 41: On Demand service

- The chosen People Mover targets the pick-up bus stop and picks up the person.

Figure 42: On Demand service

- The chosen People Mover communicates the pick up to the ASEAG Mobility App Server.
- The chosen People Mover sets course to the destination bus stop.

Figure 43: On Demand service

- The chosen People Mover stops at the destination bus stop and lets the passenger leave the vehicle.
- The chosen People Mover communicates the drop-off to the ASEAG Mobility App Server.

Figure 44: On Demand service

- Along the way, additional calls may be served.

2. **Demonstrators:**

- **For Use Case 1.4:**
  - 1 e.GO People Mover SAE L4 with communication device, Cohda Wireless MK6C EVK, provided by e.GO.
  - 1 FEV Passenger Vehicle SAE L3/L4 with communication device Cohda Wireless MK6C EVK, provided by FEV.
  - Up to 2 FEV Vehicles SAE L0 with communication device Cohda Wireless MK6C EVK, provided by FEV.

- **For Use Cases 1.1, 1.6, 1.10:**
  - Up to 2 e.GO People Mover SAE L4 with RBL client and Mobility App connection device, both provided and integrated by ASEAG.
  - Regular ASEAG PT.

3. **Vehicle types included:**

- **For Use Case 1.4:**
  - People Mover according to M2 Category
  - Pkw

- **For Use Cases 1.1, 1.6, 1.10:**
  - People Mover according to M2 Category
  - Regular PT Bus according to M2/M3 Category

4. **Involved vehicle brands:**

- e.GO MOOVE (for all UCs)
- 1 modified BMW i3 (UC1.4)
- 2 arbitrary cars (UC1.4)
- Regular PT Bus brands: Mercedes, Volvo, MAN (UCs1.1, 1.6, 1.10)

5. **Involved fleet operators:**
   - **For Use Cases 1.1, 1.6, 1.10:**
     - ASEAG for operational concerns
     - e.GO MOOVE for technical concerns regarding the People Movers

6. **Physical Infrastructure required:**

Status quo: The track for the pilot testing (“pilot track”) is located in a peri-urban campus area, mostly flat roads with 50 km/h speed limit and a stretch of 4.5 km. The campus area itself is reachable via regular public transport, partially shared with the pilot track. 6 unsignalised pedestrian (VRU) crossings along the pilot track, 13 intersections and 7 bus stops. Lane markings are of normal (medium) quality, 2 lanes (1 per opposed driving direction). No strategic traffic management / control is applied in this area. GNSS is available.

Outlook: The pilot track will be digitally mapped in higher definition. Test vehicles will be equipped with commercially available OBUs (on-board units) to communicate with each other (V2V, vehicle-to-vehicle) using mobile network communication (4G or 5G LTE). A V2I (vehicle-to-infrastructure) communication to RSUs (road-side units) is currently not planned. The protocol / messaging on OSI model layer 3 and higher for the V2V communication supporting the automated driving function will be developed based on a commercial V2X communication stack.

There will be no integration to the urban TMC, as the Pilot area is a peri-urban campus.

Link to the 5G - Mobile Network (4G / 5G LTE) is planned.

7. **Relevant WP(s)/Activity(ies) of GA:** WP1, WP6, WP7, WP9, WP11, WP12

8. **Entities involved in implementation:**

   i. **Internal entities to the Consortium: Internal entities to the Consortium:**

- e.GO MOOVE GmbH
- FEV Europe GmbH
- City of Aachen
- ASEAG
- Stadt Aachen

Explanation: Both the City of Aachen and ASEAG are involved to a certain extent because the usage of public roads and bus stops has to be aligned with them, normal public transport (bus lines) – operated through ASEAG – is regularly running along the test track.

   ii. **External entities to the Consortium**: None

9. **Entities involved in testing & demonstration:**

   i. **Internal entities to the Consortium:**

- e.GO MOOVE GmbH
- FEV Europe GmbH
- City of Aachen
- ASEAG
- Stadt Aachen

Explanation: Both the City of Aachen and ASEAG are involved to a certain extent because the usage of public roads and bus stops has to be aligned with them, normal public transport (bus lines) – operated through ASEAG – is regularly running along the test track.

ii. **External entities to the Consortium:** None

Business\ Exploitation Section

1. **Specific travellers cohorts addressed:**
    - Commuters
    - Students (UCs1.1, 1.6, 1.10)

2. **Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable):** N/A

3. **Starting point/background & Innovation in SHOW:**

Previous projects:
- L3Pilot (ongoing, FEV)
- Urban Move (ongoing, ASEAG, City of Aachen)
- APEROL (ongoing, City of Aachen, e.GO)

Innovation in SHOW: Fully integrated electrified and autonomous shuttle service in MaaS and DRT application.

4. **Training and other skills/knowledge requirements for key stakeholders involved:** To be defined.

5. **Incentives associated:**

Free transportation for students and commuters during pilot phase in the People Movers (UCs1.1, 1.6, 1.10, 3.4).

6. **Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):**

A) Mapping of use cases to CCAM (Connected and Cooperative Automated Mobility) objectives:

UC	Business Sustainability	Operational Excellence	Business Ecosystem Performance	Quality of Service
1.1		X		
1.4	**X**			
(1.6)			X	
1.10		**X**		**X**
(3.4)			X	X

UC1.1 is rather the general setting / boundary conditions.

UC1.6 is included because of the interfacing with non-automated vehicles, including those of regular public transport ("mixed traffic").

UC3.4 is included because the intended use cases include or are located at bus stops

The core use cases are 1.4 and 1.10.

B) Mapping of use cases to AV applications / business models:

UC	Autonomously Driving Vehicle	Car sharing of Autonomously Driving Vehicle	Robotaxis, AV DRT Shuttles	AV Feeders	AVs for localized PT w/ DRT
1.1					(X)
1.4	**X**		**X**		
(1.6)					
1.10			**X**	**X**	**(X)**
(3.4)					

C) Mapping of use cases to typical transport service business models:

UC	DRT (Demand Responsive Transport)	CSS (Car Sharing Services)	MaaS (Mobility as a Service)	LaaS (Logistics as a Service)	Regular PT (Public Transport)
1.1					
1.4					
(1.6)					(x)
1.10	**X**	**(0)**	**X**		**X**
(3.4)			(x)		(x)

UC1.10: Car sharing is an included mobility service in the local MaaS platform but is not considered in the course of this project. Core transport service is the regular PT.

3.1.2.3 The Braunschweig Pilot site

In the pilot site of Braunschweig the following SHOW Use Cases are going to be covered: UC1.1; UC1.6 and UC1.8.

<u>Design Section</u>

1. Site specific application of the Use Case:

i. Site specific title of the Use Case:

- **For Use Cases 1.1 & 1.6: Automated vehicle with on-demand stops**: DRT with fixed stops and including the possibility of a few virtual stops on the route.
- **For Use Cases 1.8: Platooning in urban environment demo**: Platooning showing logical coupling of vehicles, to be conducted with 2-3 vehicles on parts of the route, focusing e.g. on signalized intersections.

ii. Leading entity: DLR

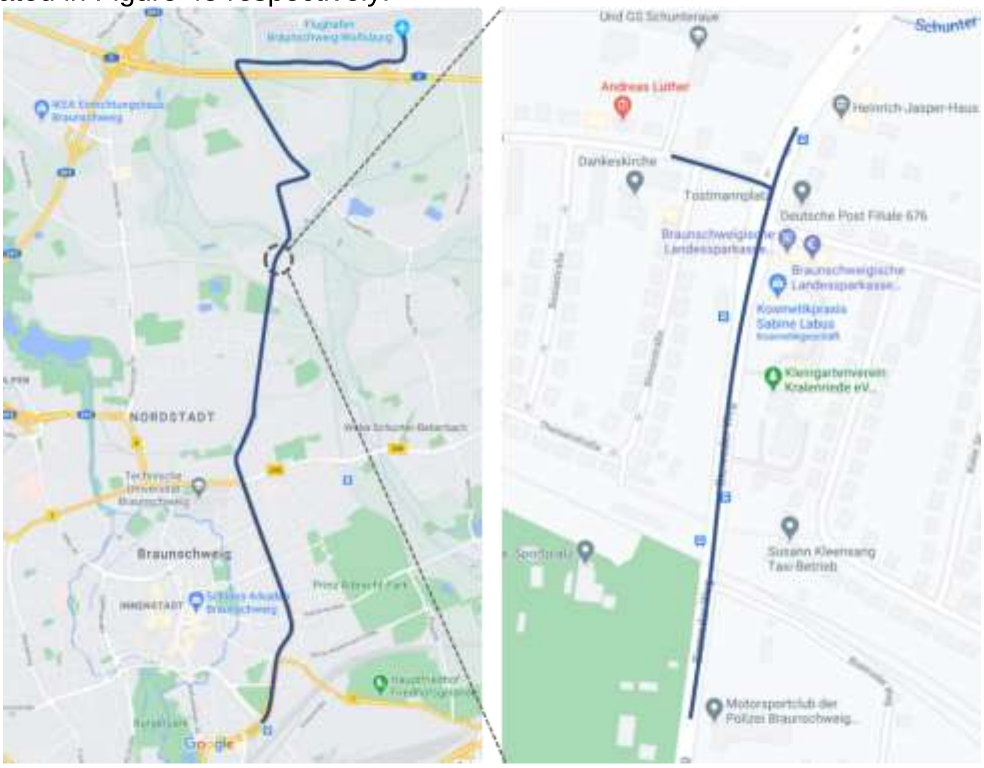
2. Ecosystem key stakeholders clusters involved:

- ✓ Research & academia
- ✓ Passengers and other road users encompassing VEC

3. Operational speed: Up to 50 km/h (cars)

4. Traffic context:

Route, adopted in the above mentioned two UCs, includes mainly urban areas and is connecting the main station in the city centre to a suburban area (airport/ DLR), route length is 10 km, part of the route is embedded in the Test Bed Lower Saxony for automated and connected mobility, most segments of the route are equipped to accommodate autonomous vehicles. The planned test routes for both UCs are indicated in Figure 45 respectively.



(a) route for shuttle with on-demand stops (b) route for the platooning demo

* Map source: Google Maps

Figure 45: Illustration of the planned test routes

5. Frequency and timeline of operation:

Transporting commuters between the airport and DLR, most likely on workdays (Monday – Friday), to be further defined.

6. **Restrictions & dependencies:**
    - Two safety drivers per vehicle are required at all times due to regulation for research vehicles.
    - No driving in extreme weather conditions, like snow storm or icy roads.
    - Charging of e-vehicles necessary throughout the day.

7. **Key risks identified:**

Currently, no key risk is identified. One of the vehicles is still under construction and may come later due to possible delay in the procurement process. We will continue monitoring the respective process.

8. **Security concerns:** None foreseen.

Development\ Implementation Section

1. **Storyboard for the site specific use cases:**
    - **For UCs1.1&1.6: "Automated shuttle with on-demand stops"** Storyboard according to current planning:
        - Vehicles waiting at airport/main station or driving on route.
        - Potential passengers are using a smartphone app where they can book a trip with start and destination along the route.
        - System calculates best pick-up and drop-off zones, and best vehicle, including timing, based on the current position, direction and available space in the shuttles.
        - Potential passenger is informed about pick-up and drop-off zones and the time of departure and arrival.
        - Potential passenger books trip.
        - Chosen shuttle drives automated to the stop at the desired time
        - Passenger uses AR in the app to see the stopping position virtually, as well as the timing, and the correct entry point of the correct shuttle
        - Passenger enters the shuttle.
        - If more shuttles are driving behind each other, they are building a logical platoon, so that they are able to reduce distances, esp. when passing signalized intersections and while accelerating at traffic lights after a stop.
        - Shuttles are stopping in between on demand.

    - **For UCs1.8: UC: "Platooning in urban environment demo"** Storyboard according to current planning:
        - Vehicles will start on the UC1 Route, south of Tostmannplatz as a platoon.
        - Vehicles interact with Roadside Infrastructure at Tostmannplatz, demonstrating AGLOSA (Adaptive Green Light Optimal Speed Advisory). Vehicles are detected by infrastructure node via camera and traffic light information is communicated from infrastructure node via V2X to platoon (ITSG5 MAPEM and SPATEM messages).
        - Vehicles will cross intersection as a platoon, either turning left through head-on traffic or crossing Tostmannplatz straight towards next on-demand stop.

2. **Demonstrators:**
    - 3 cars: VW e-Golf, VW Passat GTE, Mercedes EQV

- Vehicles are prototypes at TRL 6, they are technically able to fulfil requirements for SAE level 4 for a certain set of situations (permit for level 2)

Figure 46: Braunschweig Pilot site demonstrators

3. **Vehicle types included:** Cars

4. **Involved vehicle brands:** Mercedes and Volkswagen

5. **Involved fleet operators:** DLR

6. **Physical Infrastructure required:**

Both in UC1 and 2 V2X (ITSG5) equipped infrastructure is employed: Each vehicle-intersection traffic light on the route sends MAPEM and SPATEM messages to the 1-3 automated vehicles in the UC.

There will be no integration to the area TMC.

C-ITS nodes will be utilised.

7. **Relevant WP(s)/Activity(ies) of GA:** WP12

8. **Entities involved in implementation:**
   i. **Internal entities to the Consortium:** DLR

   ii. **External entities to the Consortium:** None

9. **Entities involved in testing & demonstration:**
   i. **Internal entities to the Consortium:** DLR

   ii. **External entities to the Consortium:** None

<u>Business\ Exploitation Section</u>

1. **Specific travellers' cohorts addressed:** Mainly commuters

2. **Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable):** N/A

3. **Starting point/background & Innovation in SHOW:**

One of the cars will already prototypically perform the service at a single demonstration, including app for booking and AR parts, and dispatching, in 2021.

Urban platooning has been developed prototypically and demonstrated at one of the intersections of the route in H2020 MAVEN.

Vehicle automation is running in the vehicles for several years. DLR has prototypically created automated driving functions in several projects.

4. **Training and other skills/knowledge requirements for key stakeholders involved:**

DLR personnel is already trained: Safety drivers are trained with a 3-day vehicle handling course. Test persons will be briefed for augmented reality and app usage as well as safety instructions for automated vehicles.

5. **Incentives associated**: Service will be free of charge.

6. **Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):** Not defined yet.

3.1.3 The Madrid Mega Pilot

In the pilot site of Madrid the following SHOW Use Cases are going to be covered: UC1.1; UC1.2; UC1.3; UC1.6; UC1.7, UC1.8, UC1.10; UC3.3; UC3.5

<u>Design Section</u>

Within the Madrid Mega Pilot, the arrangement for UCs1.1, 1.2, 1.3, 1.6 and 1.10 will run in the same scenario (Villaverde). Hence the present chapter collects - for these UC1 subcases - the detailed description below.

Figure 47 below depicts the route for all the above UCs. This includes a round itinerary from Villaverde (bajo cruce) to La Nave - to be executed by a small fleet of automated vehicles.

- A first approximation of the route from “La Nave” to the subway station “Villaverde bajo-cruce”, has been modelled using HDMaps, based on orthophotos.
- There are several spots on the route that can affect the general performance of the system due to traffic rule violations or a lack of clear traffic rules (see Key Risks below).

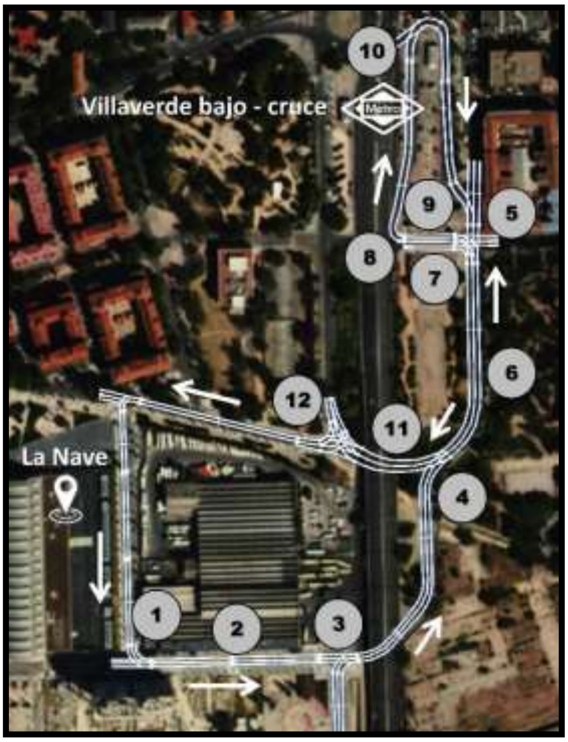


Figure 47: Madrid Mega Pilot Site - Villaverde round itinerary (for UCs1.1, 1.2, 1.3, 1.6 and 1.10)

In the particular case of Madrid Mega Pilot, Use Cases 1.7, 1.8, 3.3 and 3.5 run in Carabanchel (EMT's premises), in the areas depicted in Figures 35-37 below.

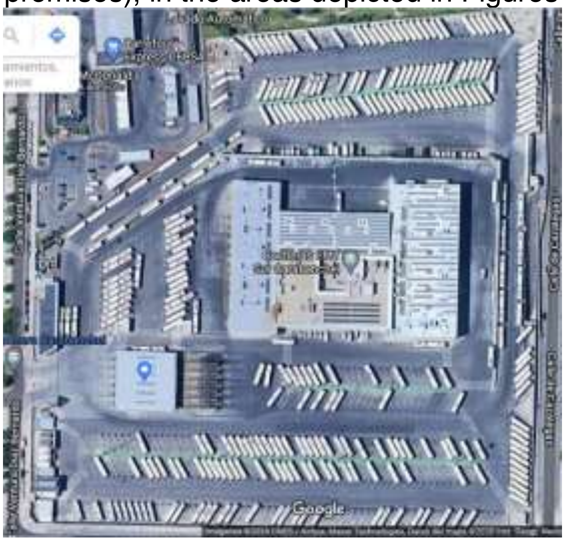


Figure 48: Madrid Mega Pilot Site – Carabanchel scenario (for UC1.7).

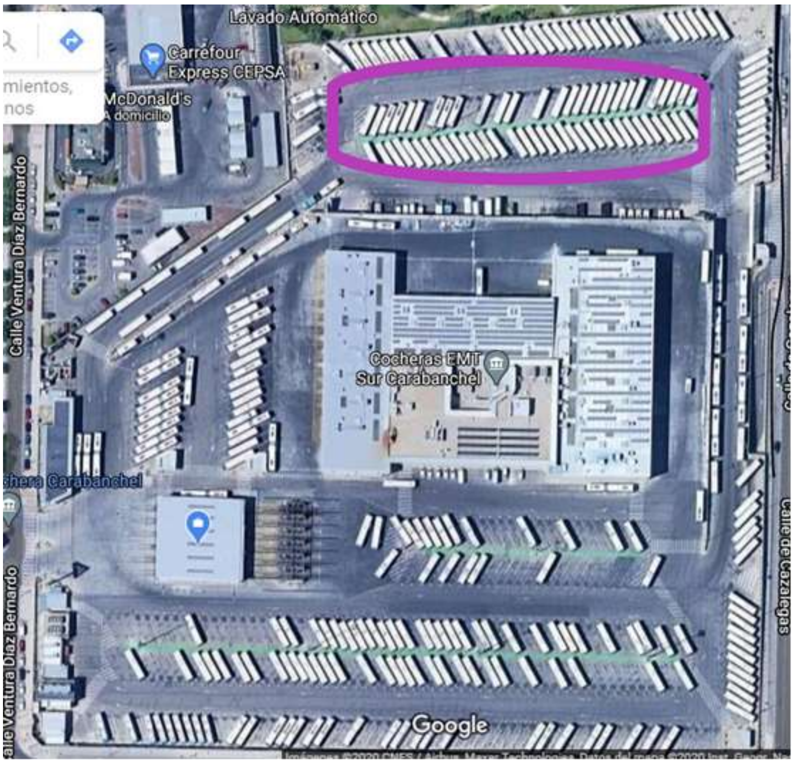


Figure 49: Madrid Mega Pilot Site – platoon scenario (for UC1.8).

Figure 50: Madrid Mega Pilot Site (for UCs3.3, 3.5)

1. **Site specific application of the Use Case:**
   i. **Site specific title of the Use Case:**

- **For Use Case 1.1:** Automated passengers' mobility in Villaverde around Nave area (normal traffic & environmental conditions).

- **For Use Case 1.2:** Automated passengers' mobility in Villaverde around Bajo Cruce (subway station) (complex traffic & environmental conditions).
- **For Use Case 1.3:** Reliable and safe VRU interfacing at Villaverde Bajo Cruce (subway station).
- **For Use Case 1.6:** Villaverde open traffic conditions.
- **For Use Case 1.7:** Shuttle teleoperation at Carabanchel depot.
- **For Use Case 1.8:** Cooperative V2V platooning for electric bus and passenger car.
- **For Use Case 1.10:** SAE L3-4 Villaverde passenger mobility.
- **For Use Case 3.3:** Shuttle and electric bus automated docking at Carabanchel depot.
- **For Use Case 3.5:** SAE L3-4 automated Depot management, at Carabanchel.

ii. Leading entity:

- **For Use Cases 1.1, 1.2, 1.3, 1.6, 1.10:** TECNALIA
- **For Use Cases 1.7, 3.3 and 3.5:** EMT
- **For Use Case 1.8:** IRIZAR/DATIK & TECNALIA

2. Ecosystem key stakeholders clusters involved:

- **For Use Cases 1.1, 1.2, 1.3, 1.6, 1.10**

✓ OEM's and transport operators
✓ Telecom operators, technology providers
✓ Research & academia
✓ Authorities (Municipalities)

- **For Use Case 1.7**

✓ Transport operators
✓ Telecom operators, technology providers

- **For Use Case 1.8, 3.3 and 3.5**

✓ OEM's and transport/mobility operators
✓ Research & academia

3. Operational speed:

The automated vehicles involved in these UCs will be operating at the following speeds:

Vehicle type	Max: km/h
Use Cases 1.1, 1.2, 1.3, 1.6, 1.10	
Bus shuttle	30
Electric bus	50
Electric car	50
Use Case 1.7	
Bus shuttle	15
Use Cases 1.8, 3.3, 3.5	
Electric bus	15
Bus shuttle	15

4. **Traffic context**:

Figure 51 depicts the traffic context of UCs1.1, 1.2, 1.3, 1.6 and 1.10 urban route, where VRUs, mixed traffic, mixed lanes and dense traffic are present.

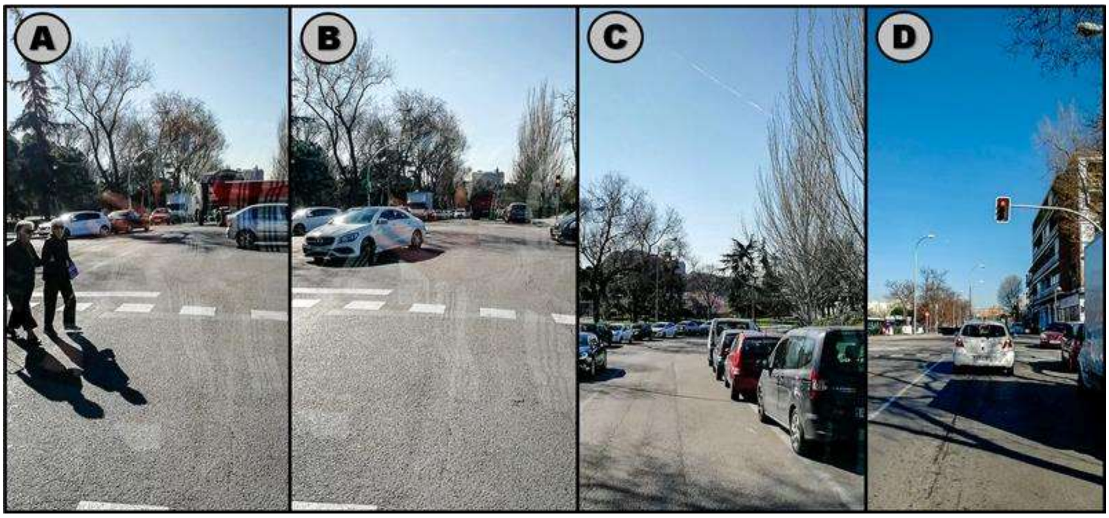


Figure 51: Madrid Mega Pilot Site – UCs1.1,1 .2, 1.3, 1.6 and 1.10 – traffic context

Figure 52 depicts the traffic context of UC1.7, where multiple buses are parked and dense traffic is present.

Figure 52: Madrid Mega Pilot Site - UC1.7 – traffic context

Figure 53 depicts the traffic context of UC1.8, where mixed and dense traffic are present.

Figure 53: Madrid Mega Pilot Site - UC1.8 – traffic context

Figure 54 depicts the traffic context of UCs3.3 and 3.5, where multiple buses are parked and dense traffic is present.

Figure 54: Madrid Mega Pilot Site - UC3.3 and 3.5 – traffic context

5. **Frequency and timeline of operation:** Weekdays on a daily basis (for all UCs).

6. **Restrictions & dependencies:**

For the realisation of the UCs 1.1, 1.2, 1.3, 1.6, 1.10, there are certain spots on the round itinerary, which under rainy conditions (unclear road marking) or holidays period (itinerary changes), will not be covered.

Figure 55: Madrid Mega Pilot Site – Restrictions and dependencies.

7. **Key risks identified:**

The following figures (Figures 56-62) show preliminary risks for the realisation of the UCs 1.1, 1.2, 1.3, 1.6, 1.10, detected on Villaverde round itinerary, which will affect the system's final perfomance (technically speaking).

Figure 56: Madrid Mega Pilot Site – Risks in spot 3.

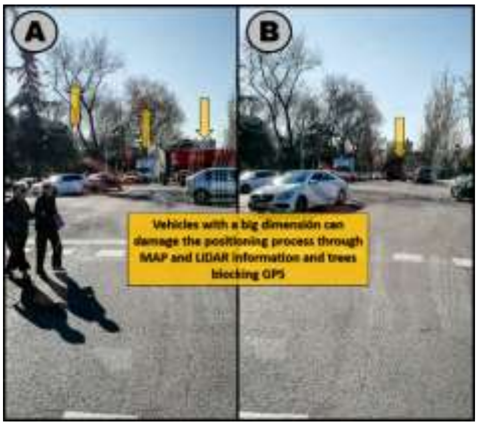


Figure 57. Madrid Mega Pilot Site – Risks in spot 5

Figure 58. Madrid Mega Pilot Site – Traffic rules while parking risks in spot 6.

Figure 59. Madrid Mega Pilot Site – Traffic lights synchronization risks in spot 7.

Figure 60. Madrid Mega Pilot Site – Lane blockage risks in spot 8.

Figure 61. Madrid Mega Pilot Site – VRUs risks in spot 10.

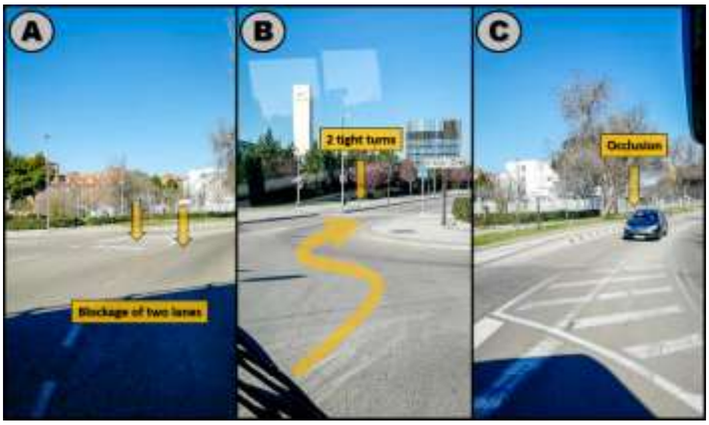


Figure 62. Madrid Mega Pilot Site – Risks in AD manoeuvres in spot 12.

Regarding the realisation of UC1.7, Figure 63 shows preliminary risks (mixed vehicles in the depot at the same time and narrow entrances), detected on Carabanchel scenario, which will affect the system's final perfomance (technically speaking).

Figure 63: Madrid Mega Pilot Site - UC1.7 – identified risks

Moreover, Figure 64 below shows the preliminary risks for the implementation of UC1.8, detected on Carabanchel scenario, which will affect the system's final perfomance in UC1.8 (technically speaking).

Figure 64: Madrid Mega Pilot Site - UC1.8 – identified risks

Finally, regarding UCs 3.3 and 3.5, the preliminary risks (mixed vehicles in the depot at the same time and narrow entrances), are depicted in Figure 65 detected on Carabanchel scenario, which will affect the system's final perfomance (technically speaking).

Figure 65: Madrid Mega Pilot Site - UCs3.3, UC3.5 – identified risks

8. **Security concerns:** None foreseen (for all UCs).

Development\ Implementation Section

1. **Storyboard for the site specific use cases:**

- **For Use Cases 1.1, 1.2, 1.3, 1.6, 1.10**

This group of use cases will be executed in the zone of La Nave and Villaverde Bajo-Cruce Subway station (Madrid). The main participants involved will be one automated shuttle Gulliver (EMT), one automated electric i2eBus (IRIZAR), and two automated Twizy (Tecnalia). These vehicles will attend the urban route that connects La nave with the Subway station and vice-versa (UC1.1).

The objective is to supply a fluid transport service to all the road users that demand an efficient way to connect both sites (UC1.2). One of the stops will be located in La Nave and the other one in the Subway station. Both stops will have an available vehicle to provide the service.

The target speed considers the maximum and minimum speed limits of the urban environments (50 km/h) that avoids a negative impact over the traffic flow UC1.10). Nevertheless, the automated shuttle operational speed will be around 15-30 km/h due to vehicle limitations of the power system.

Moreover, the vehicles will be capable to execute an automated re-planning process in case of unexpected situations or pedestrians on the road (#SHOW UC 1.3). Smooth and comfortable speed profiles, interaction with connected and non-automated vehicles through V2X or lighting symbols, information of future actions to the users of the service, obstacle avoidance, and overtaking capacities will ensure the operation in mixed traffic circumstances (UC 1.6).

- **For Use Case 1.7**

In this use case, the target vehicle will be one of the EMT's Gulliver shuttle. The objective is to operate this vehicle remotely from a control center in Carabanchel when it arrives at the depot. This procedure will increase the efficiency of the drivers through daily operation and the process of parking the vehicles. Moreover, an expert depot operator will organize them in the parking area based on his expertise and knowledge of the daily operations. Long-range communications, e.g. 5G, are considered for this use case due to the need for transmitting and receiving video information in real-time.

- **For Use Case 1.8**

In this use case, the Twizy vehicle will guide the automated IRIZAR's bus using a platoon formation. This procedure will permit the movement of multiple vehicles with one driver or guiding vehicle in the EMT's depot that improves the performance of daily operative. The zone to execute the manoeuvre is located in the dense parking zone of Carabanchel (north-east) which demands efficiency while executing the exit and parking processes of the buses. Further analysis needs to be done in order to identify where in the depot this cooperative manoeuvre will take place.

- **For Use Cases 3.3 & 3.5**

This use case will provide the capacities of parking automatically the shuttle and bus in the best spots in the depot. Moreover, the docking processes in the charge stations will be performed with the use of the automated parking algorithms (UC 3.3). The depot management (UC 3.5) has a relation with other use cases of the Madrid pilot, such as platooning and teleoperation, although, the automated parking process has a stronger relationship with the efficiency of the depot.

2. Demonstrators:

The following demonstrators are involved in the Madrid Pilot site:

No. of vehicles	Name (partner)	SAE level	Relevant UCs
2	Gulliver (EMT)	SAE L3-4	1.1, 1.2, 1.3, 1.6, 1.7, 1.10, 3.3,3.5
1	i2eBus (IRIZAR)	SAE L3-4	1.1, 1.2, 1.3, 1.6, 1.8, 1.10, 3.3,3.5
2	Twizy (TECNALIA)	SAE L3-4	1.1, 1.2, 1.3, 1.6, 1.8, 1.10,

3. Vehicle types included:

The following vehicle types are involved in the Madrid Pilot site:

Number of vehicles	Name (partner)	Vehicle type	Relevant UCs
2	Gulliver (EMT)	Shuttle	1.1, 1.2, 1.3, 1.6, 1.7, 1.10, 3.3, 3.5
1	i2eBus (IRIZAR)	12m electric bus	1.1, 1.2, 1.3, 1.6, 1.8, 1.10, 3.3, 3.5

1	Twizy (TECNALIA)	Electric car	1.1, 1.2, 1.3, 1.6, 1.8, 1.10

4. **Involved vehicle brands:**

Vehicle name	Vehicle brand	Relevant UCs
Gulliver (EMT)	TECNOBUS	1.1, 1.2, 1.3, 1.6, 1.7, 1.10, 3.3, 3.5
i2eBus (IRIZAR)	IRIZAR	1.1, 1.2, 1.3, 1.6, 1.8, 1.10, 3.3, 3.5
Twizy (TECNALIA)	RENAULT	1.1, 1.2, 1.3, 1.6, 1.8, 1.10

5. **Involved fleet operators:** SHOW partner EMT - Madrid Public transport Company (Empresa Municipal de Transportes).

6. **Physical Infrastructure required:**

In order to cover the use cases foreseen in UCs 1.1, 1.2, 1.3, 1.6 and 1.10 Villaverde round route, the following two elements are identified:

(1) Communications antenna – to be placed on a mast / traffic light / lamppost, with connection to an Ethernet cable connected to the equipment of the point (2)

(2) Route + POE + Power supply, with access to power outlet. There are two options:

1. Use an existing closet to include the equipment.
2. Install a new cabinet as shown in the right figure below

There will be no integration to the urban TMC and teleoperation will be limited in supervision of autonomous vehicle and decision aid.

C-ITS (G5) nodes will be employed for some of the UCs.

Addition ally, in order to cover the use cases foreseen in UCs 1.7, 1.8, 3.3 and 3.5 at Carabanchel EMT depot, the following two elements are identified:

V2V	4th generation of Commsignia's vehicular connectivity system, which offers superior performance coupled with V2X Software stack. The unit provides low-

	cost and easy aftermarket integration, offering built in Tamper-proof Hardware Security Module, CAN, and high range V2V radio. 
V2I	Cinegears Ghost-Eye Wireless HDMI & SDI Transmitter 300M, transmit high fidelity, uncompressed HD video transmission (3G and HDMI inputs and outputs, and 10 workable transmission frequencies) 

7. Relevant WP(s)/Activity(ies) of GA:

- **For Use Cases 1.1, 1.2, 1.3, 1.6 and 1.10**

Input from:

- WP2 and WP3 deliverables will set business models and legal permits, respectively
- WP4 SHOW system architecture will be taken into account in Madrid Mega Pilot’s open modular system architecture, interfacing its own dashboard to SHOW‘s

Output to:

- WP5, WP6 and WP7 will consider UCs1.1, 1.2, 1.3, 1.6 and 1.10 customised to Madrid Mega pilot big data platform, operational services and AD strategies (perception, decision and collaborative comms.)
- WP9 will consider UCs1.1, 1.2, 1.3, 1.6 and 1.10 in the validation plan and tools adopted in Madrid Mega pilot.

- **For Use Case 1.7**

Input from:

- WP4 SHOW system architecture will be taken into account in Madrid Mega Pilot’s open modular system architecture, interfacing its own dashboard to SHOW‘s

Output to:

- WP5, WP6 and WP7 will consider UC1.7 customised to Madrid Mega pilot AD strategies (perception, decision and collaborative communications.)
- WP9 will consider UC1.7 in the validation plan and tools adopted in Madrid Mega pilot.

- **For Use Case 1.8**

Input from:

- WP4 SHOW system architecture will be taken into account in Madrid Mega Pilot's open modular system architecture, interfacing its own dashboard to SHOW's

Output to:

- WP5, WP6 and WP7 will consider UC1.8 customised to Madrid Mega pilot big data platform, operational services and AD strategies (perception, decision and collaborative comms.).
- WP9 will consider UC1.8 in the validation plan and tools adopted in Madrid Mega pilot.

- **For Use Cases 3.3 & 3.5**

Input from:

- WP2 and WP3 deliverables will set business models and legal permits, respectively.
- WP4 SHOW system architecture will be taken into account in Madrid Mega Pilot's open modular system architecture, interfacing its own dashboard to SHOW's.

Output to:

- WP5, WP6 and WP7 will consider UC3.3 and UC3.5 customised to Madrid Mega pilot AD strategies (perception, decision and collaborative comms.).
- WP9 will consider UC3.3 and UC3.5 in the validation plan and tools adopted in Madrid Mega pilot.

8. Entities involved in implementation:

iii. Internal entities to the Consortium:

Entity	Relevant Use Case(s)
Madrid Public transport Company (EMT)	1.1, 1.2, 1.3, 1.6, 1.7, 1.10, 3.3, 3.5
INDRA (IT provider)	1.1, 1.2, 1.3, 1.6, 1.10
IRIZAR (Electric bus OEM)	1.1, 1.2, 1.3, 1.6, 1.8, 1.10, 3.3, 3.5
TECNALIA (Pilot leader and CAM technology provider)	1.1, 1.2, 1.3, 1.6, 1.8, 1.10.

iv. External entities to the Consortium: None

9. Entities involved in testing & demonstration:

iii. Internal entities to the Consortium:

Entity	Relevant Use Case(s)
Madrid Public transport Company (EMT)	1.1, 1.2, 1.3, 1.6, 1.7, 1.10, 3.3, 3.5
INDRA (IT provider)	1.1, 1.2, 1.3, 1.6, 1.10
IRIZAR (Electric bus OEM)	1.1, 1.2, 1.3, 1.6, 1.8, 1.10, 3.3, 3.5
TECNALIA (Pilot leader and CAM technology provider)	1.1, 1.2, 1.3, 1.6, 1.8, 1.10

iv. External entities to the Consortium:

Entity	Relevant Use Case(s)
Madrid municipality - Permits provider (city)	1.1, 1.2, 1.3, 1.6, 1.10
DGT - Permits provider (vehicle)	1.1, 1.2, 1.3, 1.6, 1.10

Business\ Exploitation Section

1. **Specific travellers' cohorts addressed:**

   - For UCs 1.1, 1.2, 1.3, 1.6, 1.7, 1.10: Commuters, VRUs
   - For UC 1.7: Maintenance personnel and VRUs
   - For UC 1.8: IRIZAR's drivers
   - For UCs 3.3, 3.5: Maintenance personnel and VRUs.

2. **Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable):** N/A

3. **Starting point/background & Innovation in SHOW:**

   - **For UCs 1.1, 1.2, 1.3, 1.6, 1.7, 1.10**
     → **Starting point**: AUTODRIVE project: AD driving use cases (SAE L2-3) on a dedicated scenario, using i2eBus (1 electric bus, IRIZAR). Internal research: AD driving use cases (SAE L2-3) on proper premises, using automated Twizy (1 electric car, TECNALIA).
     → **Innovation**: run specific UCs in real traffic conditions with higher AV level and speed.
   - **For UCs 1.7, 1.8, 3.3, 3.5:** There is no background relevant to these UCs from the Madrid Mega pilot partners.

4. **Training and other skills/knowledge requirements for key stakeholders involved:**

Automated driving technology training is needed for EMT's drivers and maintenance personnel, as well as for IRIZAR drivers.

5. **Incentives associated**: N/A

6. **Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):**

The different UCs of the Madrid Mega site, can be grouped in two different ones (according to the two locations of our demo)

- As a publicly owned public transport operator our mission is to improve the service for the sake of the city and its citizens. Therefore, EMT does not have economic interest as such on automation (from the point of view of business opportunities) but as a tool to improve operations, optimize resources and boost innovation to provide the best services.
- At one hand, for instance, for the demo to be deployed in Villaverde area (service under real traffic conditions), the use of automation will imply improvements in accessibility and intermodality, as well as increasing the occupancy rate, the vehicle utilisation efficiency and rate, and optimization of duration/length/number of trips, increasing inclusiveness at the same time.
- At the other hand, at the Carabanchel area (service within the bus depot), automation can mean an optimization in parking and charging time, as well as improvements in CAPEX and OPEX.

3.1.4 The Swedish twin Mega Pilot

3.1.4.1 The Linköping Pilot site

In the pilot site of Linköping the following Use Cases are going to be covered: UC1.1; UC1.3; UC1.6; UC1.7; UC3.1, 3.2 and 3.4.

<u>Design Section</u>

1. **Site specific application of the Use Case:**

   i. **Site specific title of the Use Case:**
      - UC1.1: Automated passengers/cargo mobility in Cities under normal traffic & environmental conditions
        → **Title: First & Last mile public transportation in normal traffic**
      - UC1.3: Interfacing non automated vehicles/ travellers (VRU)
        → **Title: First & Last mile public transportation at shared space with VRU**
      - UC1.6: Mixed traffic flows
        → **Title: First & Last mile public transportation in mixed traffic**
      - UC1.7: Connection to Operation Centre for tele-operation and remote supervision
        → **Title: Elin operational Dashboard**
      - UC3.4: Automated services at bus stops
        → **Title: On-demand stop signal at bus stops**
      - UC3.1: Self-learning Demand Response Passengers/Cargo mobility
        → **Title: Route optimisation based on passenger counting**.
      - UC3.2: Big data/AI based added value services for Passengers/ Cargo mobility
        → **Title: Personalised route (on & off) suggestions**

   ii. **Leading entity:** VTI

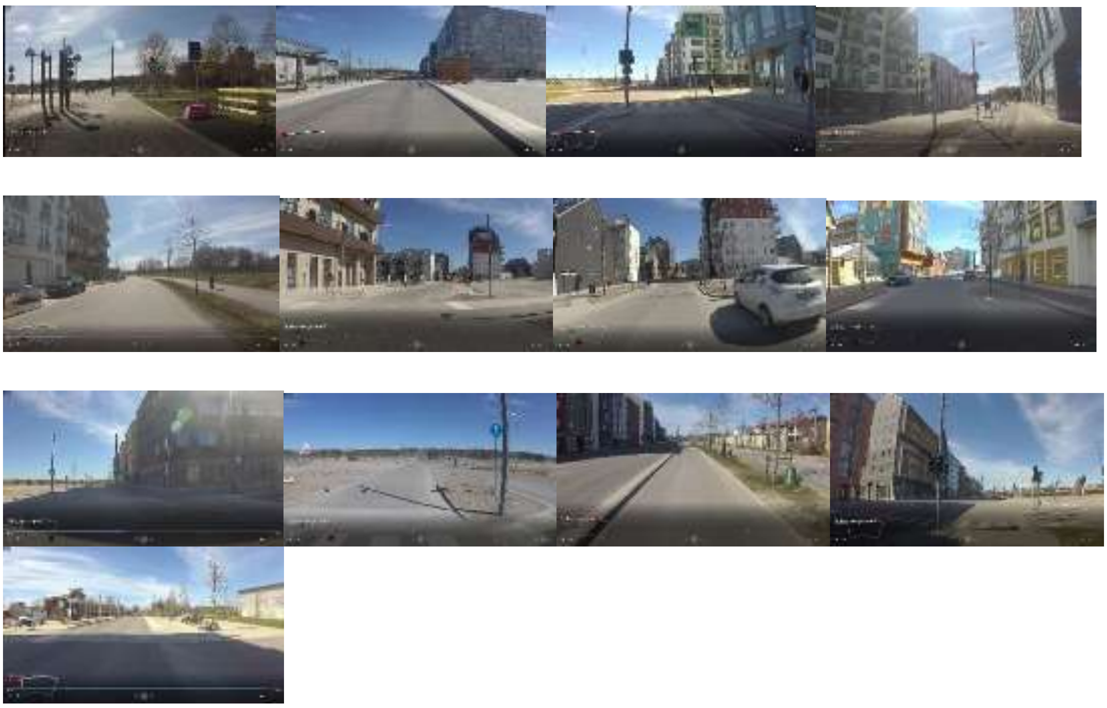
2. **Ecosystem key stakeholders clusters involved:**
   ✓ OEM's and transport/mobility operators
   ✓ Research & academia
   ✓ Passengers and other road users encompassing VEC
   ✓ Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers
   ✓ Other (please define):
      - Property/facility owners (Akademiska hus)
      - Science part (Linköpings science park)

3. **Operational speed:** Up to 14 km/h

4. **Traffic context**:
   - The Campus route – existing route:
      - The first row describes the context where the shuttles interact with other vehicles including PTs. There are several crossings for pedestrians and parallel bicycle lanes.
      - The second row describe the Core path on the Campus area. No vehicles, expect maintain vehicles are permitted. The number of pedestrians and cyclists are high.

- The third row is again a context with interaction with other vehicles.

- The Vallastaden route – new area:
  - The first row is in mixed traffic with PT prioritisation through API supported red lights.
  - The second row is through the residential area with parking facilities and restaurants along the roadside.
  - The third row is a mixed area that will be fully developed in spring 2021. The third row, left photo is the building with the school and the elderly residential home. The last photo is back at the turning point of the existing route.



5. Frequency and timeline of operation:

- Monday-Friday: 2 shuttles operating between 7.30-19.00, 6 runs per hour.
- Saturday-Sunday: 1 shuttle operating between 9.00 – 16.00, 3 runs per hour.

6. Restrictions & dependencies:

- Heavy snow, or temperatures below -10 degrees.
- Maintenance dependent. Heavy snow might cause problems.
- No operation will take place during July and mid-December-mid January due to lack of passengers (holiday period).
- No operation will take place if there are official events at Campus Linköping.
- No operation will take place if there are major constructions (short period) in the area of Vallastaden.

7. Key risks identified:

- **User acceptance** – Low speed, Lack of capacity during peak hours,
- **Technical** – a static environment that requires dynamic mapping of route (grass, leaves, snow, moveable objects in the environment)
- **Operational** – Lack of safety drivers, update of permission by TrSt, delays during technical service due to lack of workshop close to Linköping (low scale of operation – test vehicles)
- **Behavioural** – uncomfortable rides due to non-smooth run (continuously braking.
- **Business** – SHOW is dependent on an existing operation. In COVID-19 times it is unsure if what is promised needs to be negotiated due to lack of budget or other priorities. This is relevant for both operation and from user perspective.

8. Security concerns:

- Not relevant. A safety driver is on board.

Development\ Implementation Section

1. Storyboard for the site specific use case:

UC1.1: Automated passengers/cargo mobility in Cities under normal traffic & environmental conditions → Title: First and Last mile to public transportation in mixed traffic.

"Along the route there is a school for children with special needs and in the same building there is a residential for elderly people. The distance from this building to the PT trunk line is >300 meter and hence too long to walk."

Justification: The municipality use more than 20 taxis during morning and evening to bring the children to and from school. In addition, a lot of taxis is needed to bring the elderly to hospital visits and activities. Thanks to the shuttles that pass the building and further on to the PT bus stop, the children and the elderly will have access to an increased mobility, the use of PT will increase and the cost for taxis provided by the municipality will be lower."

UC1.3: Interfacing non automated vehicles/ travellers (VRU) → First and Last mile public transportation at shared space with VRU.

“The area at the Campus Core consist of a dedicated area for pedestrians and cyclists. The AV shuttles will be integrated as an additional mobility solution and used to get to the existing PT bus stops, rental e-bikes or parking space in the out boundaries of the area.”

UC1.6: Mixed traffic flows First and last mile public transportation in mixed traffic.
“In the area of Vallastaden the operation is done on real road and integrated with passenger cars, buses and trucks using the same lanes. In addition, pedestrian/cycle crossing exists, sometimes with prioritisation for the shuttles and sometimes not“.

UC1.7: Connection to Operation Centre for tele-operation and remote supervision → Elin operational dashboard.
“Using the shuttles APIs for monitoring and the APIs for control (to initiate actions) and potentially additional sensors, the shuttles connect to an operation centre via a dashboard solution. Initially the connection will only be to monitor operation (and save data for further use). In a second step simple control functions will be added, i.e. for stopping at specific bus stops etc. (route is fixed). The connection to central operations centre system will also be used to connect our service with connecting services, like PT, trough Linköping Maas”.

UC3.4: Automated services at bus stops → On demand stop signal at bus stops.
“The shuttles to stop only when there is an actual demand. Using the busses control APIs, the shuttles will stop only when travellers wants to get on or off. A simple but connected “stop button” is placed along the route. The button (and potentially other sources like an app or Linköping MaaS) will signal the operation centre and automatic create a stop order at the correct bus stop”

Justification: SoA is that the shuttles stop at each predefined bus stop regardless if there is a passenger or not. This cause extra delays and increased travel time. This effect the perceived service and the willingness to use the shuttles.

UC3.1: Self-learning Demand Response Passengers/Cargo mobility → Route optimisation based on passenger counting.
“Using historical travel data (number of travellers, boarding and disembarking per stop, date and time) a self-learning solution for route optimisation is used for suggesting number of shuttles per sub route, frequency and automatic stops along the routes”.

UC3.2: Big data/AI based added value services for Passengers/ Cargo mobility → Personalised route guidance.

"Combining Linköping MaaS, real time data city wide public transport information, historical travel data and passenger information suggest the most optimal way of transport for any and all individual users of this service in terms of where and when to embark and disembark.

- Strategic (when to leave home/work/school to get to the shuttle that connects to PT, etc.).
- Tactical (to know when and where to go and to get off the bus stop taking the passengers specific needs into consideration).

The system considers the users' personal preferences and/or limitations, e.g special needs.

2. Demonstrators:

- 1 Navya Autonomous DL4 (Shuttle)
- 1 EasyMile EZ10 gen 2 (Shuttle)
- 1 still open (maintenance AV or 1 shuttle. Decision in beginning of 2021)

3. Vehicle types included: Shuttles

4. Involved vehicle brands: Navya and EasyMile

5. Involved fleet operators: Transdev Sverige AB

6. Physical Infrastructure required:

The shuttles interact with other vehicles including PTs. There are several crossings for pedestrians and parallel bicycle lane. The speed is max 30 kph, it is flat, there are 5 intersections, 2 areas with parking along the roadside, the area is a mix of residential and industry. The road has maximum 1 lane per direction.

There will be no integration to the city TMC.

The vehicle will run autonomously employing only a GPS RTK.

7. Relevant WP(s)/Activity(ies) of GA:

- WP3 on Ethical and permission
- WP4 on Dashboard.
- WP5 on Big data
- WP7 on Vehicle SW development
- WP9 on Evaluation
- WP10 on Simulation
- WP13 on User experience

8. Entities involved in implementation:

i. **Internal entities to the Consortium:**

- Transdev Sverige AB – operation
- VTI – demo site leader and evaluation responsible
- Rise – digital infrastructure/ dashboard/ big data providers
- Combitech – control center developer

ii. **External entities to the Consortium:**

- Linköpings municipality – infrastructure and permits, owner of land, communication leader for the existing operation (ELIN), provider of Linköpings Maas.
- Akademiska hus – local adaptation of infrastructure and permits, owner of land
- Linköpings universitet – user of infrastructure (right to use), responsible for students and teachers,
- Östgöta trafiken – PT provider, owner of connected PT.
- Veredict – subcontractor to VTI. DRT and big data solution developer.

9. **Entities involved in testing & demonstration:**

i. **Internal entities to the Consortium:** As above
ii. **External entities to the Consortium:**

   - As above
   - Users in general, elderly and children with special needs at the school.

Business\ Exploitation Section

1. **Specific travellers' cohorts addressed**:

- Elderly living at the retirement residential area in Vallastaden.
- Children with special needs at the school in Vallastaden.

2. **Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable):** N/A

3. **Starting point/background & Innovation in SHOW:** In Linköping 2 shuttles exist and is up running. They will be used also in SHOW for the new area Vallastaden.

4. **Training and other skills/knowledge requirements for key stakeholders involved:** The safety drivers need driving licence category D, specific training for bus drivers (YKB) and 4 days training for the specific shuttle they are working on.

5. **Incentives associated:** The operation is for free.

6. **Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):**

For **MaaS** the Linköping test site will provide the data about position of the buses etc.; using APIs to the local MaaS developers. In addition we will develop a similar approach that is dedicated to elderly and children with an easy to use map-centric solution for smartphones, a big screen solution for public display application, a web based application, an on-board application for safety drivers and a solution to make sure the SHOW route is integrated with PT in the area.

The dedicated solution will be developed by our subcontractor (out for tender soon, to make sure we get best value for money).

For **DRT**, we aim to work in a simple way making it possible to use a function (button, icon on smartphone/screen) to send information to the system that a person want to use.

3.1.4.2 The Kista Pilot site

In the pilot site of Kista the following SHOW Use Cases are going to be covered:
UC1.1; UC1.2; UC1.3; UC1.6; UC1.7; UC3.4

<u>Design Section</u>

1. **Site specific application of the Use Case:**
   i. **Site specific title of the Use Case:**
      - UC1.1 First/last mile PT in Kista
      - UC1.2 First/last mile PT in Kista under complex environmental conditions
      - UC1.3 Control Tower connecting to other travellers in Kista
      - UC1.6 First/last mile PT in Kista in mixed traffic
      - UC1.7 Assistance of driverless vehicle by Control Tower
      - UC3.4 Autonomous driving functions at bus stop

   ii. **Leading entity:**
      - Jan Jansson, Keolis Sweden (jan.jansson@keolis.se)
      - Cilli Sobiech, RISE AB (cilli.sobiech@ri.se)

2. **Ecosystem key stakeholders clusters involved:**
   - ✓ OEM's and transport/mobility operators
   - ✓ Tier 1 suppliers, telecom operators, technology providers, SME's
   - ✓ Research & academia
   - ✓ Passengers and other road users encompassing VEC
   - ✓ Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers

3. **Operational speed:** Up to 20 km/h

4. **Traffic context**:

   In the SHOW project, Keolis is managing autonomous vehicles for first/last mile passenger transport pilots in Kista, a suburb north of the center of Stockholm.

Figure 66: Kista Science City, aerial view

The Kista site is an urban area, Stockholm´s leading ICT centre with 40 000 commuting every day to Ericsson, Stockholm University and Royal Institute of Technology and approx. 1000 other companies. Kista Science City is an important component to the economic engine of Stockholm, however, despite the existence of a light rail station and a metro station, there remain significant portions of the working population that commute by private vehicle, creating congestion issues and using valuable land resources for parking that would otherwise go into denser commercial or residential development.

There are four bus lines that serve Kista Centrum, two commuting trains and one metro line (the 11). Parking charges around Kista reflect the high land prices; fees are applicable 24 hours a day, at rates of 1-4 hrs SEK 35/hr, 4-6 hrs SEK 125, or 24 hrs SEK 150. Today there are no AV operations in the area. The area type is urban with mainly business/commercial character with the Kista Fair and the shopping centre Kista Galleria.

The route for the demonstration in Kista is shown in the figure below:

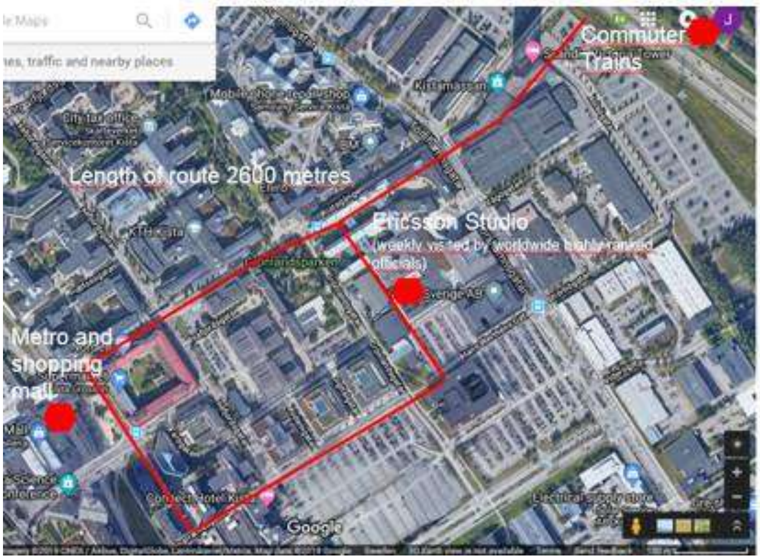


Figure 67: Kista route for the SHOW demonstration

The route:

- Shuttle starts close to the commuter train station. The route is approx. 2km long and has approx. 5-7 stops.
- The vehicle is driving on a designated route in an urban area with mixed traffic and interacts with PT. Several crossings and bicycle lanes, pedestrians, etc. (4-5 crossings) are on the vehicle´s route.
- Route is planned according to mobility needs, in an area where most people work but with limited access to PT.

5. Frequency and timeline of operation:

- Monday-Friday: 1-2 shuttles operating between 7.30-18.00 (to be further evaluated according to needs)
- No weekend service

6. Restrictions & dependencies:

- No service on weekends and during public holidays
- No service under too complex environmental conditions such as too much snow and temperatures under -5 degrees.
- No service if major constructions are ongoing (none planned so far).

7. Key risks identified:

- **User acceptance**: An earlier pilot with automated vehicles in Kista 2018 showed that there are two specific user groups that are sceptical about AV service; special attention will be given to those two user groups (Their scepticism relates to: 1. AV as low quality/poor comfort vehicle – 2. the safety of AV).
- **COVID-19** can also affect the user acceptance and utilisation rate of the shared, small vehicle, as well as due to the fact that less people commute to Kista but work mainly from home instead.
- **Behavioural:** A significant portions of the working population (53%) commute by private vehicle instead of by PT.
- **Pricing:** An earlier pilot in Kista showed that if AV services were priced competitively in comparison to traveling by metro and train given the same distance, existing car owners would switch from driving to using the service. This is the key goal with first/last mile AV services in the Kista area.
- **Technical:** Problems with the Traffic Control Tower connection, with the vehicle itself or on the route can affect the demonstration.
- **Operational:** Delays due to a lack of safety operator, permission or stakeholders rearranging due to COVID-19 can affect the demonstration.

8. Security concerns:

- In the first pre-demo, a safety driver and a steering wheel is available. During the full-scale demonstration a safety operator may be located outside the vehicle.
- When connected to Control Tower, the vehicle will brake in case of loss of connection to the Traffic Control Tower.

Development\ Implementation Section

1. Storyboard for the site specific use case:

UC1: Automated mobility in cities	
UC1.1	Automated passengers mobility in cities under **normal** traffic & environmental conditions
Storyboard: Close to the commuter station Helenelund, the AV starts its drive along a designated route in the urban area of Kista Science City. To get to the job close to the Kista Galleria, several passengers leaving Helenelund station take the shuttle bus.	
UC1.2	Automated passengers mobility in cities under **complex** traffic & environmental conditions
Storyboard: It is lightly snowing in Kista. Thanks to the AV service, passengers easily and comfortable can commute to/from their job with PT.	
UC1.3	Interfacing non automated vehicles/travellers (VRU)
Storyboard: The Control Tower can connect to other passengers in the surroundings of the shuttle, as on the route VRUs might be.	
UC1.6	Automated passengers mobility in cities in **mixed** traffic flows
Storyboard: The AV is driving on a designated route, yet it crosses streets, bicycle lanes and pedestrian crossings on its way. Few bus stops are the same as for PT buses.	
UC1.7	Connection to operation centre for tele-operation and remote supervision
Storyboard: The Control Tower is permanently connected to the vehicle and the 5G infrastructure enables to e.g. ask for confirmation about an action, inform about assistance need or an obstacle, to change to remote operation or to change the route. The Control Tower can also send a request for additional information to the vehicles APIs. If the connection to the Control Tower is lost, the vehicle brakes.	
UC3: Added Value services for Cooperative and Connected Automated mobility in cities	
UC3.4	Automated service at bus stop
Storyboard: Assistance systems will help the vehicle at the bus stops (need to be further defined).	

2. **Demonstrators:**
   - 1 t-engineering CM7 van (2020)
   - 1 t-engineering SAE5 shuttle (tbd under 2021)
   - 1 tbd (2021)

3. **Vehicle types included:**

The t-engineering CM7 (approved in sweden) will be used initially in Stockholm

Stockholm /Djurgården

The t-engineering shuttle, perfect for ”driver outside the vehicle” for 2021 SAE 5

Stockholm/Djurgården only static at inauguration

4. **Involved vehicle brands**: t-engineering

5. **Involved fleet operators:** Keolis Sverige AB

6. **Physical Infrastructure required:**

The vehicle is driving on a designated route in an urban area with mixed traffic (UC1.1; UC1.2 & UC1.6). Several crossings and bicycle lanes, pedestrians, etc. (4-5 crossings) are on the vehicle´s route. A few bus stops are the same as for PT buses and the vehicle interacts with PT (UC1.3).

The Control Tower is permanently connected to the vehicle and the 5G infrastructure enables to e.g. ask for confirmation about an action, inform about assistance need or an obstacle, to change to remote operation or to change the route (UC 1.7). The Control Tower can send a request for additional information to the vehicle’s APIs. If the connection to the Control Tower is lost, the vehicle brakes. The Control Tower can connect also to other passengers in the surroundings of the shuttle (UC1.3).

There will be no integration to the urban TMC. AV vehicles will be supervised (and teleoperated in case of an event or emergency from Ericsson Control Tower by Keolis personnel)

5G connectivity will be employed.

7. **Relevant WP(s)/Activity(ies) of GA:**
   - WP3 – Ethical & legal issues
   - WP4 – System architecture – SHOW Dashboard
   - WP6 – Operational services
   - WP9 – Pilot plans
   - WP13 – User experience

8. **Entities involved in implementation:**

   i. **Internal entities to the Consortium:**

   - Keolis Sverige AB
   - Ericsson AB
   - RISE AB

   ii. **External entities to the Consortium:**

   - T-engineering
   - Intel
   - Telia
   - Stockholm Länstrafik (PTA)
   - Kista Science City

9. **Entities involved in testing & demonstration:**

   iii. **Internal entities to the Consortium:**

   - Keolis Sverige AB
   - Ericsson AB
   - RISE AB

   iv. **External entities to the Consortium:**

   - T-engineering
   - Intel
   - Telia
   - Stockholm Länstrafik (PTA)
   - Kista Science City

Business\ Exploitation Section

1. **Specific travellers' cohorts addressed**:
   - Commuters, Kista fair visitors, passengers visiting Kista Galleria/mall, VRU

2. **Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable):** N/A

3. **Starting point/background & Innovation in SHOW:**
   - There has been a pilot in 2018 in Kista with a different brand of AVs
   - For SHOW demonstration, we use a different route for the AV
   - New in the SHOW demonstration is that the AV is connected to the Control Tower by 5G

4. **Training and other skills/knowledge requirements for key stakeholders involved:**
   - Training for safety operator, Keolis has a programme developed for this.
   - Training in Control Tower, Ericsson/Keolis will developed training for this.

5. **Incentives associated:** To be defined.

6. **Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):**

For DRT, Kista aims to extend public mobility services to increase first/last mile transport in the area which can act as a substitute to individual transport solutions.

3.1.5 The Austrian triplet Mega Pilot

A change has occurred within the Austrian triplet Mega Pilot since the Vienna site has not been to fulfil its requirements as described in the GA, especially the one concerning the acquisition and use of the robotaxi. To this extend, the replacement of this site is currently under organisation (soon to be defined), most probably with the site of Carinthia (led by AustriaTech), with the participation of Wiener Linen (with a respective budget transfer between them for the realisation of the pilot)[4].

3.1.5.1 The Graz Pilot site

In the pilot site of Graz the following SHOW Use Cases are going to be covered:
UC1.2; UC1.3; UC3.4.

There are no differences for the implementation of UCs in Graz. There is one common implementation, where an automated shuttle drives along a route (UC1.2), detects VRUs (UC1.3) and serves a bus stop (UC3.4).

<u>Design Section</u>

1. **Site specific application of the Use Case:**
   i. **Site specific title of the Use Case:** Automated shuttle service at public transport terminal – Graz
   ii. **Leading entity:** VIF

2. **Ecosystem key stakeholders clusters involved:**
   - ✓ Tier 1 suppliers, telecom operators, technology providers, SME's
   - ✓ Research & academia
   - ✓ Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers

3. **Operational speed:** Up to 20 km/h

4. **Traffic context**:

   An existing public transport terminal (bus, tram, train) will be extended with automated shuttles that provide rides to a shopping center. In this urban scenario the automated shuttles will stop at the terminal, pick up people and drive through the public stops where there are many pedestrians.

[4] Provisionally, pending amendment.

Figure 68: Pilot site at Graz

5. **Frequency and timeline of operation:** Not yet defined

6. **Restrictions & dependencies:**

This scenario deals with an operating terminal with high bus and passenger traffic. The passage of the AD shuttle through the terminal depends on the frequency of other public transport vehicles. Therefore, there is a strong dependency on other vehicles.

7. **Key risks identified:**

Key risks is that there is not enough space to safety test and operate the shuttle in this crowded and challenging environment.

8. Security concerns:

Image recognition of vehicle and associated infrastructure may pose privacy concerns.

Development\ Implementation Section

1. Storyboard for the site specific use case:

A passenger gets off a public bus and wants to proceed to a shopping center. He either books an onward journey with his smartphone or decides spontaneously to take the AD shuttle. The passenger recognizes that the shuttle is available and gets on board. After a confirmation of the departure and a safety check, the shuttle starts and autonomously searches for a passage through the terminal. The shuttle follows a predefined route and crosses a traffic light controlled intersection. When the shuttle reaches the destination the passenger gets off and the vehicle drives back on its own.

2. Demonstrators:

- 1 x Research demonstrator, Ford Fusion, SAE level 4
- 1 x Research demonstrator, Kia e-Soul, SAE level 4
- A safety driver will be present for the given scenario but will not perform any driving functions in normal operation. The passenger is not expected to take over the car at any time. Therefore, we assume SAE level 4 for the predefined shuttle route.

3. Vehicle types included:

Passenger cars for the initial tests performing as shuttle.

4. Involved vehicle brands:

- Ford Fusion, SAE level 4
- Kia e-Soul, SAE level 4

5. Involved fleet operators: N/A

6. Physical Infrastructure required:

- **For UC1.2**: No physical infrastructure foreseen
- **For UC1.3**: Smart camera platform from Siemens will be used on infrastructure to augment detection capabilities of vehicles sensors. Travellers and public busses will be detected with this system.
- **For UC3.4:** Automated services at bus stops. Smart camera platform from Siemens will be used to monitor bus stop, which is a transfer point for passengers between busses and the automated shuttle.

Moreover, there will be no integration to the TMC. As for digital infrastructure, there will be a system for environmental detection.

7. Relevant WP(s)/Activity(ies) of GA:

WP10 – Simulations: The drive of the shuttle will be simulated beforehand.

8. Entities involved in implementation:

i. **Internal entities to the Consortium:**

- VIF
- AVL
- SIEMENS

ii. **External entities to the Consortium:** None

9. **Entities involved in testing & demonstration:**

i. **Internal entities to the Consortium:**

- VIF
- AVL
- SIEMENS
- IESTA

ii. **External entities to the Consortium:** Holding Graz – Kommunale Dienstleistungen GmbH

Business\ Exploitation Section

1. **Specific travellers' cohorts addressed**: Commuters, tourists, shoppers.

2. **Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable):**

Freight transportation will involve the brought or purchased goods of the passengers. This will also cover functions, such as opening and closing of the trunk of the vehicle and detection of the state of freight.

3. **Starting point/background & Innovation in SHOW:**

The scenario is completely new and has not been tried in the past.

4. **Training and other skills/knowledge requirements for key stakeholders involved:**

The scenario targets passengers without specific training. The ride should be self-explanatory.

5. **Incentives associated:** Under consideration

6. **Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):**

Applicable business models for Graz are oriented towards business models that cover a dedicated automated shuttle route as an extension to public transport.

- For UC1.2: Mapping to the Business Model of Kista/Stockholm.
- For UCs1.3 and UC3.4: Included in UC1.2, no separate Business Model.

3.1.5.2 The Salzburg Pilot site

In the pilot site of Salzburg the following SHOW Use Cases are going to be covered: UC1.2; UC1.3; UC1.5; UC1.6; UC3.1.

Design Section

1. Site specific application of the Use Case:

i. Site specific title of the Use Case:

Automated passenger mobility under complex traffic & environmental conditions in peri-urban areas serving as a first & last mile transport supported by a C-ITS enabled bus corridor connecting the peri-urban area to the city centre.

Explanation:

The Pilot site Salzburg envisages the implementation of two scenarios (scenario 1 and scenario 2). With these scenarios, the pilot site will be able to cover the following UCs: 1.2, 1.3, 1.6 and 3.1.

Scenario 1: Testing automated demand responsive transport (DRT) for connecting a peri-urban area to a city centre via an intermodal mobility hub. Demand-responsive automated shuttles are used to bridge the first/last mile.

Scenario 2: Testing of a C-ITS enabled bus corridor, connecting an intermodal mobility hub to the city centre at high efficiency. It is planned that the buses will be equipped with OBU's and that RSU's connected to the TMC of Salzburg will be installed.

ii. Leading entity: VIF and Salzburg Research.

2. Ecosystem key stakeholders clusters involved:

- ✓ OEM's and transport/mobility operators
- ✓ Tier 1 suppliers, telecom operators, technology providers, SME's
- ✓ Research & academia
- ✓ Passengers and other road users encompassing VEC
- ✓ Umbrella associations
- ✓ Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers

3. Operational speed:

Scenario 1: Up to 20 km/h in automatic driving mode (maximum speed allowed according to the Austrian automated driving regulation).

Scenario 2: speed of public buses under normal service conditions.

4. Traffic context:

Scenario 1 will be realized in the municipality of Koppl. The municipality is located in the peri-urban area of the City of Salzburg. The route links the centre of Koppl municipality to the "Sperrbrücke" bus stop, which is situated on the main road to Salzburg city centre. "Sperrbrücke" bus stop is a stop of the public bus line no. 150 connecting the peri-urban areas to the city centre. Therefore, "Koppl Sperrbrücke" acts as an intermodal interchange where passengers are able to change from the automated shuttle bus to the public bus line. The bus stop has been equipped with an area for safely turning the automated shuttle.

The length of the autonomous shuttle route is approximately 1.4 km one-way. It is a slightly curved asphalt road with a maximum of 8 percent incline (equivalent to 65 m height difference). The whole route has driving lanes for both directions. Including start and terminus stops, the route serves four bus stops in each direction.

The whole route is fully equipped with ETSI ITS-G5-enabled Roadside Stations (5). Also, a HD map of the whole route has been created.

The rural location of this route presents a number of challenges (e.g. partly lacking points of reference such as buildings or road markings for the reliable positioning of the vehicle), poor GNSS signal quality, and rudimentary road infrastructure without signalized intersections, as well as the maximal road gradient of 8%.

From main road to Koppl centre	From Koppl centre to main road
	
	
	

Figure 69: Pictures of the environment for scenario 1 (Source: Salzburg Research; EasyMile; 2019)

Scenario 2 focuses on the public bus corridor between “Koppl Sperrbrücke” and the City of Salzburg. The public bus line 150 connects the peri-urban area Koppl with the city centre on an arterial, rural road. The length of the route is approximately 7.9 km one-way, the maximum speed limit is 80 km/h. It is a partly curvy asphalt road with separate driving lanes bridging nearly 300 meters height difference between the starting point in Koppl and the arrival point in the city of Salzburg. There are eleven bus stops in each direction on this route.

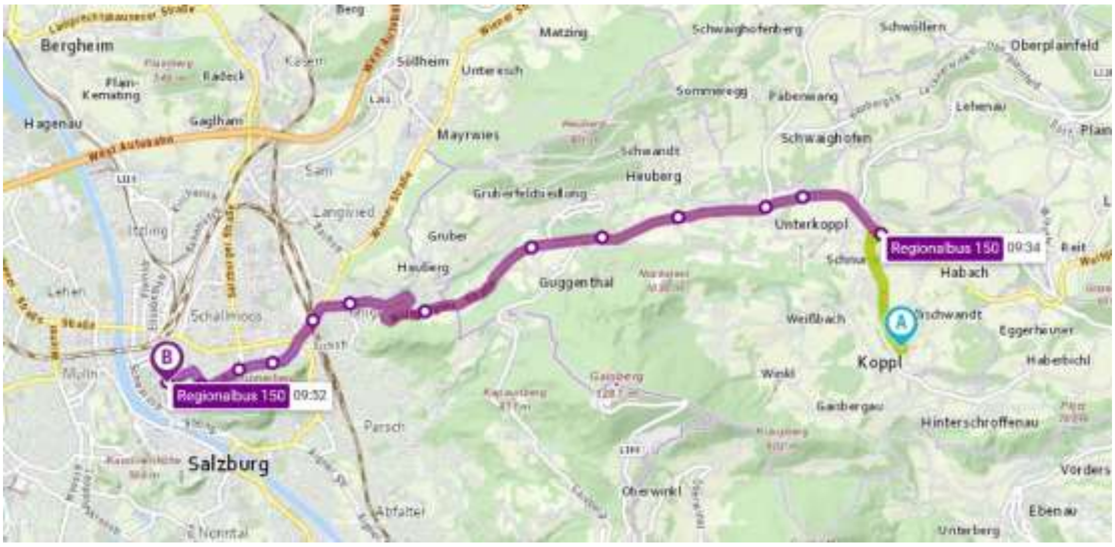


Figure 70: Bus line 150 from Koppl Sperrbrücke to Salzburg City Centre

Figure 71: Intermodal interchange at Koppl Sperrbrücke where passengers change from the public bus to the automated shuttle and vice versa (Source: Google Street View)

Figure 72: Aterial road to Salzburg City Centre with partly dedicated bus lane and prioritized traffic signals (Source: Google Street View)

Figure 73: Major intersection in the City of Salzburg with traffic-aware and prioritized traffic signals (Source: Google Street View)

5. Frequency and timeline of operation:

Scenario 1: working days (Monday to Friday), up to 5 times a day.

Scenario 2: exact timetable and frequency of operation during pre-demo and demonstration period yet unknown, but most probably every 30 minutes on working days.

6. Restrictions & dependencies:

Stations requirements for operating an automated shuttle bus:

- The recommended distance between two stations is 200-300 m.
- The stations are ideally located adjacent to sidewalks (max. 20 cm above street level) or at street level.
- There must be at least 1 m of unobstructed space to deploy the ramp and an additional 0,8 m at minimum to allow wheelchair access.
- The signage indicating the stations must be visible to road users, unobscured by low obstacles.
- Road markings must indicate where to stand, where to enter and exit the vehicle and direct passenger flow in order to prevent passengers from blocking the AV route.

Safe Operating conditions	
Temperature	From -10 °C to +35 °C
Humidity	Between 5 % and 95 %
Rain	Up to 10mm/h
Snow	Up to heavy or medium snowfall
Water accumulation or flow on the track	Up to 20 mm of water at 10 km/h
Wind	Up to 50 km/h, or 65 km/h peak
Dust, fog, vapour on the track	Up to 200 m visibility

Additional requirements for the automated shuttle route:

- It is of high relevance that there are enough structural elements on both sides along the test road in order to improve LIDAR localization.
- Due to the maximum speed of 20 km/h of the automated shuttle, it is recommended to decrease the speed limit on relevant sections of public roads for other road users to 50 km/h.
- The track must be signposted as a test track for automated driving.

7. Key risks identified:

Decreased GNSS-RTK localization quality caused e.g. by overhanging trees, dense building areas or insufficient 4G coverage, may have a negative impact on the localization of the automated vehicle. A high degree of localization uncertainty may result in a reduced speed or service availability.

The risk of a deviation of the automated vehicle from its track is aggravated by:

- Open areas, resulting in a lack of structural elements and a low accuracy of LIDAR based localization
- Curved or inclined trajectories, since computation in sharp curves or slopes/gradients is more complex.

- Changes between the mapped and the real environment (e.g. construction areas) may cause an instability.

A negative impact on service safety would be the result.

User acceptance has to be tested. There is a possible risk of low capacity utilization on the route.

8. Security concerns:

Security concerns are currently under investigation and are evaluated in a risk assessment report, which stipulates suggested mitigation measures.

Development\ Implementation Section

1. Storyboard for the site specific use case:

Scenario 1: Passengers exit the C-ITS enabled bus line 150 from Salzburg city centre at the station "Koppl Sperrbrücke" and board an automated electrified shuttle to bridge the last mile to their destination. They take a seat and fasten their seatbelts. The safety operator on board welcomes the passengers and starts the automated service from "Koppl Sperrbrücke" to "Koppl centre". The shuttle is following a pre-defined trajectory along the 1.4 km stretch of road, stopping at two stations, giving passengers the opportunity to exit or enter the shuttle. At the terminal stop "Koppl centre", all passengers have to exit the shuttle. From there the shuttle takes up the service from the village centre back to the intermodal mobility hub. In addition, DRT functionalities should enhance the service quality. Due to the limited capacity of the automated electrified shuttle, the possibility of reserving/booking a seat in the shuttle before the trip is essential for the acceptance of a first/last mile transport by the users. With the use of recorded travel data (e.g. number of travellers per service, boarding and disembarking per stop recorded via an on board passenger counter) a self-learning solution for optimisation should be used in order to establish the most suitable timetable (frequency of the service) along the route.

Scenario 2: C-ITS enabled buses equipped with OBU's connect the station "Koppl Sperrbrücke" with the city centre. It is planned that the route will be equipped with ETSI ITS-G5-enabled Roadside Stations which are connected to the TMC of Salzburg, enabling e.g. ITS-G5-based traffic light prioritization for public busses.

2. Demonstrators:

Scenario 1: to be defined, probably EasyMile EZ 10 automated electrified shuttle (SAE Level 4)

Scenario 2: to be defined

3. Vehicle types included:

- Scenario 1: Automated electrified shuttle.
- Scenario 2: CITS-enabled buses on a public bus line.

4. Involved vehicle brands:

Scenario 1: to be defined, probably EasyMile

5. Involved fleet operators:

- Scenario 1: Salzburg Research, probably another fleet operator, to be negotiated with Salzburg Transport Association.
- Scenario 2: The involved fleet operator depends on public procurement of Salzburg Transport Association.

6. Physical Infrastructure required:

There will be an interface to the local TMC and C-ITS nodes will be used in parts of the traffic environments.

Also long range wireless communication network (3GPP 4G LTE); IP Communication will be employed.

7. Relevant WP(s)/Activity(ies) of GA:

- WP 3 Ethical and legal issues
- WP 4 System architecture and tools
- WP 8 Infrastructure functions and systems
- WP 9 Pilot plans, tools & ecosystem engagement
- WP 11 Technical verification and pre-demo evaluation
- WP 12 Real-life demonstrations

8. Entities involved in implementation:

i. Internal entities to the Consortium:

- Salzburg Research Forschungsgesellschaft m.b.H
- Shuttle provider (probably Easymile)
- Kapsch TrafficCom AG
- Austriatech – Gesellschaft des Bundes für technologiepolitische
- Maßnahmen GmbH
- AIT – Austrian Institute of Technology GmbH

ii. External entities to the Consortium:

- Municipality of Koppl
- Federal State of Salzburg
- Salzburg Transport Association

9. Entities involved in testing & demonstration:

i. Internal entities to the Consortium:

- Salzburg Research Forschungsgesellschaft m.b.H
- Shuttle provider (probably Easymile)
- Kapsch TrafficCom AG

ii. External entities to the Consortium:

- Municipality of Koppl
- Federal State of Salzburg
- Salzburg Transport Association

Business\ Exploitation Section

1. Specific travellers' cohorts addressed:

The two scenarios in Salzburg are aimed at the user groups of commuters and residents, day-trippers and tourists.

2. **Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable):** N/A

3. **Starting point/background & Innovation in SHOW:**

Salzburg Research has been conducting research projects/tests with automated electrified shuttles (OEM: Navya, EasyMile; SAE Level 3) since 2016. The main goals were the researching and testing of a reliable and safe operation of automated shuttles in public transport as part of an intermodal regional mobility system. Simulations and tests were performed, analysing in various driving scenarios the reliability, driving safety, technical infrastructure as well as communication with other road users and passengers

Valuable experiences were gained during those tests, which enables Salzburg Research to conduct the Pre-Demo tests as well as the real-life demonstrations scheduled for SHOW. Risk analyses, site assessments and mitigation measures are regularly performed.

4. **Training and other skills/knowledge requirements for key stakeholders involved:**

A “safety operator” training is the minimum requirement for anyone who wants to operate the autonomous shuttle. Within Salzburg Research there is a sufficient amount of people who have been successfully trained by EasyMile as safety operators. Within this training, the topics of “Product Basics”, “Vehicle handling”, “Vehicle operation” and “Emergency procedures” are covered. The safety operator is individually responsible, or in the interest of his employer, for carrying out the activities mentioned above in accordance with the rules laid down by “EasyMile” defined within the security rules and the instructions from the provided product documentation (user manual, operating instructions, software user manuals). The safety operator always pays attention to his personal safety and that of the passengers as well as the integrity of the vehicle.

In addition, one person at Salzburg Research is evaluated as chief operator, L1 setup designer and traffic supervisor. This enables him to perform tasks in the field of “advanced operation”, “diagnostics”, “deployment process”, “setup L1” and “traffic supervision.

5. **Incentives associated:**

Transportation service is currently free of charge. Experience has shown that non-monetary incentives, associated by the passengers with the use of the service, are important as well. Tests in a real environment lead to first experiences of the passenger with automated vehicles and are essential for the development of awareness and trust. Such test drives sensitize the passengers, demonstrate that trips with automated shuttle buses are already reality and that they can be carried out on public roads.

6. **Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):**

Applicable business models for the pilot site Salzburg are oriented towards "mixed mobility service models" (as outlined in D2.1 under 10.4.5) which cover a dedicated automated shuttle route, serving as first and last mile public transport supported by a C-ITS enabled bus corridor connecting the peri-urban area to the city centre."

3.2 Satellite Pilots

3.2.1 The Brainport Satellite site

In the pilot site of Brainport the following SHOW Use Cases are going to be covered: UC1.1; UC1.3 and UC1.8.

<u>Design Section</u>

The overview of the Brainport site (750,000 inhabitants) demonstration will take place in Eindhoven city (230,000 inhabitants). Eindhoven is the 5th largest city in the Netherlands, with a clear strategic interest in mobility innovations.

The city has been and it is further equipped with C-ITS infrastructure. The corridor used for the demonstration will depend on the maturity of the infrastructure on certain roads. The figure below shows with three colours the possible corridors that will be used (one specific corridor will be driven that contains the various use cases of in the Brainport site.).

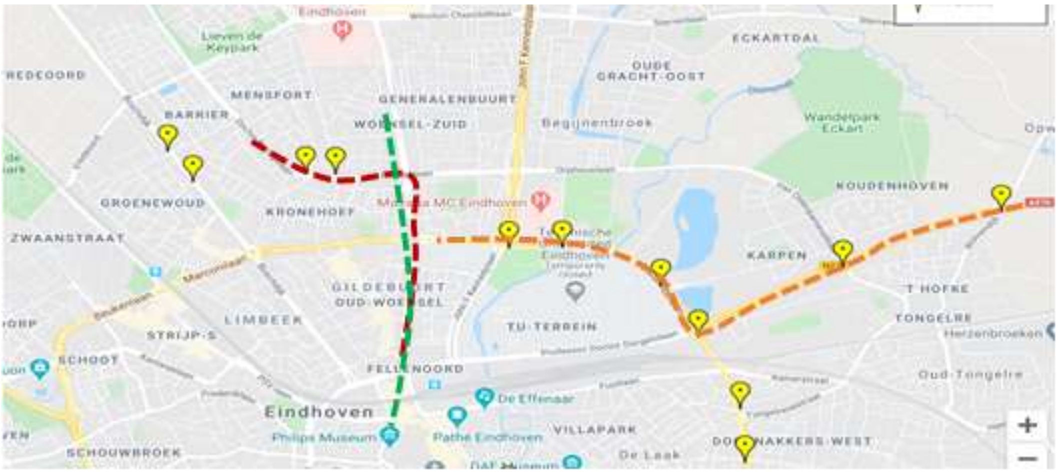


Figure 74: Brainport site possible corridors

1. **Site specific application of the Use Case:**

   i. **Site specific title of the Use Case:**

- For UC1.1: Intersection crossing at normal operational speed
- For UC1.3: Safety for VRU at intersections.
- For UC1.8: Vehicle relocation for automated mobility using platooning

   ii. **Leading entity**: TNO

2. **Ecosystem key stakeholders clusters involved:**
   - ✓ OEM's and transport/mobility operators
   - ✓ Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers

   (through associate partnerships only)

3. **Operational speed:**

The vehicles will drive on bus lanes in typical peri-urban or urban conditions, (e.g. up to 50 km/h), that will be used to demonstrate the technologies developed in connection to this site.

4. **Traffic context**:

- **For UC1.1:**

This site will focus on peri-urban and urban scenarios including: straight roads and curved roads as dedicated bus lanes (see example of Eindhoven bus lane below), intersections with traffic lights, crossing traffic at intersections, mixed traffic of passenger cars for automated mobility and busses. The bus lanes intersect normal traffic lanes, cyclists and pedestrian crossings.

Figure 75: Eindhoven bus lane

- **For UC1.3**

Urban scenario – crossing with C-ITS intersections that provide a variety of day-1 services such a GLOSA, Green Priority, Emergency Vehicle Waring, Red-light violation warning, etc. The crossing traffic that is considered concerns motor vehicles and cyclists, which the challenge that not traffic participants obey the traffic rules.

- **For UC1.8**

Urban scenario – platooning on dedicated bus lanes for relocation of vehicles, dual lanes to consider evasive strategies.

5. **Frequency and timeline of operation:** Under definition.

6. **Restrictions & dependencies:**

- **For UC1.1:** Only normal weather conditions are assumed.
- **For UC1.3:** Only possible on dedicated bus lanes with typically low traffic density.
- **For UC1.8:** This scenario cannot be performed in heavy traffic.

7. **Key risks identified:**

To use the bus lanes requires co-ordination with the Bus operators and City of Eindhoven which is necessary in order to not disrupt the bus schedules. The road exemption conditions for approval need to be respected, which may imply closure of the road for other traffic during certain test events.

8. **Security concerns:** None specific.

Development\ Implementation Section

1. Storyboard for the site specific use case:

➢ **For UC1.1**

Actors: Driver, Passenger, C-ITS (for traffic light information)

Scenario 1:

- The automated vehicle will start at point A (e.g. a bus stop and pick up a passenger) that needs to reach a destination in a point B.
- The vehicle will handle preceding traffic, will pass through intersections and for that it will be capable of handling information that comes from traffic light
- The vehicle will stop at point B to drop off the passenger (e.g. another bus stop).

Figure 76: Driving with preceding traffic

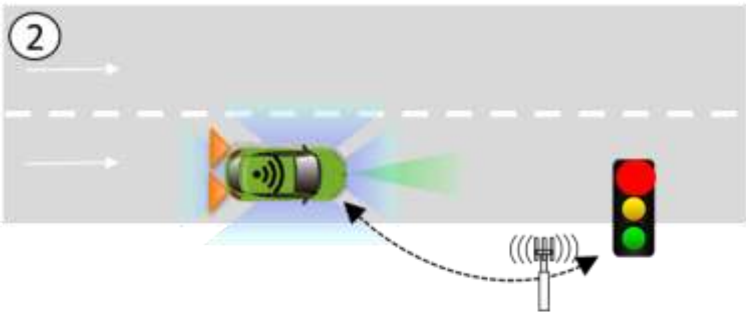


Figure 77: Automatic braking based on time to red information from traffic light

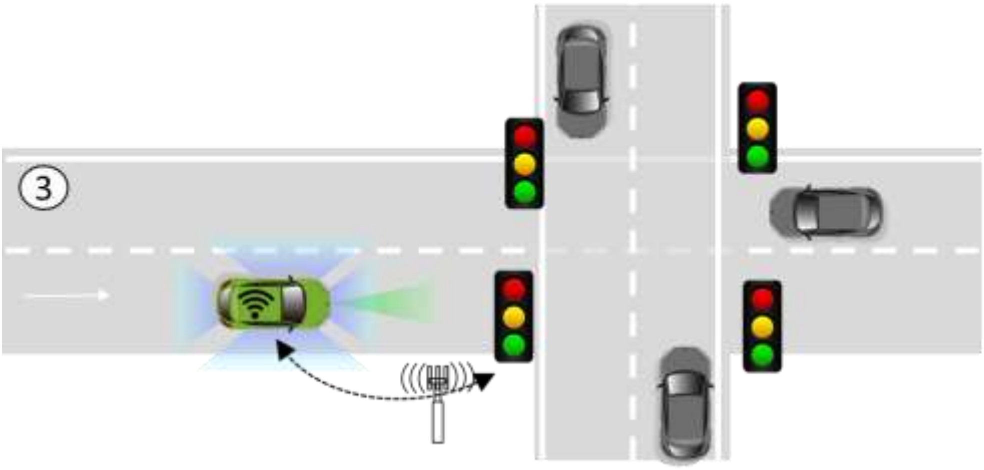


Figure 78: Automatic manoeuvre at intersections

➢ **For UC1.3:**

Actors: Driver, Passenger, C-ITS (for traffic light information), VRUs.

Scenario 1:

- The vehicle will start at point A which will be a bus stop and pick up a passenger.
- The vehicle will handle preceding traffic and will pass through intersections. At intersections it will handle interactions with VRUs.
- The vehicle will stop at point B to drop off the passenger which will be another bus stop.

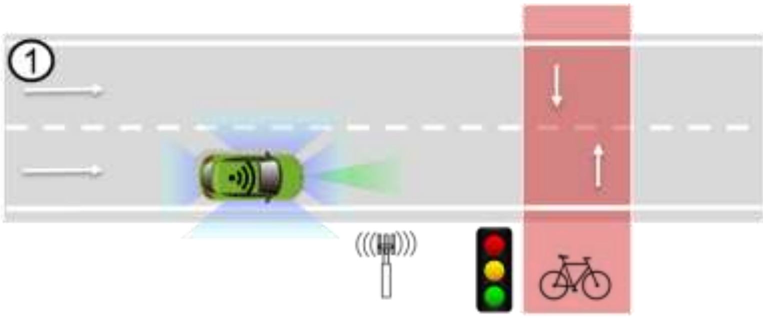


Figure 79: Handling of VRU at controlled traffic light

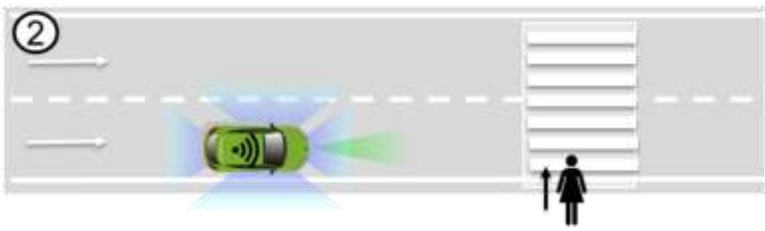


Figure 80: Handling of VRU at uncontrolled intersections/roads

Scenario 2:

- The automated vehicle will start at point A (e.g. a bus stop and pick up a passenger) that needs to reach a destination in a point B.
- The vehicle will handle preceding traffic and will pass through intersections. In case The VRU violates the traffic light at intersections, the vehicle will be capable to react to that.
- The vehicle will stop at point B to drop off the passenger (e.g. another bus stop).

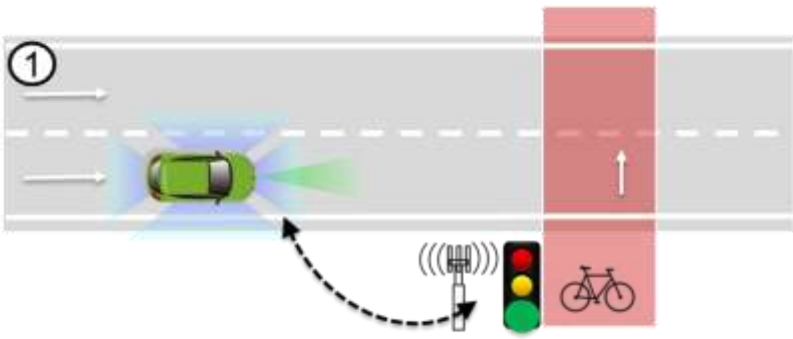


Figure 81: Reacting to green traffic light

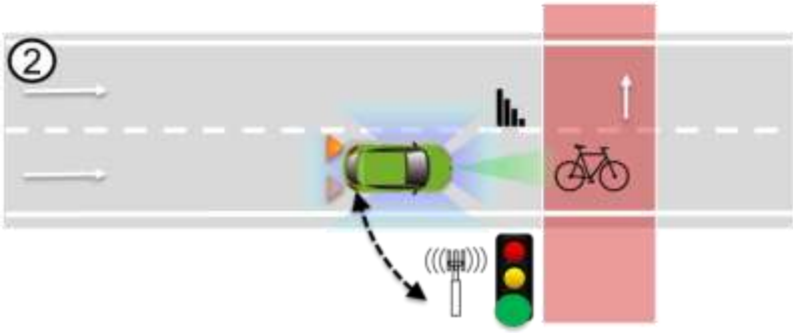


Figure 82: Braking in case of VRU traffic light violation

- **For UC1.8**

Actors: Driver, C-ITS (for traffic light information).

Scenario 1:

- At a bus stop or predefined point, empty automated vehicles will form a platoon. The leader of the platoon can be a non-automated vehicle driven manually by a driver.
- The platoon of vehicles will drive to a predefined destination to be parked at the end of service time.

Scenario 2:

- At a bus stop or while driving, the vehicle will detect another communicating/ automated vehicle on the same lane. After destination check, ask to form a platoon.
- The platoon of vehicles will drive from point A to point B.
- At point B the platoon will disassemble.

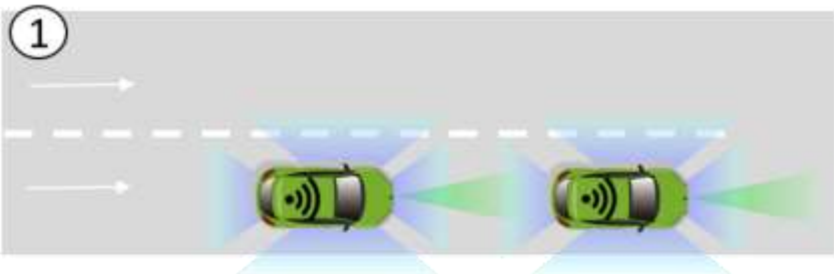


Figure 83: Two automated vehicles driving in the same lane

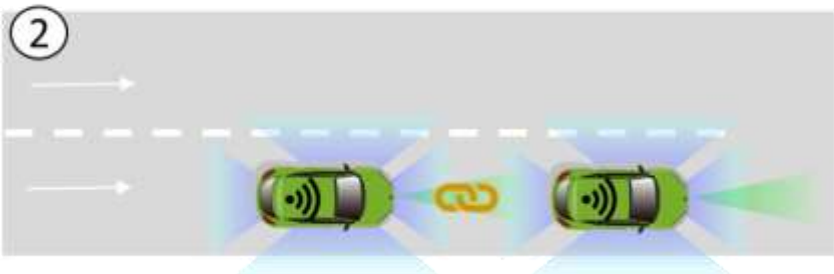


Figure 84: The vehicles drive as a platoon

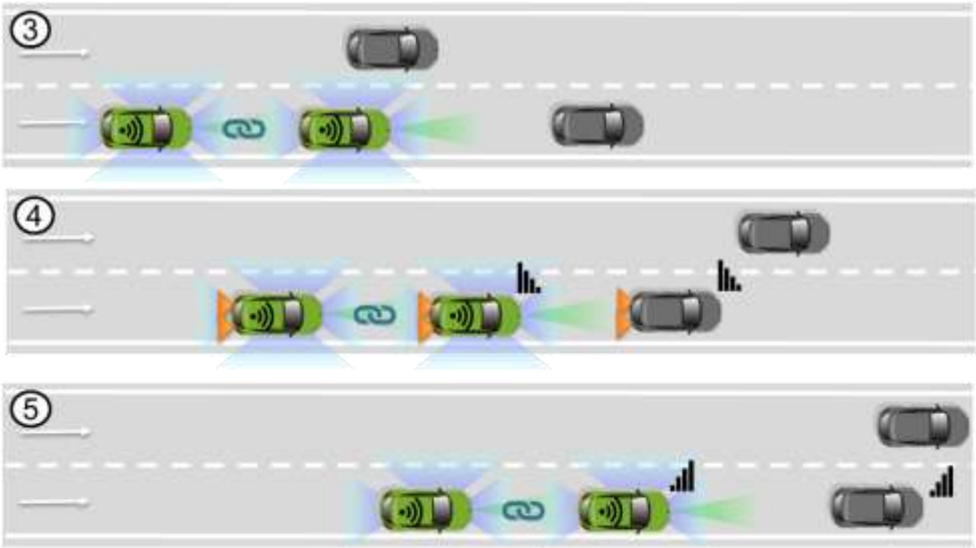


Figure 85: Platoon handling preceding traffic

2. **Demonstrators:**

Minimum two TNO car labs vehicles, Bus* driving with L3+ functions and safety drivers that can pick up control at the ODD limit (Operational design domain). The TNO car labs vehicles are Renault Clio platforms.

3. **Vehicle types included:**

Passenger vehicles and Bus

4. **Involved vehicle brands**: TNO car labs (for UC1.1)

5. **Involved fleet operators:** N/A

6. **Physical Infrastructure required:**
   - L5 technology enhanced by hybrid ITS G5/cellular C-ITS services, full 4G coverage, early 5G deployment and IoT service networks (for UC1.1).
   - There will be no link to the local TMC.
   - C-ITS (G5), IoT, L5 technology and 4G coverage will be integrated.

7. **Relevant WP(s)/Activity(ies) of GA:** WP4, WP7, WP 9, WP 10, WP 13

8. **Entities involved in implementation:**
   i. **Internal entities to the Consortium:** TNO

   ii. **External entities to the Consortium:** None

9. **Entities involved in testing & demonstration:**
   i. **Internal entities to the Consortium:** TNO

   ii. **External entities to the Consortium:** None

Business\ Exploitation Section

1. **Specific travellers' cohorts addressed**:
    - **For UCs1.1 & 1.3**: Travellers (e.g. students, pensioners, commuters).
    - **For UC1.8**: Drivers

2. **Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable):** N/A

3. **Starting point/background & Innovation in SHOW:**

In previous projects that had demonstrations in the Brainport region, parts of these technologies have been already shown for a limited set of use cases. For example crossing intersections with time to green and time to red communicated from the infrastructure through Vehicle-to-Infrastructure (V2I and I2V) technologies. The ambition in the SHOW pilot is to demonstrate the potential of using predicted information either from within the car or from infrastructure and enable proactive and safe decision making. Specifically, we will focus on scaling decision making, tactical algorithms for more use cases and understand the benefits that predicted data (e.g. motion of other road users, red light violation notification of VRUs via I2V) can bring in terms of safety and comfort.

4. **Training and other skills/knowledge requirements for key stakeholders involved:** None

5. **Incentives associated:** None

6. **Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):**

The developments mainly concerns technology for intersection crossing and platooning. This technology can be applied for mobility concepts that operate environments involving intersections with other traffic. In that sense it cannot be related to an individual business or operating model for public transport. Platooning is also a general technology that can be applied for different modes of public transport. In the current context it is demonstrated for relocation of shared automated vehicles. Shared vehicle are mentioned for Rouen so it can be related to its business and operating models.

3.2.2 The Brno Satellite site

The Brno satellite site is located in the city of Brno, which is the centre of many universities and progressive technological companies. The single most important use case is **UC1.7 Connection to Operation Centre for tele-operation and remote supervision** with site specific application **Traffic centre controlled remote automated driving over long distance (up to 200 km)**. Besides that, additional use cases will be implemented and tested, namely UC1.1, UC1.2, UC1.3 and UC1.6.

Design Section

1. **Site specific application of the Use Case:**
    i. **Site specific title of the Use Case:**

    - **For Use Case 1.1:** Normal speed robotaxi service serving residential area.

- **For Use Case 1.2:** Lower speed shuttle service.
- **For Use Case 1.3:** Lower speed shuttle service, interfacing VRUs.
- **For Use Case 1.6:** Lower speed shuttle service serving students, commuters, tourists, operating at mixed lanes.
- **For Use Case 1.7:** Traffic centre controlled remote automated driving over long distance (up to 200 km).

ii. **Leading entity:** CDV

2. **Ecosystem key stakeholders clusters involved:**

✓ Tier 1 suppliers, telecom operators, technology providers, SME's
✓ Research & academia
✓ Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers

3. **Operational speed:**

- **For Use Cases 1.1 & 1.7:** Up to 40 km/h
- **For Use Case 1.2, 1.3 & 1.6:** Up to 22 km/h

4. **Traffic context:**

- **For Use Case 1.1**: Urban area, less traffic.
- **For Use Case 1.2:** Urban area, mixed lanes shared with buses, cars, bikes, motorbikes, and mopeds, also crossroads and jaywalking pedestrians
- **For Use Cases 1.3, 1.6 & 1.7:** Urban area, mixed lanes shared with other road users, including VRUs.

5. **Frequency and timeline of operation:** At least 4 days a week

6. **Restrictions & dependencies:**

For Use Case 1.7: Dependent on mobile carrier signals and wireless networks.

7. **Key risks identified:**

- **For Use Case 1.1:** User acceptance, speeds, other road users' behaviour, a lot of parking around roads.
- **For Use Case 1.2:** User acceptance, speeds, other road users' behaviour, a reckless drivers.
- **For Use Case 1.3:** Erratic behaviour of VRUs around AVs.
- **For Use Case 1.6: O**ther road users' behaviour, rush hours, reckless drivers.
- **For Use Case 1.7:** User acceptance, technical risks.

8. **Security concerns:**

- Cybersecurity (for UC1.7)
- Security concerns in relation to teleoperation:
  - Authentication of a remote control center for access to the vehicle.
  - Remote operator authentication.
  - Authorization of remote control operator to drive vehicle.
  - Ensuring the authenticity of control messages (electronic signing).
  - Video transmission encryption.
  - Control commands encryption.
  - Vehicle identity control.
  - Availability of a central service node (DDOS protection).
  - Protection of individual black box records from vehicles

Development\ Implementation Section

1. **Storyboard for the site specific use case(s)**:

- **Transport service in the city center**:

The goal is to demonstrate the possibility of autonomous transport in the historic part of the city, which is inaccessible to ordinary urban transport. An electric shuttle will be used for this task.

- **DRT and services for seniors**:

The goal is to demonstrate a DRT model where a site with a home for the elderly will be served on the basis of a scheduled order.
An electric shuttle and a Robotaxi will be used for this task.

- **Transportation of goods in the city:**

The goal is to demonstrate the transport of goods in the city based on an order. The current pandemic has shown a critical interest in the use of logistics services. The robotic logistics truck will be used to implement this scenario. Delivery of food, shopping, and other small packages is possible.

2. **Demonstrators:**

- UC1.1, 1.7: RoboTaxi (Hyundai i40)
- UC1.2, 1.3, 1.6, 1.7: RoboShuttle (EasyMile EZ10)
- UC1.2, 1.7: RoboCargo (Robotics Delivery Platform) (dependent upon the amendment approval).

3. **Vehicle types included:**

- Robotaxi (Hyundai i40) – UC1.1, 1.7
- RoboShuttle (EasyMile EZ10) – UC1.2, 1.3, 1.6, 1.7
- RoboCargo (Robotics Delivery Platform) – UC1.2, 1.7 (dependent upon the amendment approval).

4. **Involved vehicle brands**:

- Hyundai i40 (UC1.1, 1.7)
- EasyMile EZ10 (UC1.2, 1.3, 1.6, 1.7)
- Robotics Delivery Platform (UC1.2, 1.7) (dependent upon the amendment approval).

5. **Involved fleet operators:** ARTIN (for all UCs)

6. **Physical Infrastructure required:**

Not required and not necessary, but might be useful: machine readable signs (for instance QR codes) in places difficult to navigate for autonomous vehicles (all UCs).

The teleoperated vehicles will be interfaced to the TMC.

LTE (4G) connectivity will be used.

7. **Relevant WP(s)/Activity(ies) of GA:**

WP1, WP2, WP3, WP4, WP6, WP7, WP8, WP9, WP11, WP12, WP15, WP16

8. **Entities involved in implementation:**

i. **Internal entities to the Consortium:** CDV and ARTIN

ii. **External entities to the Consortium:** City of Brno

9. **Entities involved in testing & demonstration:**

   i. **Internal entities to the Consortium:** CDV and ARTIN

   ii. **External entities to the Consortium:** City of Brno

Business\ Exploitation Section

1. **Specific travellers' cohorts addressed:**
   - Students (all UCs)
   - Commuters (all UCs)
   - Tourists (all UCs)
   - Elderly (UCs 1.1, 1.2, 1.3, 1.7)
   - People with disabilities (UCs 1.1, 1.2)

2. **Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable):** N/A

3. **Starting point/background & Innovation in SHOW:**

Up to today there has been no service of autonomous vehicles in the Czech Republic. This service constitutes the very first very first operation of autonomous vehicles in the country. SHOW allows the general public to get own personal experience with autonomous mobility. Second, it supports and motivates the industry to actively participate in this new sphere of mobility. Thirdly, it creates the environment for further implementations of autonomous vehicles and associated mobility solutions (all UCs).

4. **Training and other skills/knowledge requirements for key stakeholders involved:**

The training will be provided to tele-operators to meet safety standards (UC1.7).

5. **Incentives associated:** Not planned

6. **Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):**

Possibility of operating shuttle service after the project ends as a normal service under the tariffs usually used by public transport authority for regular services and operations (UC1.2, 1.3, 1.6).

3.2.3 The Copenhagen Satellite site

Design Section

1. **Site specific application of the Use Case:**

   i. **Site specific title of the Use Case:**
   - **For Use Case 1.1**: “Feeder service to Multi Modal PT Hub”
   - **For Use Case 1.2**: “Driving in heavy traffic and intersections”

- **For Use Case 1.3**: “Presence of vulnerable road users in intersections” / “Presence of vulnerable road users in AVs driving SAE4 without a safety driver on board”
- **For Use Case 1.4**: “Operator neutral intelligent planning”
- **For Use Case 1.5:** “Integration to local TMC”
- **For Use Case 1.6:** “Operation in mixed traffic on smaller private roads & large public roads”
- **For Use Case 1.7:** “AV Supervision center”
- **For Use Case 3.1**: “Shift between route and DRT mode”
- **For Use Case 3.2:** “Real time planning and information to passengers”
- **For Use Case 3.4:** “Automated service at bus stop”

ii. **Leading entity:** Movia Public Transport Authority

2. **Ecosystem key stakeholders clusters involved:**
   - ✓ OEM’s and transport/mobility operators
   - ✓ Research & academia
   - ✓ Passengers and other road users encompassing VEC
   - ✓ Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers
   - ✓ Other (please define): International businesses, Technical University and other education located at the area.

3. **Operational speed: Up to** 40 km/h for normal operation; up to 60 km/h tested.

4. **Traffic context:**

The test site, the Lautrup bussinnes area is a peri-urban environment located 15 km Northwest of Copenhagen in the municipality of Ballerup, Denmark. Lautrup is often mentioned as the Danish Silicon Valley due to its concentration of ambitious TECH businesses and skilled IT/knowledge specialists in combination with the Technical University of Denmark (DTU) and a local high school with strong technology profile (3500 students in total).

The area, where the Copenhagen Commute AV’s are planned to be deployed, is located along a 2 km main road crossing through the business district. The AV’s will be deployed in mixed traffic/mixed lanes, and will be driving on two types of roads: Smaller private roads (speed limits app. 20-30 km/h) and larger public roads that currently have speed regulation from 50-70 km/h. The area has several intersections. The plan is to implement a BRT infrastructure during the project, which will then change the environment to dedicated lanes.

The Lautrup area has heavy morning rush hour from 7AM to 9AM and a more spread out afternoon rush from 2PM to 6PM. During the rest of the day, the traffic carrying people in and out of the area is primarily limited to students coming to and from school, people doing grocery shopping and visitors to the companies in the area. Person transportation in general is primarily taking place from 6AM to 6PM, meaning very limited traffic during the rest of the evening and night.

The area is currently served by both buses and S-trains. Bus Lines in the area are named 40E, 55E, 350S and S-train lines are named H and C. It is also possible to take bus lines 440S and 164 to stops very close to the test site.

5. **Frequency and timeline of operation**: AV services will be available all workdays primarily within regular business hours from 07.00 to 20:00. Evening service will potential be tested.

6. **Restrictions & dependencies:**
    - The operation is naturally depending on obtaining a vehicle approval of the AV's used on the site, as well as an overall approval of the project coming from the Danish Authorities as well as a third party assessor.
    - The specific restrictions and dependencies in regards to the AV's (and e.g. their connection to integration platforms, bus stops, intersections) cannot be defined at this point, since it is not yet decided which vehicles will be deployed. This is decided in a public tender, which will be concluded in March 2021.

7. **Key risks identified:**
    - The specific risks are very much depending on which AV will be deployed on the site. This is decided in a public tender, which will be concluded in March 2021. Hence, it is hard to answer the operational, technical as well as regulatory risks we will encounter at this point of time.
    - There is a risk of not reaching the anticipated amount of passengers riding on the buses, due to COVID 19 restrictions, since more space is required among the passengers.

8. **Security concerns:** None

Development\ Implementation Section

1. **Storyboard for the site specific use case**:

- ***UC1.1: "Feeder service to Multi Modal PT Hub"***

The small and medium-sized AVs will operate as integral part of the existing PT bus service – creating a stronger connecting between the multimodal PT hub "Malmparken" and the companies and schools in the area.

- ***UC1.2: "Driving in heavy traffic and intersections"***

The Lautrup area has heavy morning rush hour from 7AM to 9AM and a more spread out afternoon rush from 2PM to 6PM. Cars, bicycles, trucks and buses are all part of the daily traffic scenario.

- ***UC1.3: "Presence of vulnerable road users in intersections" / "Presence* of vulnerable road users in AVs driving SAE4 without a safety driver on *board"***

Vulnerable road users are expected as part of the daily operation on the site. Both outside and inside the AVs.

- ***UC1.4: "Operator neutral intelligent planning"***

The operator-neutral intelligent planning and dispatching of vehicles will optimize energy and take into account the optimal charging pattern.

- **UC1.5*: "Integration to local TMC"***

All AVs will be part of the local TMC.

- **UC1.6*: "Operation in mixed t*raffic on smaller private roads & large public *roads"***

Cars, bicycles, trucks and buses are all part of the daily traffic scenario.

- **UC1.7*: "AV Supervision center"***

Depending on AVs chosen in public tender, the aim is to have an AV Supervision center, from where operation can be monitored.

- ***UC3.1: "Shift between route and DRT mode"***

The AVs will shift between route and DRT mode, according to time of day and demand.

- **UC3.2*: "Real time planning and information to passengers"***

The objective is to demonstrate the intelligent, real-time planning and dispatching of the AVs combined with real time information to passengers.

- **UC3.4*: "Automated service at bus stop"***

Adjust all bus stops to accommodate AVs. Further bus stops will be added to the network.

2. Demonstrators:

The specific vehicles will be determined through a public tender that will be complete by March 2021.

The following is envisioned: 3 bus shuttles DL4, 2 medium sized busses DL 4

3. Vehicle types included:

The specific vehicle type in operation will be determined be public tender, finalised by March 2021.

The foreseen vehicle types are:
- 3 AV mini buses (shuttles)
- 2 AV mid-size buses

4. Involved vehicle brands: Specific vehicle brands pending public tender.

5. Involved fleet operators: Fleet operator will be selected based on public tender to be completed by March 2021.

6. Physical Infrastructure required:

There will be an interface to the local TMC, while teleoperation and digital infrastructure depend on the AVs and operator. This will be decided when the public tender is closed in March 2021.

7. Relevant WP(s)/Activity(ies) of GA: WP2, WP3, WP5, WP6

8. Entities involved in implementation:

i. Internal entities to the Consortium:

- Ballerup Kommune
- DTU, Danmarks Tekniske Universitet

ii. External entities to the Consortium:

- Danish Authorities responsible for handling the vehicle and project approval:
  - Danish Ministry of Transport
  - Danish Road Directorate
  - Danish Road Traffic Authority

    - Danish Police
    - Director of Public Prosecutions
- Assessor: A third party, required by Danish law, which approves overall project safety.
- Local business Network

9. Entities involved in testing & demonstration:

i. Internal entities to the Consortium:

- Ballerup Kommune

ii. External entities to the Consortium:

- Assessor: A third party, required by Danish law, which approves overall project safety.
- Local business Network

Business\ Exploitation Section

1. Specific travellers' cohorts addressed:

The main focus group is commuters, both for jobs (app 20.000) and education/academia (app 3.500). However, the demo site will have also elderly, young adults and persons with reduced mobility.

2. Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable): N/A

3. Starting point/background & Innovation in SHOW:

Copenhagen Commute is built on ongoing test of autonomous buses around Copenhagen. Two test are conducted by external partners, and 1 by Movia.
Movia tested in 2018 one Navya Arma bus (level 3) in both scheduled and DRT operation. In 2021 Movia conduct test of two Navya Arma busses in open traffic at a hospital site. The busses will operate in both scheduled and DRT operation on a 4 km route.

Innovation points at Copenhagen Commute test site is:
- Full integration with existing Public Transport, both train and busses.
- Local operator-neutral operation site (pending public tender)
- Test of AVs on 60 km/h roads in mixed traffic
- Test of AVs operating at BRT lanes with ordinary PT

4. Training and other skills/knowledge requirements for key stakeholders involved: None

5. Incentives associated:

AV's will be operating free of charge for passengers during the full test period. Special information/incentive packages will be employed in cooperation with businesses in the area.

6. Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):

To be defined

3.2.4 The Tampere Satellite site

In the pilot site of Turin the following SHOW Use Cases are going to be covered: UC1.1; UC1.2; UC1.4; UC1.7; UC3.1.

Design Section

1. **Site specific application of the Use Case:**
   i. **Site specific title of the Use Case:**
      - **For Use Case 1.1**: Hervanta smooth
      - **For Use Case 1.3**: Hervanta complex
      - **For Use Case 1.4**: Hervanta sustainable
      - **For Use Case 1.7**: Hervanta remote
      - **For Use Case 3.1**: Hervanta DRT

   ii. **Leading entity:** Sitowise (Pekka Eloranta)

2. **Ecosystem key stakeholders clusters involved:**
   - ✓ OEM's and transport/mobility operators .
   - ✓ Tier 1 suppliers, telecom operators, technology providers, SME's.
   - ✓ Research & academia.
   - ✓ Passengers and other road users encompassing VEC
   - ✓ Umbrella associations
   - ✓ Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers.

3. **Operational speed:** Up to 40 km/h

4. **Traffic context:**

- **For UCs1.1 & 1.2:**

Those will be performed in the residential area in Hervanta suburb in southern Tampere (the route is normally easy and smooth, but during winter challenging and includes also driving on the tram line corridor). Thus the Hervanta site constitutes a rather easy environment. No dedicated lanes, pre-defined route, two roundabouts, no need for self-change of lane, mostly no heavy traffic, however extreme weather conditions do exist (e.g, snowflakes or heavy rain). Passenger mobility. Feeder service to tramline.

- **For UC1.4**

Electric autonomous vehicles will be used and thus related solutions are needed and will be piloted. Charging stations are used making the service sustainable. Modes addressed: feeder transport to tram, in a seamless way, readiness for DRT exists. The Hervanta site constitutes generally an easy environment (except peak hours and extreme weather conditions, see UCs 1.1 and 1.2).

- **For UC1.7**

Remote supervision and teleoperation of AV (or fleets) by a control centre will be included in the Hervanta pilot. The Hervanta site constitutes generally an easy environment (except peak hours and extreme weather conditions, see Use Cases 1.1 and 1.2).

- **For UC3.1**

DRT operations are planned to be deployed. Readiness to run DRT does exist, vehicles can use route deviations and the planning system with needed algorithms are available. DRT will include planning, routing, operation self-learning services for passenger transport. DRT services constitute an essential part of the special user services in the City of Tampere already today and will be part of autonomous feeder transport in Tampere.

5. **Frequency and timeline of operation:** During pilot the frequency is every day (at least weekdays).

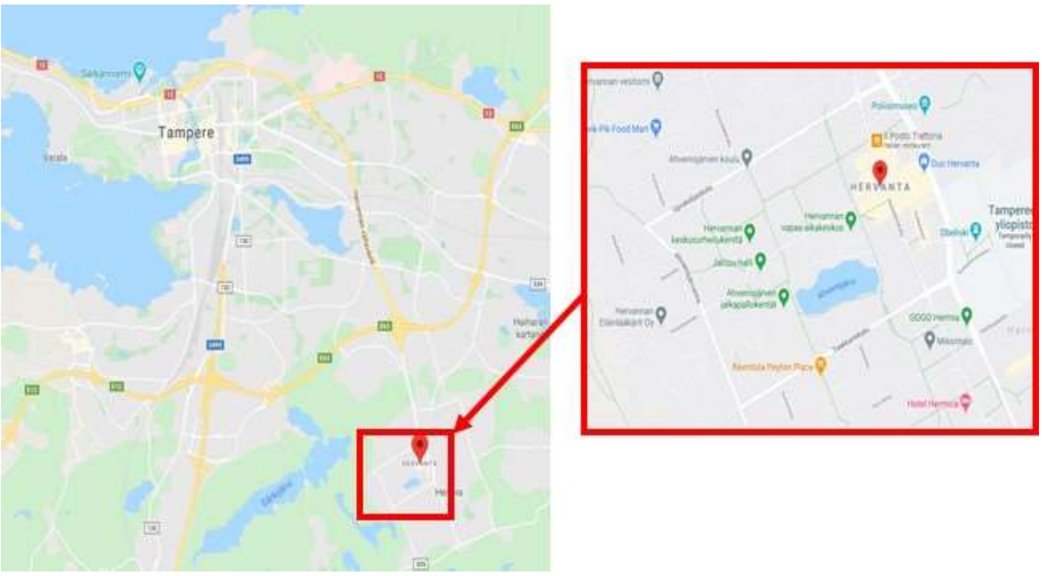


Figure 86: Hervanta suburb residential area in southern Tampere

6. **Restrictions & dependencies:**

Proven/tested vehicles and technologies. Traffic lights do exist. No environmental restrictions (running in all conditions). Very low temperatures, rain, snow, ice, etc. in wintertime.

7. **Key risks identified:**

COVID-19 situation may cause challenges for funding and time schedule. Cybersecurity risks will be acknowledged and taken into account. There are plans to implement the DRT services in Tampere. However, because of COVID 19 situation and funding challenges, the DRT services may be added later, and it is possible that they will not be piloted during the SHOW-project. However they in the future DRT will be part of the integrated PT services in Tampere and also in Hervanta.

8. **Security concerns:**

Passenger safety and cybersecurity risks have been acknowledged.

Development\ Implementation Section

1. **Storyboard for the site specific use case(s)**:

In Tampere, Hervanta suburb shuttle buses to be provided and operated by Sensible 4. There will be some 2-3 vehicles in the pilot.

- Studies of the existing and needed changes and improvements to be carried out in 2020 following the SUMP (Sustainable Urban Mobility Planning).
- In the autumn 2020 the City of Tampere has made a decision to further develop the Hervanta suburb as a testbed for automated transport. This decision will underline the importance of the SHOW-piloting in Hervanta. The testbed aims to develop and offer digital and physical infrastructures needed to run and operate level 4 autonomous vehicles, both cars and buses in Hervanta during and after the SHOW project activities.
- 5G and 4G/LTE are available in Hervanta. The same goes with ITS-G5 which will be available, if needed
- The negotiations will take place between the City of Tampere and Sensible 4. This phase has been almost done and will be ready before the end of 2020.
- Preliminary changes and improvements to digital and physical infra have been planned and the needed improvements will be carried out by autumn 2021.
- Sensible 4 has checked and approved the route and is now preparing the vehicles, technical devices and software so that the vehicle will be ready before the autumn 2021, perhaps already earlier. This will include building a link to the remote control centre that will be provided by Sensible 4.
- Link to the City TMC has been discussed and will be initiated.

2. **Demonstrators:**

All the above mentioned use cases will be piloted in Tampere/Hervanta suburb. SAE Level 4 vehicles will be provided by Sensible 4 in all the Tampere/Hervanta Use Cases.

3. **Vehicle types included:** Shuttle buses

4. **Involved vehicle brands:** Sensible 4 buses (brand will be named soon).

5. **Involved fleet operators:** Sensible 4

6. **Physical Infrastructure required:**

The route has been defined and will be physically and digitally upgraded if/when needed. 5G and 4G/LTE are available in Hervanta. The same goes with ITS-G5 which will be available, if needed. Traffic lights for the tram have been added to the infra. As mentioned there has been a major decision by the City that Hervanta will the also in the future the test environment for autonomous driving tests (Smart City Testbed – Towards Level 4 Automatic Traffic). City of Tampere aims to be among the leading cities in terms of technical development. Key focus areas are smart traffic solutions and autonomous driving. The City is aware that Level 4 autonomous driving sets new requirements both for physical and digital infrastructure. Therefore Level 4 capable testbed helps to understand these requirements and is essential for autonomous driving development. In order to meet the ambitious targets by the City of Tampere it is essential to implement Level 4 capable test area as soon as possible. There are not many Level 4 test areas that are located among normal city infrastructure. Therefore Level 4 testbed in Hervanta will have significant international novelty value. Level 4 test area will increase the international interest in Tampere area and will improve the competitiveness of the area as a whole in the areas of smart traffic and autonomous vehicles. Level 4 test area will improve Tampere position as a partner in international co-operation partner towards international companies.

7. **Relevant WP(s)/Activity(ies) of GA:** WP1, WP2, WP4, WP5, WP6, WP8, WP9

8. **Entities involved in implementation:**
   i. **Internal entities to the Consortium:**
      - Sensible 4
      - VTT
      - City of Tampere
      - Sitowise

   ii. **External entities to the Consortium:**
      - Vinka
      - Cinia
      - Roboride.

9. **Entities involved in testing & demonstration:**
   i. **Internal entities to the Consortium:**
      - Sensible 4
      - VTT
      - City of Tampere
      - Sitowise

   ii. **External entities to the Consortium:**
      - Vinka
      - Cinia
      - Roboride

Business\ Exploitation Section

1. **Specific travellers' cohorts addressed:**

All passenger groups that need first/last-mile services, including users with special needs.

2. **Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable):** N/A

3. **Starting point/background & Innovation in SHOW:**

In Hervanta autonomous buses (EasyMile). The autonomous integrated feeder transport service is a strategic goal for Tampere and here Hervanta pilot is essential. Automation level 4 is targeted.

4. **Training and other skills/knowledge requirements for key stakeholders involved:**

The most important issue will be informing the users and marketing the service.

5. **Incentives associated:**

Integrated public transport and integrated payment are targeted to attract the users. The feeder services will be included in the ticket/fare and thus there will be no additional fees for the users of the feeder service. Publicity campaigns and marketing will be carried out inform the users of the new service. This will cover conventional media, social media and also direct marketing.

6. **Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):**

The objective is to continue after piloting the services so that they will be part of the integrated public transport service. The City of Tampere will expand the feeder service to the tram and also elsewhere. There will be competitive bidding processes, in which the City will choose and make contracts with either service operators or OEM's directly. The objective is to improve and integrate the mobility system with autonomous feeder buses and shared services as MaaS. Autonomous transport is among the strategic objectives of the City of Tampere.

3.2.5 The Trikala Satellite site

In the pilot site of Trikala the following SHOW Use Cases are going to be covered: UC1.1; UC1.2; UC1.3; UC1.5; UC1.6; UC1.7; UC1.8; UC1.10.

Design Section

1. **Site specific application of the Use Case:**

   i. **Site specific title of the Use Case:**

- **For Use Case 1.1a**: Autonomous shuttles operation in real urban mixed-traffic environment connecting City Centre with central Intercity Bus Station.
- **For Use Case 1.1b**: Autonomous cargo vehicle operation in real urban pedestrian city-centre environment.
- **For Use Case 1.2a**: Autonomous shuttles operation in real urban mixed and complex traffic environments involving intersections and roundabout connecting City Centre with central Intercity Bus Station.
- **For Use Case 1.2b**: Autonomous cargo vehicle operation and parking in real urban pedestrian city-centre environment.
- **For Use Case 1.3a**: Autonomous shuttles operation in real urban mixed and complex traffic environments involving pedestrian crossings and VRUs connecting City Centre with central Intercity Bus Station.
- **For Use Case 1.3b**: Autonomous cargo vehicle operation, smooth braking and immobilisation in real urban pedestrian city-centre environment.
- **For Use Case 1.5:** Integration of the remote control centre of UC1.7 in a TMC nucleus for the city.
- **For Use Case 1.6**: This is combined with 1.2., as part of the routes will be performed in mixed lanes, with other vehicles.
- **For Use Case 1.7**: Autonomous shuttles and cargo vehicle remote monitoring and emergency braking for immobilization mechanism via the connection with the remote control center.
- **For Use Case 1.8**: Platooning of two passenger cars.
- **For Use Case 1.10**: Autonomous shuttles fixed route and DRT operation in real urban mixed traffic environment connecting City Centre with central Intercity Bus Station. Use of 2 autonomous cars for last mile operation, using local Maas Service.

   ii. **Leading entity:**

For all the use cases ICCS is the pilot leader in the city of Trikala, while e-Trikala is locally organising the pilot. CERTH is responsible for the TMC infrastructure integration as well as for the 2 passengers' cars (BMWi3 robo-taxis) autonomous operation and integration with the shuttles operation and MaaS service.

2. Ecosystem key stakeholders clusters involved:

- ✓ OEM's and transport/mobility operators .
- ✓ Tier 1 suppliers, telecom operators, technology providers, SME's.
- ✓ Research & academia.
- ✓ Passengers and other road users encompassing VEC.
- ✓ Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers.
- ✓ Insurance companies.

3. Operational speed:

- For Use Cases 1.1a, 1.2a, 1.3a, 1.6, 1.7 and 1.10 the operational speed for the two urban buses is 25 km/h.
- For Use Cases 1.1b, 1.2b. 1.3b, 1.7 and the freight vehicle is 15 km/h.
- In addition, for Use Cases 1.8 and 1.10 operational speed and the robot-taxis is 40 km/h within the city and 50 km/h under platooning.

4. Traffic context:

For Use Cases 1.1a, 1.2a, 1.3a, 1.6, 1.7, 1.8 and 1.10, the real-life scenario is urban. There is no dedicated lane. The traffic is mixed with a heavy density in specific hours per day.

Figure 87: Trikala pilot site

For Use Cases 1.1b, 1.2b. 1.3b, 1.7, the envisaged scenario is not clearly defined yet. However, the length of the route is about 1-3m. There is no traffic density as it is a pedestrian road. Possibility of a dedicated lane is considered.

5. Frequency and timeline of operation:

The 2 urban buses (UCs: 1.1a, 1.2a, 1.3a, 1.6, 1.7 and 1.10a) are estimated to operate approximately on a daily basis from early morning to afternoon, while it is to be decided for the freight vehicle (1.1b, 1.2b. 1.3b, 1.7) and the robot taxis (1.8 and part of 1.10) according to the customer requirements for last mile transport and beyond.

6. Restrictions & dependencies:

- The 2 urban buses (UCs: 1.1a, 1.2a, 1.3a, 1.6, 1.7 and 1.10a) cannot perform under extreme weather conditions.
- For the freight vehicle (UCs: 1.1b, 1.2b. 1.3b, 1.7), there is the possibility to have some restrictions for its operation from the Municipality related with operational aspects as the use cases are performed in a pedestrian road.
- For the passengers cars (1.8 and 1.10), a bordering limitation of travel and distance will be specified. Also their operation in adverse weather will have to be assessed when the prototypes are ready.

7. Key risks identified:

- Legal permits: currently there is no existing legal basis for the freight vehicle autonomous operation in real traffic environment in Greece. One of the main goals of Trikala Pilot is to contribute to the creation of an appropriate legal environment for autonomous cargo vehicles operation. The same applies for the autonomous passenger cars operation.
- Supply and delivery of vehicles: Given that the market is limited and the COVID-19 situation restrictions, the estimated time between procurement and final delivery of the shuttles at Trikala pilot site is more than expected.
- User acceptance: How users will accept to use the autonomous shuttles instead of the current public transportation service?
- Technical risk: 5G connectivity has to be tested real-time for all the use cases related routes.

8. Security concerns:

Latency and security issues as regards communication of the vehicles with the remote control center and real time data transmission need to be tested and checked thoroughly before pilots' realisation.

Development\ Implementation Section

1. Storyboard for the site specific use case:

- **For Use Case 1.1**

UC 1.1a): Two autonomous shuttles will operate on a fixed line with the following characteristics.
The route of the automated shuttles runs between the city center and the intercity bus station covering also specific points of interest of the citizens such as Hospital, Milk Factory, major suburbs and villages. In more detail:

- Total Route Length= 6.850meters
- Three 4-way signalized intersections
- Recommendations of 4 signalized T-Intersection
- One roundabout
- 13 pedestrian crossings

The estimated daily passenger traffic for this line is 200 passengers / day (according to studies executed in year 2019) for the Intercity KTEL Station, and constitutes 50% of the existing passenger traffic. The envisaged operating frequency of the buses will be 6 times per hour (every 10 minutes) but this is still under investigation.

The scenario for the operation is as follows:

1. The bus starts its route from the terminal at the city center under normal traffic and environmental conditions with a maximum speed of 25km/h.

2. The remote PT operator monitors continuously the bus via the fleet management software installed in the control center.
3. The bus follows the heavy traffic in front, adjusts accordingly its speed and brakes smoothly following the traffic in front.
4. Passengers wait at the predefined bus stations and are informed for the bus arrival time via their mobile application.
5. The bus stations are also equipped with the bus schedule.
6. The bus follows the route and stops at each station where passengers are detected.
7. The passenger enters the vehicle.
8. The bus arrives at a signalised intersection and communicates with the traffic lights in order the green wave to be implemented.
9. The bus stops at the next bus station upon the request of the passenger via the stop button installed inside the vehicle.
10. The passenger exits the bus.
11. The bus continues the route, follows the roundabout on the route with priority and reaches its final destination at the depot area.

UC 1.1b): The cargo autonomous vehicle FURBOT will deliver goods within a pedestrian road at the center of Trikala city. The operation of this vehicle will be performed at night with a duration of 2-3 hours with a maximum speed of 15km/h. Two to three local businesses will be benefited from each operation. In more detail its operation is as follows:

1. The FURBOT vehicle load is packaged in freights boxes with the help of the vehicle operator.
2. The safety driver on board monitors continuously the vehicle's route.
3. The FURBOT follows its predefined route and stops at the fixed location in order to unload part of its cargo.
4. The vehicle parks safely in an autonomous way.
5. The local business stakeholder picks up the load via the robotised freight boxes.
6. The vehicle continues its route, stops at every delivery location until all the goods are delivered.
7. The vehicle parks at the depot area.

- **For Use Cases 1.2 & 1.6**

UC1.2a: Two autonomous shuttles will operate on a fixed line with the following characteristics.
The route of the automated shuttles runs between the city center and the intercity bus station covering also specific points of interest of the citizens such as Hospital, Milk Factory, major suburbs and villages. In more detail:

- Total Length= 6.850meters
- Three 4-way signalized intersections
- Recommendations of 4 signalized T-Intersection
- One roundabout
- 13 pedestrian crossings

The estimated daily passenger traffic for this line is 200 passengers / day (according to studies executed in year 2019) for the Intercity KTEL Station, and constitutes 50% of the existing passenger traffic. The operating frequency of the buses will be 6 times per hour (every 10 minutes).

The scenario for the operation is as follows:

1. The bus starts its route from the terminal under normal traffic and environmental conditions with a maximum speed of 25km/h.

2. The remote PT operator monitors continuously the bus via the fleet management software installed in the control center.
3. The bus follows the heavy traffic in front, adjusts accordingly its speed and brakes smoothly whenever the vehicles in front are braking.
4. Passengers wait at the predefined bus stations and are informed for the bus arrival time via their mobile application.
5. The bus stations are also equipped with the bus schedule.
6. The bus follows the route and stops at each station where passengers are detected.
7. The passenger enters the vehicle.
8. The bus arrives at a signalised intersection and communicates with the traffic lights in order the green wave to be implemented.
9. The bus stops at the next bus station upon the request of the passenger via the stop button installed inside the vehicle.
10. The passenger exits the bus.
11. The bus continues the route but another vehicle is blocking the road as the bus in not running in a dedicated lane.
12. The bus detects this obstacle and is safely immobilised.
13. The remote operator monitors the situation for the remote control center.
14. After the vehicle moves and unblocks the road the bus continues its route.
15. The routing schedule is updated and the passengers are informed for the new arrival times at each station.
16. The bus continues the route, delivers the rest of the passengers at the next stations and after all the passengers are exit, follows the roundabout on the route with priority and reaches its final destination at the depot area.

UC1.2b: The cargo autonomous vehicle FURBOT will deliver goods within a pedestrian road at the center of Trikala city. The operation of this vehicle will be performed at night with a duration of 2-3 hours with a maximum speed of 20km/h. Two to three local businesses will be benefited from each operation. In more detail its operations is as follows:

1. The FURBOT vehicle load is packaged in freights boxes with the help of the operator
2. The safety driver on board monitors the vehicle's route
3. The FURBOT follows its predefined route and stops at the fixed location in order to unload part of its cargo
4. The vehicle parks safely in an autonomous way
5. The local business stakeholder picks up the load via the robotised freight boxes
6. The vehicle continues its route, stops at every delivery location until all the goods are delivered.
7. The vehicle return back at the depot area.

- **For Use Case 1.3**

UC1.3a: Two autonomous shuttles will operate on a fixed line with the following characteristics.

The route of the automated shuttles runs between the city center and the intercity bus station covering also specific points of interest of the citizens such as Hospital, Milk Factory, major suburbs and villages. In more detail:

- Total Length= 6.850meters
- Three 4-way signalized intersections
- Recommendations of 4 signalized T-Intersection
- One roundabout
- 13 pedestrian crossings

The estimated daily passenger traffic for this line is 200 passengers / day (according to studies executed in year 2019) for the Intercity KTEL Station, and constitutes 50% of the existing passenger traffic. The operating frequency of the buses will be 6 times per hour (every 10 minutes).

The scenario for the operation is as follows:
1. The bus starts its route from the terminal under normal traffic and environmental conditions with a maximum speed of 25km/h
2. The remote PT operator monitors continuously the bus via the fleet management software installed in the control center
3. The bus follows the traffic in front and reached a pedestrian crossing where people are waiting to cross the road
4. The bus adjusts accordingly its speed, brakes smoothly and stops until all the pedestrians cross the road.
5. The bus starts again its operation, follows its the route and stops at each station where passengers are detected
6. The passenger enters the vehicle
7. The bus arrives at a signalised intersection and communicates with the traffic lights in order the green wave to be implemented.
8. The bus stops at the next bus station upon the request of the passenger via the stop button installed inside the vehicle
9. The passenger exits the bus
10. The bus continues the route but a cyclist is in front and illegally stops along the route as the bus in not running in a dedicated lane.
11. The bus detects this obstacle and is safely immobilized.
12. The remote operator monitors the situation for the remote control center.
13. After the cyclist moves and unblocks the road the bus continues its route.
14. The routing schedule is updated and the passengers are informed for the new arrival times at each station.
15. The bus continues the route, delivers the rest of the passengers at the next stations and after all the passengers are exit, follows the roundabout on the route with priority and reaches its final destination at the depot area.

UC1.3b: The cargo autonomous vehicle FURBOT will deliver goods within a pedestrian road at the center of Trikala city. The operation of this vehicle will be performed at night with a duration of 2-3 hours with a maximum speed of 20km/h.

Two to three local businesses will be benefited from each operation. In more detail its operations is as follows:
1. The FURBOT vehicle load is packaged in freights boxes with the help of the operator.
2. The safety driver on board monitors the vehicle’s route
3. The FURBOT follows its predefined route and stops at the fixed location in order to unload part of its cargo.
4. The vehicle parks safely in an autonomous way.
5. The local business stakeholder picks up the load via the robotised freight boxes
6. The vehicle continues its route but a pedestrian is crossing the road.
7. The vehicle detects the pedestrian, adjusts its speed and stops smoothly.
8. The safety person on board activates also the emergency brake.
9. After the pedestrian moves and the road is unblocked the vehicle continues its route towards every delivery location until all the goods are delivered.
10. The vehicle parks at the depot area.

- **For Use Case 1.5**

A novel TMC, able to manage traffic of connected and automated as well as of conventional vehicles, will be set-up for the Trikala pilot. It will be able to support operationally the following:

- Creation of traffic management scenarios, related to a) automated vehicles use cases that take part in Trikala, b) fleet management needs for the use cases that take part in Trikala, c) regular traffic management (subject to available local infrastructures/installations)
- Provision of a user-friendly visual interface for a) scenario management and b) dashboard for monitoring related KPIs on digital maps and selected graphs/charts
- Access to the above for the pilot execution through secure web interfaces, providing C-ITS enabled Traffic Management as a Service for the Trikala pilot.

- **For Use Case 1.8**

Whenever the on-demand MaaS service includes a trip outside the boundaries of the “”control area” (city centre), the service will be provided by a L4 vehicle (with driver) and for higher groups (above 3 persons) both passenger and cargo operation as a platoon.

- **For Use Case 1.7**

The operations of this use cases are covered by use cases 1.1-1.3, i.e. monitoring, emergency brake and immobilisation.

- **For Use Case 1.10**

Two autonomous shuttles will operate on a fixed line on demand with the following characteristics.

The route of the automated shuttles runs between the city center and the intercity bus station covering also specific points of interest of the citizens such as Hospital, Milk Factory, major suburbs and villages. In more detail:

- Total Length= 6.850meters
- Three 4-way signalized intersections
- Recommendations of 4 signalized T-Intersection
- One roundabout
- 13 pedestrian crossings

The estimated daily passenger traffic for this line is 200 passengers / day (according to studies executed in year 2019) for the Intercity KTEL Station, and constitutes 50% of the existing passenger traffic. The operating frequency of the buses will be scheduled in advance according to the demand.

The on demand operation is based on the following:

- The time and place of departure and arrival are pre-defined (from/to pick-up points, to/from transport hubs)
- The users will be able to select the origin and destination points as well as the time of departure and/or arrival (during a specific time-frame [e.g. during the previous day] in order to allow the operator to schedule the service in advance)
- The operator will be able to approve or reject the demand
- The operator will be able to inform the users about the service schedule (for the next day), via a variety of ways, including web interface and smart-phone application
- The users will be able to access the service in a variety of ways, according to their preferences (for example web interface and smart-phone application).

- Users training will be offered – for platform usage.
- Ways of providing motivation to users (rewards, discounts) will be examined, so as to increase the demand for the new dial-a-ride service, and therefore make the service viable

Therefore in more detail:

1. The user requests a ride via its mobile application by setting the pickup bus station, its destination bus station and time of departure.
2. The system collects all the relevant requests and performs the optimised route scheduling.
3. The passengers are informed about their request (accept or deny).
4. The bus starts its route from the terminal under normal traffic and environmental conditions with a maximum speed of 25km/h.
5. The remote PT operator monitors continuously the bus via the fleet management software installed in the control center.
6. Passengers wait at the requested bus stations and are informed for the bus arrival time via their mobile application.
7. The bus stations are also equipped with the bus schedule.
8. The bus follows the route and stops at each station where the system has provided.
9. The passenger enters the vehicle.
10. The bus arrives at a signalised intersection and communicates with the traffic lights in order the green wave to be implemented.
11. The bus stops at the requested by the system bus stations.
12. The passenger exits the bus.
13. The bus continues the route, follows the roundabout on the route with priority and reaches its final destination at the depot area.

For the last mile operation 2 autonomous passenger cars will be used, through local Maas Service in the same area. Beyond this area, will be used in the form of platooning.

2. Demonstrators:

- 2 iDriverPlus shuttles DL4 (for UCs 1.1, 1.2, 1.3, 1.6, 1.7, 1.10)
- 1 cargo vehicle named FURBOT DL3 (for UCs 1.1, 1.2, 1.3, 1.6, 1.7)
- 2 passenger cars BMWi3 DL4/5 (for UCs 1.5, 1.7, 1.8, 1.10)

3. Vehicle types included:

- Shuttles, cars
- Freight vehicle
- Passenger cars

4. Involved vehicle brands:

- 2 ZhongTong shuttles provided by iDriverPlus (for UCs 1.1, 1.2, 1.3, 1.6, 1.7, 1.10)
- FURBOT vehicle prototype provided by UNIGE (for UCs 1.1, 1.2, 1.3, 1.6, 1.7)
- i3BMW (for UCs 1.5, 1.7, 1.8, 1.10)

5. Involved fleet operators:

- e-Trikala,
- Municipality of Trikala
- ASTIKO KTEL Trikalon

6. **Physical Infrastructure required:**

A local TMC will be developed and linked to the supervision of the AV fleet. C-ITS nodes will be employed. Potential use of 5G will be explored and decided later whether to integrate or not.

7. **Relevant WP(s)/Activity(ies) of GA:**

- WP1 Ecosystem Views & SHOW UCs
- WP2 Business / Operating models
- WP4 System architecture and tools
- WP5 Big Data Collection, processing and analytics
- WP6 Services Marketplace
- WP8 Infrastructure functions and systems
- WP13 Impact assessment

8. **Entities involved in implementation:**

i. Internal entities to the Consortium:

- ICCS
- e-Trikala
- UNIGE
- CERTH/HIT

ii. External entities to the Consortium:

- Vodafone telecom operator

9. **Entities involved in testing & demonstration:**

i. Internal entities to the Consortium:

- ICCS
- e-Trikala
- UNIGE
- CERTH/HIT

ii. External entities to the Consortium:

- Vodafone telecom operator
- Local business stakeholders
- Astiko Ktel Trikalon

Business\ Exploitation Section

1. **Specific travellers' cohorts addressed:**

- For the use cases 1.1a, 1.2a, 1.3a, 1.6, 1.7, 1.8 and 1.10, the travellers are commuters, tourists, residents as well as VRU.
- For the 1.1b, 1.2b. 1.3b, 1.7, local business stakeholders will benefit from the operation of the freight vehicle.

2. **Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable):**

During the Trikala pilot operation, the operation will affect a daily traffic of approximately 200-250 passengers per day (assuming 320 operating days a year this equals to around 80000 per year), while for UC2, assuming that the freight schedule will include 6 deliveries by average (day and night) will lead to 1920 cargo deliveries a year (assuming 320 working days a year). Finally, MaaS UC (3), assuming that each car will transport 1,5 users and 3 routes per day by average, will accommodate the transport of 9 passengers per day; thus 2280 passenger transports per year. Thus, overall around 83000 passengers and 1920 cargo transports are estimated on annual basis in Trikala pilot.

3. Starting point/background & Innovation in SHOW:

The operation of an Automated Road Transport System (ARTS) pilot was carried out in the city of Trikala by ICCS and e-Trikala through the program CityMobil2, lasting from November 2015 until the end of February 2016. During this period, the six automated minibuses completed 1,490 trips and carried 12,138 passengers in the city centre. The fleet of six robot buses was used for public transportation and each bus had a capacity of 11 passenger. For formulating a more familiar experience, each robot bus was named after a famous singer and the singer's songs were played in each bus during each trip. The route was different to the one of SHOW and used a dedicated lane, had a length of 2.4 km that lasted 29min on average and included nine bus stops, located close to important touristic attractions and points of interest in the city of Trikala. Trained operators at the control centre supervised, communicated and controlled the minibuses. An operator was on board each minibus to intervene if needed. The operator mingled with the rest passengers, so as to reduce his/her presence. The demonstration and results of the project CityMobil2 shaped, transformed and re-identified the passengers', citizens' and stakeholders' acceptance of the automated road transport system, drove their satisfaction, attitudes and opinions towards the use of automated vehicles in the future and more generally towards new innovative systems and services. The automation level was 3, while now it is 4 in the context of SHOW. The legal framework already exists and the partners are in the process of updating it with the Ministry of Transport aiming to real-life operation and mixed-traffic environments as well as higher speed, no dedicated lane required etc.

Furthermore, prior to SHOW demonstration pilot the autonomous shuttles operation and their communication and connectivity with the remote control center will be tested and demonstrated via the national funded program AVINT.

4. Training and other skills/knowledge requirements for key stakeholders involved:

Training will be required for the remote control centre operators. Training or instructions will also be needed for the users of DRT service. Also training for the PT, DRT and MaaS (in case of platooning) drivers of L4.

5. Incentives associated:

Incentives will be defined at a later stage, but the service will be free of change during pilot demonstration.

6. Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):

The automated buses operation is expected to be a permanent DRT service in the future, on demand with predefined stops. Demand has been assessed for the two automated urban buses with a route connecting the city center and the Intercity Bus Station. A feasibility plan has been conducted in the context of AVINT project and the service is proved to be financially viable. The two automated buses will be eventually integrated within the local transportation system of Trikala and be exploited in the future by the public operator. In the context of the demonstration, the vehicles will be owned by e-Trikala. DRT will be also the business model for the robot-taxis MaaS service to complement the buses business cases an implying improvements in accessibility, increasing the occupancy for this route of high demand, the buses utilisation and service efficiency, and optimization of duration/length/number of trips, increasing inclusiveness at the same time. An initial feasibility assessment is expected in order to analyse the case of becoming a permanent line. Last, regarding FURBOT freight vehicle and LaaS, it will be assessed how it will meet the requirements of multiple stakeholders to be engaged with its operation in Trikala. Its business value will be related to de-congestion of the commercial pedestrian road that the city center is covered, from freight vehicles within the day, as its operation is considered to be during evening-night hours.

Regarding the infrastructure what is written to the excel file is considered for all the use cases. 5G and 4G will be used. Teleoperation aspect is only related with specific remote operations via the established remote control center such as emergency break and immobilization. TLC and OBU are also considered.

Beyond the project duration:

- Cost-benefit analysis will be held for the new line within the national project AVINT regarding the shuttles operation.
- For the robo-taxis, a business plan for a sustainable MaaS service beyond the project duration will be performed; involving also local SMEs.

3.2.6 The Turin Satellite site

In the pilot site of Turin the following SHOW Use Cases are going to be covered:
UC1.2; UC1.3; UC1.5; UC1.7; UC1.10.

<u>Design Section</u>

1. **Site specific application of the Use Case:**

   iii. **Site specific title of the Use Case:**
   - **For Use Case 1.2**: “Door-to-door transport of hospital patients in mixed traffic on public roads”
   - For Use Case 1.3: “Presence of vulnerable road user on smart crossing equipped with C-ITS capabilities ”
   - **For Use Case 1.5**: “Traffic light priority to autonomous shuttle”
   - **For Use Case 1.7**: “Tele-operated vehicle towards the hospital”
   - **For Use Case 1.10**: “Link between the railway station and the hospital”

   iv. **Leading entity:** Fondazione LINKS (Brunella Caroleo)

2. **Ecosystem key stakeholders clusters involved:**
   - ✓ OEM’s and transport/mobility operators .
   - ✓ Tier 1 suppliers, telecom operators, technology providers, SME’s.
   - ✓ Research & academia.
   - ✓ Umbrella associations
   - ✓ Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers.
   - ✓ Other (please define): 5T (subcontractor: large enterprise that provides mobility services for Local Administrations and citizens, like: Traffic

Management and Control, Infomobility, MaaS, Sustainable Mobility (Mobility Management) and Smart Ticketing)

3. Operational speed:

- **NAVYA SHUTTLE:** Maximum speed currently at 18 km/h; estimated to arrive at 25 km/h during the lifespan of the project in Turin.
- **TELE-OPERATED CAR:** Currently limited at 10 km/h, estimated to arrive at 15 km/h before the pilot phase; the target for the final demonstrator if all the technical requirements are met, is 30 km/h.

4. Traffic context:

The pre-pilot (involving 1 Local Motors Olli automated shuttle) took place at the ITC ILO campus (International Training Centre of the International Labour Organization) from March to July 2020. The shuttle circulated within the campus, i.e. in an area closed to the open traffic but where pedestrians, cyclists and the employees' cars circulate freely.

The pilot (involving 1 Navya shuttle and 1 tele-operated car) will take place in the urban area of Turin, in condition of normal/high traffic density. The two automated vehicles will arrive at the hospital of 'Città della Salute e della Scienza di Torino' passing through the usual traffic of the city, mainly on mixed lanes.

The first figure shows one of the entries of the hospital, while the second and the third ones show some possible paths towards the hospital.

Figure 88: The Turin pilot site

5. Frequency and timeline of operation:

The service will be available only during the days of medical visits in the hospital (from Monday to Friday) and during the hours of access to medical examinations (most likely 7-20).

Since it is a DRT (Demand-Responsive Transport) service, there is no predefined frequency.

6. Restrictions & dependencies:

Dedicated high-speed data connection is required.

For the NAVYA shuttle and the tele-operated car (retrofitted by OBJECTIVE-LUXOFT) the environmental conditions in which the vehicles do not operate are the following:

- Fog with visibility < 100 m
- Ice fog
- Rain impacted visibility
- Snow impacted road stability or/and visibility
- Thunderstorm
- Ice
- Operation temperature < -10°C or > 40°C
- (Objective-Luxoft) Bad network coverage
- (Objective-Luxoft) Front camera not working
- (Objective-Luxoft) Control system not working

Other constraints:

- Localisation: no automatic operation without path programmed;
- Speed: the shuttle cannot operate in environments where the other road users go beyond 50 km/h;
- Minimum width of path: 3 m (highly recommended);
- Presence of landmarks around the route that help for Lidar localisation.

7. Key risks identified:

- Double parking (in the absence of a dedicated lane);
- user acceptance of the autonomous vehicle / fear of staying on the automated vehicle;
- technical problems blocking the autonomous vehicle;
- accident with another vehicle / accident with a VRU;
- lack of service efficiency / delays;
- network connection problems;
- safety of users on board linked to the COVID emergency;
- vehicle capacity limits (allowing in only passengers with a booking);
- management of delays in the transport chain (for UC 1.10: how to manage possible train delays).

8. Security concerns:

A safety driver is on board.

For the NAVYA shuttle:

- There is support for cryptographic keys and storage provided by the OS.
- It is possible to eliminate and/or isolate non-crucial technologies, such as Bluetooth and wi-fi.

- Logs able to detect cyber threats, code analyser.

For the OBJECTIVE-LUXOFT tele-operated car:
- Full disk encryption (including boot sector)
- Support for cryptographic keys and storage
- It is possible to eliminate and/or isolate non-crucial technologies, such as Bluetooth
- File transfer protocols used for the communication channels: RTSP, UDP under VPN
- The connection between the vehicle and server will be established through a point2point VPN. Ports do not appear as open under a scan.

Development\ Implementation Section

1. Storyboard for the site specific use case(s):

- **For Use Case 1.2**

Title: "Door-to-door patients' transport on public roads and mixed traffic towards the hospital"

A patient books a visit at the hospital of the "City of Health and Science of Turin". If this patient is part of the target group, at the same time the operator will also book the door-to-door automated transport service to the hospital for him. At the agreed time, the autonomous vehicle will pick up the patient and take him to the hospital entrance. Along the way, it will also collect the other patients who have booked the service. At the end of the visit, the autonomous vehicle will bring the patient back.

Figure 89: Description of Turin Pilot site UC1.2

- **For Use Case 1.3**

Title: "Presence of vulnerable road user on smart crossing equipped with C-ITS capabilities"

A C-ITS system composed by a smart RSU with sensors (e.g. camera and/or LiDAR, etc…) located at a crossing, detects the presence of pedestrians/cyclists in transit and communicates, in real-time, this information to an autonomous vehicle. The information is used to avoid an accident or to minimize its impact on the VRU.

- **For Use Case 1.5**

Title: "Traffic light priority to autonomous shuttle"

The autonomous shuttle is close to a traffic light junction managed by the TMC of the city of Turin. As the vehicle approaches, priority is given to the shuttle, which can then cross the intersection more quickly and safely.

- **For Use Case 1.7**

Title: "Tele-operated vehicle towards the hospital"

The booking system requires that the tele-operated car picks up a patient at a certain address to bring him to the hospital at the visit time. A remote driver drives the tele-operated car to the specified address, the patient gets into the vehicle, and the car takes him/her to the hospital.

- **For Use Case 1.10**

Title: "Link between the railway station and the hospital"

A patient from outside the city booked a medical visit to the hospital of the "City of Health and Science of Turin". Being part of the target group, when booking the visit, he requested the autonomous transport service at the hospital. The patient travels to Turin by train, gets into the autonomous vehicle that awaits him at the agreed time outside the railway station, and is taken to the hospital entrance.

2. **Demonstrators:**
   - 1 NAVYA DL4 (shuttle), SAE level 4
   - 1 tele-operated vehicle (car retrofitted by Objective-Luxoft), SAE level 4

Association vehicle / use case:

	1 NAVYA DL4 (shuttle)	1 tele-operated vehicle (car)
UC1.2	X	X
UC1.3	X	
UC1.5	X	
UC1.7		X
UC1.10	X	X

3. **Vehicle types included:**
   - 1 shuttle
   - 1 retrofitted car

4. **Involved vehicle brands**:
   - Navya
   - KIA (still to be confirmed), or in any case a vehicle compatible with Polysync technology

5. **Involved fleet operators:** None

6. **Physical Infrastructure required:**

The Turin pilot (involving 1 Navya shuttle and 1 tele-operated car) will take place in the urban area of Turin, in condition of normal/high traffic density. The two automated vehicles will arrive at the hospital of 'Città della Salute e della Scienza di Torino' passing through the usual traffic of the city, mainly on mixed lanes (UC1.2, UC1.7).

The routes of both vehicles are currently being defined in collaboration with the City of Turin, but it is likely that the vehicles will pass along the roads already considered suitable by the Municipality to test autonomous vehicles.

As regards 1.3, a C-ITS system composed by a smart RSU with sensors (e.g. camera and/or LiDAR, etc.) located at a crossing, detects the presence of pedestrians/cyclists in transit and communicates, in real-time, this information to the autonomous vehicle. The information is used to avoid an accident or to minimize its impact on the VRU.

As regards UC1.5, when the autonomous shuttle approaches a traffic light junction managed by the TMC of the city of Turin, priority is given to the automated vehicle, which can then cross the intersection more quickly and safely.

In order to cover UC1.10, it is envisaged a pick-up point close to Lingotto railway station, so that patients getting off the train can arrive at the hospital travelling on the automated vehicle.

7. **Relevant WP(s)/Activity(ies) of GA:** WP1, WP3, WP4, WP7, WP8, WP9, WP15.

8. **Entities involved in implementation:**

   i. **Internal entities to the Consortium:**

- FONDAZIONE LINKS - LEADING INNOVATION & KNOWLEDGE FOR SOCIETY (LINKS) [Research & Academia]
- NAVYA (NAVYA) [OEM & Operators]
- GTT (GTT) [OEM & Operators]
- SWARCO MIZAR SRL (SWARCO) [Other industry]
- Objective Software Italia SRL (OBJECTIVE) [Other industry]
- BESTMILE SA (BESTMILE) [SME]

   ii. **External entities to the Consortium:**

- 5T srl [SWARCO subcontractor]
- TTS (Associazione Nazionale per la Telematica per i Trasporti e la Sicurezza) [LINKS subcontractor]
- Turin City Council [Letter of Commitment from Cities/Municipalities/Regions]
- Città della Salute e della Scienza (Hospital Management Agency) [Letter of Committment from Stakeholders**.**

9. **Entities involved in testing & demonstration:**

   i. **Internal entities to the Consortium:**

- FONDAZIONE LINKS - LEADING INNOVATION & KNOWLEDGE FOR SOCIETY (LINKS) [Research & Academia]
- NAVYA (NAVYA) [OEM & Operators]
- GTT (GTT) [OEM & Operators]
- SWARCO MIZAR SRL (SWARCO) [Other industry]
- Objective Software Italia SRL (OBJECTIVE) [Other industry]
- BESTMILE SA (BESTMILE) [SME]

   ii. **External entities to the Consortium:**

- 5T srl [SWARCO subcontractor]
- TTS (Associazione Nazionale per la Telematica per i Trasporti e la Sicurezza) [LINKS subcontractor]

- Turin City Council [Letter of Commitment from Cities/Municipalities/Regions]
- Città della Salute e della Scienza (Hospital Management Agency) [Letter of Commitment from Stakeholders]

Business\ Exploitation Section

1. Specific travellers' cohorts addressed:

Patients of the hospital in "Città della Salute e della Scienza" of Turin.
VRUs that interact with an autonomous vehicle.

2. Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable): N/A

3. Starting point/background & Innovation in SHOW:

- In the past, the target hospital had already experimented with a pilot project providing (not autonomous) transport service to some of the patients. There is currently no door-to-door transportation service for patients at this hospital.
- Many cities and projects have deployed autonomous shuttles on the past few years. Nonetheless, many aspects remain to detail and discover in order to reach the level of expectation of the market for the level of service existing on other public transportation means. The Turin project will be the opportunity to push forward the integration of autonomous shuttles in mixed traffic with other vehicles, fully integrated in a demand-responsive system, along with V2X communication with traffic light.
- During the pre-pilot phase, that took place in Turin from March to July 2020 at the ITC-ILO campus, LINKS Foundation began to assess the user acceptance and the user experience of Local Motors Olli autonomous shuttle. During this phase, LINKS had also the opportunity to assess the drivers and the barriers of the implementation process.
- As regards the tele-operated car, the Teleoperated Driving Project (started in 2016) was aimed to turn a passenger vehicle into a remotely controlled vehicle by adding two main features: (i) a system for controlling the pedals and the steering wheel of the vehicle; (ii) a real-time video streaming service providing a HD quality livestream from the front camera. These features allow one person to control the vehicle remotely, even from another city. For the purpose of this project, a BMW i3 vehicle was customized by Objective-Luxoft, which added a mechatronic system for controlling the vehicle. The first prototype was based on a WiFi connection, which would allow a high video quality but only supported a limited area in which the vehicle could operate. Nonetheless, the solution proved already successful: it was possible to control the vehicle in a test field and the video and control latency were low enough for driving the vehicle following any trajectory. During later iteration of the project, some changes were applied for supporting 4G and 5G networks. The video streaming application was adapted for supporting forward error correction, better compression and new streaming protocols. In the following test of the application, the car was controlled in real traffic in a city scenario. Controlled from another city, with a distance greater than 500 km. The control system was also updated: some of the actuators were removed in favor of electronic and bus-based controls, further reducing the control latency and complexity. This solution allowed to replicate the solution on other vehicles in shorter time.
- As regards the interface with Vulnerable Road Users (VRUs), LINKS Foundation has already developed a first prototype of RSU (Road Side Unit) with VRU protection in the H2020 Autopilot project (in a controlled

environment). Moreover, LINKS is currently extending this concept in the H2020 ICT4CART project. In SHOW the concept will be further refined, by enhancing the precision of the detection and of the accident prediction algorithms.

4. **Training and other skills/knowledge requirements for key stakeholders involved:**
    - Training of the drivers, both Navya's shuttle and the tele-operated car ones.
    - Permits and legal authorisations.
    - Maintenance and cleaning of the vehicles.

5. **Incentives associated:** The operation is free for use upon reservation, during the project.

6. **Provisional business plans for post-project operation:**

7. **Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):**

For UC1.2: The considered hospital is located in a busy area in the city center. Choosing such facility is difficult from technical point of view, but allows to broaden the target group of customers by patients living in the densely populated central areas. Moreover, often public transport is used for reaching such zones, however in the time of pandemic a demand-responsive door-to-door transport brings extra value to the customers regarding exposure to health risk.

The key activity is to design a route for the vehicle that will be safe, efficient and feasible. The AV must be able to reach all the required destinations without losing too much time. Moreover, the operational domains of currently available AVs are rather limited, therefore finding optimal route requires close cooperation among many stakeholders, most importantly the vehicle designers, traffic managers, municipality etc.

For UC1.3: Since the AV will operate in densely populated urban area interactions with VRUs are unavoidable. For that reason it is necessary to ensure that the vehicle operates safely within its operational domain, which was already addressed in relation to UC1.2.

Moreover, it is necessary to communicate to general public that the experiment is underway in order to ensure extra safety. Especially the people living in the area of the demonstration should be reached.

For UC1.5: Integrating movements of AVs with the traffic management system is important for creating value for the customers. Thanks to such coordination it is possible to give priority for the AV on intersections which improves safety and reduces the time spent in traffic jams. Not only it increases the value of the service for the users, but might also contribute to improvement of overall traffic conditions.

The key activity is redesigning the traffic management system and synchronising it with the AVs fleet. In Turin case, it requires cooperation between Navya (the AV manufacturer) as well as Swarco and 5T which are responsible for the necessary modifications of traffic infrastructure. Necessary activities also include further maintenance.

The described adjustments constitute also the fixed cost of the operation, with possible extra maintenance costs.

For UC1.7: The AVs are coordinated by a centralized operation centre which is responsible for planning and optimizing their schedules, and also for remote steering in the case of tele-operated car. Added value for the customers is created by minimizing waiting time and keeping them updated about the state of their booking. Moreover, thanks to optimization also cost of the service is reduced.

In case of tele-operated car these activities are carried out by Luxoft, which is also responsible for the key task of retrofitting the vehicle. In the case of autonomous shuttle cooperation of the vehicle owner (Navya) and Bestmile is required. The latter is responsible for developing the key resources: dedicated software and infrastructure for communication between the vehicle and operational centre.

The operator also handles communication with the customer. It is possible for the user to check the position of the vehicle, the expected arrival time as well as possible delay. This communication is possible by using a dedicated mobile application provided by Bestmile.

For UC1.10: The AV service is intended to be connected with Lingotto station, so that the hospital patients arriving by train to the station will be able to seamlessly transfer to the AV. In this way added value for customers is created, thanks to providing shorter waiting time and more convenient way of reaching the hospital. Moreover, by including patients outside Turin the target group of customers is further extended.

The key activity is designing an interchange node between the two transport modes. It requires finding a location close to the station, where the AV can safely park and wait for the passenger. It might require cooperation with the municipality and the local public transport operator, since preferably bus stop will be used for this purpose.

Important issue from the customer relationship standpoint is also proper communication of the parking point to the users, so that it can be quickly and easily reached from the station.

Beyond the project:

During the pilot the service is free of charge upon reservation, therefore an optimal pricing scheme will need to be established to make the project economically viable. Moreover, the funding can be possibly supported by some form of public-private partnership, for example within the recently established Italian National Innovation Fund. Further growth should be focused on increasing the service coverage, by adding more transport nodes (e.g. other train stations), hospitals and types of patients. It is also important to establish a convenient way to book the service at the same time when making an appointment at the hospital.

Regarding scalability, potential problems might appear with extending both the road network covered by the service and the target group. The duration of permission process required by law for using AVs might differ depending on the road, and eventually some roads might be deemed not feasible. Another possible challenge is further integration of the booking system of the vehicle with the hospital booking system. Most of the hospitals in the area are served by a regional booking system, therefore booking should be integrated with this system if more hospitals are added. Although it might be a challenging task from technical and political point of view, it is highly recommended for attracting new clients and improving users’ experience.

4 Conclusions

The current document presents the SHOW Use Cases, as those have been emerged through the methodology that has been defined in the project in the context of WP1: “Ecosystem vies and SHOW Use Cases”. In specific, this project activity (A1.3) aims to the identification and elaboration of the priority urban automated mobility Use Cases of the project, all meeting stakeholder interest and preliminary acceptance. The identified UCs (3 UC families and 17 single UCs) have revised and updated the pre-defined use cases from the proposal phase, described also in the GA. The Consortium experts provided their view and filtered them, in order for the final UCs to be more precise and inclusive, reducing to the greatest possible extend any duplications among them, while they have been also prioritised through a dedicated session during the 1st SHOW Pan-European Workshop that took place at the 18th of September 2020 with the participation of stakeholder representatives covering the whole value chain. According to the results of this prioritisation the UCs have been clustered into 3 categories, namely the Essential, the Secondary and the Additional UCs (Section 2.2). During the interactive session of the Workshop, it was obvious that the SHOW project already convinced stakeholders for its revolutionary vision; still, partially because of the stage it currently is, with no demonstration results but this has also led to the collection of valuable feedback that will be certainly taken into consideration in the next stages of the project.

All Use Cases are being addressed by different pilot sites of the project, in different extent, from 1 to 12 pilot sites for single UCs (Section 3).

These final UCs correspond to the stakeholders’ needs, priorities and views that have been already captured through a desktop research (described in D1.1). This mapping is presented in Section 0, while also a preliminary mapping has been also made to the SPACE UCs (Section 2.1.3) and to the current KPIs of the project (Section 2.4) that will be updated after the KPIs finalisation.

All Use Cases are described upon a consistent format following the template provided in Appendix 1 of this document. This format will allow them to serve as compliance checklists for the implementation to follow in WP4-WP8 of the project but also for the demonstration activities to follow in WP11 and WP12. All the advantages, drawbacks, enablers, challenges and prerequisites, risks are reported in detail for each pilot site of SHOW (Section 3).

The Use Cases will constitute across the whole project lifespan the reference point for all development and demonstration/pilot activities and if needed **the Use Cases of the project will be revised** after each demonstration round and changes will be reported to the Pilot Plans/ Pilot reporting deliverables.

References

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3. SWOV (2012): Vulnerable road users. SWOV Fact sheet, July 2012.
4. OECD (1998): Safety of vulnerable road users. DSTI/DOT/RTR/RS7(98)1/FINAL, 1998.
5. Avenoso, A., Beckmann, J. (2005): The Safety of Vulnerable Road Users in the Southern, Eastern and Central European Countries. European Transport Safety Council, Brussels, 2005.

Appendix I

Design Section

1. **Site specific application of the Use Case(s):** Each Use Case specific application may be different from each site to another.

   i. **Site specific title of the Use Case(s):** We need a title that will not be general this time but will be representative of what is going to happen in each site respectively.

   ii. **Leading entity:** Please define a leader of the demo site community that will be the contact entity for this overall

2. **Ecosystem key stakeholders clusters involved:** Please tick the involved ones.

   ☐ OEM's and transport/mobility operators
   ☐ Tier 1 suppliers, telecom operators, technology providers, SME's
   ☐ Research & academia
   ☐ Passengers and other road users encompassing VEC
   ☐ Umbrella associations
   ☐ Road operators, Authorities (Cities, Municipalities, Ministries) & policy makers
   ☐ Insurance companies
   ☐ Other: please define

3. **Operational speed:**

4. **Traffic context**: Please define the traffic context the real-life scenario will be realized. If it is urban, peri-urban, mixed lanes, dedicated lanes, refer to traffic density, number and name of operational lines. Please also provide photos of the real life environment where this will take place

5. **Frequency and timeline of operation**: Please define the frequency of operation (every two days, on daily basis, etc.

6. **Restrictions & dependencies:** Please refer to environmental and other restrictions, i.e. this scenario cannot be performed under rainy conditions, or low temperatures of …, or during holidays period, etc. Also refer to operational and technical ones

7. **Key risks identified:** Please refer to any type of risks that you think it is associated to this (user acceptance, technical, operational, behavioural, business,…). But please only serious and key ones.

8. **Security concerns:** Please refer to any security related concerns, e.g risk; including cybersecurity ones

Development\ Implementation Section

1. **Storyboard for the site specific use case:** **This is the scenario, upon which the experimental scenarios of WP9 will rely upon. The actors participating in the scenario should be evident. Could be "the vehicle", the "driver", the "passenger", the "PT operator", the "remote operator" and any other actors involved, the "system" (meaning the digital services or other elements provided by the SHOW infrastructure other than the vehicle.**

2. **Demonstrators:** **Please define the number and type of the demonstrators, the name of the provider and the SAE level for each, i.e. 3 NAVYA shuttle buses DL4.**

3. **Vehicle types included** (e.g. bus, shuttle, car, etc.)

4. **Involved vehicle brands:** **Please list all**

5. **Involved fleet operators:** **Please list all per vehicle/ vehicle type**

6. **Physical Infrastructure required:**

7. **Relevant WP(s)/Activity(ies) of GA:**

8. **Entities involved in implementation:** **Please list all those beneficiaries; internal and external to the Consortium (including third parties) that will be involved to make this happen. For internal beneficiaries, please use the official beneficiary names of the Consortium. And for external their official commercial name**

   i. **Internal entities to the Consortium:**
   ii. **External entities to the Consortium:**

9. **Entities involved in testing & demonstration:** **Please define the internal and external entities that will be involved in testing and demonstration. Please use the official beneficiary names of the Consortium for the internal entities**

   i. **Internal entities to the Consortium:**
   ii. **External entities to the Consortium:**

Business\ Exploitation Section

1. **Specific travellers' cohorts addressed:** **Please define the travellers' categories that will benefit from that. Tourists, VRU, commuters,…)**

2. **Target freight transport/operation in pre-demonstrations and final demonstration phases (if applicable):**

3. **Starting point/background & Innovation in SHOW:** **What is the background (has this been tried partially in the past, which vehicles (types, nr) pre-existed for this transport service? Automation level? capacity? QoS?) that will support it in your site and what is to be done more**

4. **Training and other skills/knowledge requirements for key stakeholders involved:**

5. **Incentives associated**: **Please refer to any incentives that you are going to apply especially in the final demonstration activities phase (e.g. lower tickets, vouchers, etc.**

6. **Provisional mapping to business and operating models of A2.1/D2.1 (to be revisited in D2.2):**